

Indicators of Hydrologic Alteration

Version 7.1

User's Manual



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Smythe Scientific Software

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Indicators of Hydrologic Alteration

Version 7.1

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1 Introduction

1.1 Welcome

Welcome to the rapidly growing community of Indicators of Hydrologic Alteration (IHA) software users! This software has been developed by The Nature Conservancy (TNC) as an easy-to-use tool for calculating the characteristics of natural and altered hydrologic regimes. The method and software will work on any type of daily hydrologic data, such as streamflows, river stages, ground water levels, or lake levels. The power of the IHA method is that it can be used to summarize long periods of daily hydrologic data into a much more manageable series of ecologically relevant hydrologic parameters.

The main IHA webpage is: <http://conserveonline.org/workspaces/iba>.

The scientific basis behind the software and some sample applications are described in Richter et al. (1996, 1997, 1998), which are available on the website. Note that the definition of some of the parameters and the methods for calculating them has changed since these papers were published. Additionally, TNC maintains a database of IHA users, which describes many different applications of the software. The database is also available on the website. Lastly, the website now has additional training resources on the IHA, including an on-line course in English and Spanish.

We hope that you will find these methods useful for understanding and managing changes in hydrologic systems.

For those using the IHA for the first time, a basic tutorial is available. The tutorial document is available on your program menu once the software is installed, and is also located in the IHA installation directory (default is c:\Program files\IHAV7).

1.2 What's New in Version 7

Version 7 of the IHA has some significant improvements from earlier versions. The most important new features are:

- (1) A new and improved interface, with enhanced spreadsheet and graphing tools for viewing IHA results. Results tables can now be viewed and edited in spreadsheet format, and saved as Excel spreadsheets. A new graphing package has also been incorporated into the IHA to provide users with the capability to create publication quality graphs inside the IHA.
- (2) The ability to import flow data in three different formats. Data can be imported directly from files downloaded from the U.S. Geological Survey website, from a generic two column text file format, and from .dat files created by the data import utility in Version 6 of the IHA.
- (3) Many of the calculations have been revamped to improve the consistency between how different flow parameters are calculated, and also to improve the non-parametric nature of some of the statistical calculations. See [Analyzing Hydrologic Data Using the IHA](#) and also

the [Technical Notes](#) for details on how different calculations are done. Be aware that these changes mean that some parameter values will be different than those computed by earlier versions of the software. In particular, the values in the [Annual Summaries Table](#) for non-parametric analysis are now medians of the relevant sub-annual data, whereas in earlier versions of the software, these values were means.

- (4) An improved help system, with context-sensitive help. To get help from within the program, click on **Help | IHA Help**, hit the available Help button, or hit F1 on your keyboard. A basic tutorial on how to use the software is also included. The tutorial document is available on your program menu once the software is installed, and is also located in the IHA installation directory (default is c:\Program files\IHAV7).
- (5) Environmental Flow Components (EFCs). This is a large new suite of hydrologic flow parameters, which represent an attempt to automatically identify and compute statistics on hydrological events such as floods and droughts. EFCs were actually initiated in Version 6 of the software, but are mentioned here because that version was not widely distributed. For a further description of EFCs, see [EFC Parameters](#).

Version 7.1 also has the following additional features:

- (1) The ability to compare two different flow datasets. This gives users the ability to compare flows from two different stream gauges or from two different model runs or scenarios. The computations are identical to a comparison of two different periods in a single flow dataset. See [Introduction to Projects](#) and [Project Definition Tab](#) for more information on this option.
- (2) The EFC algorithm has been improved to simplify the default version of the algorithm, and also to provide greater flexibility in calibration. See [EFC Calculation Algorithm](#) and [Calibrating the EFC Algorithm](#) for description of these features.
- (3) Flow duration curves (FDCs) have been added to the IHA. IHA will compute FDCs using the same periods, years, and days used for the 33 IHA statistics. FDC results are displayed in a new tab on the results spreadsheet, and are computed annually and for each month. It is possible to view any number of FDCs on the same graph. See [Flow Duration Curves](#) for more information.
- (4) Spanish language user manual and help system.
- (5) Note that while Version 7.1 of the IHA will open projects created in Version 7, once that is done, it will no longer be possible to use those projects with Version 7, since some alterations will be made in the IHA data files.

1.3 System Requirements

The program has been tested and will run reliably under the Windows 98, ME, NT, 2000, XP, and Vista Operating Systems. Brief tests indicate that it will not work reliably under Windows 95.

The installation will require approximately 6 MB of disk space. The calculations require very little computing power, but the graphics will have satisfactory performance only on Pentium 3 and faster processors.

1.4 Obtaining Hydrologic Data for Use in the IHA Software

The IHA software uses **daily** data for its calculations. The IHA statistics will be meaningful only when calculated for a sufficiently long hydrologic record. The length of record necessary to obtain reliable pre- vs. post-impact comparisons (with minimal influence of climatic variation) is a matter of current research. Presently, we are recommending that at least twenty years of daily records be used for each pre-impact and post-impact period, as well as for trend analysis. This is based on Richter et al. (1997), who found that for three different types of streams in the United States, measures of the central tendency or dispersion of annual 1-day maximum flows converged around the long-term mean when at least 20 years of data were used.

Some other recent articles on the issue of how many years of data are necessary to obtain reliable results are Taylor et al. (2003) and Huh et al. (2005). When Taylor et al. (unpublished) tested the impact of different record lengths on IHA output statistics for a highly variable South African river, they found that for some IHA parameters 20 years was sufficient to account for natural climatic variability, but for others 35 or more years of data were needed. More data was needed for more variable parameters and for extreme events such as large floods. In sum, while 20 years should be considered a good baseline requirement for the amount of data needed, the number of years of data needed may vary depending on the (1) degree of climate variability; (2) the frequency or variability of the particular parameter; (3) the severity of the hydrologic alteration that you are trying to detect; (4) and whether the goal is to characterize the central tendency or range of inter-annual variability (it seems to take less data to adequately characterize changes in the central tendency). If there is doubt about how much data is enough, some tests to see how different record lengths affect IHA statistics would be prudent.

Richter et al. (1997) also discuss various methods for extending hydrologic records, filling in missing data, or estimating daily hydrologic data from simulation modeling.

The IHA automatically does linear interpolation over gaps in the data; therefore, users should regard any IHA results from datasets with missing records with appropriate caution!

Hydrologic data can usually be obtained directly from the agency or organization that collects the data. In the United States, the vast majority of streamflow data are collected by the U.S. Geological Survey (USGS). Their data archive is conveniently available on the internet at <http://water.usgs.gov/usa/nwis>. Daily streamflow data downloaded from this website can be imported directly into the IHA.

Other federal agencies within the U.S., such as the U.S. Forest Service or U.S. Bureau of Land Management, also collect streamflow data on some of the streams located on lands they

manage. Some lake level and ground water well data are also available from the USGS, but much of this type of data is collected and managed by other local governmental entities. Usually, a few phone calls to local water departments or natural resource departments will lead you to the appropriate source of the data you are seeking, if it exists.

Private vendors, such as Hydrosphere Data (<http://www.hydrosphere.com>) have compiled USGS data onto CD-ROM disks, which are available for an annual subscription fee.

Daily flow data from the Water Survey of Canada are available on the internet at <http://www.wsc.ec.gc.ca/hydat/H2O/>.

Finally, the IHA can also be run using daily flow data generated by a hydrologic model or other simulation method.

While the IHA is primarily designed for analyzing streamflow data expressed in units of flow (cubic feet per second or cubic meters per second), there is no reason why data in different units or groundwater and lake levels expressed as elevations could not be also used in the IHA.

See [Allowable Data Formats](#) for more information on data import formats and requirements.

2 Analyzing Hydrologic Data Using the IHA

2.1 Introduction to Using the IHA

The IHA will calculate a total of 67 statistical parameters. These parameters are subdivided into 2 groups, the IHA parameters and the Environmental Flow Component (EFC) parameters. There are 33 [IHA Parameters](#) and 34 [EFC Parameters](#). This software has many options which can be used to control how these parameters are calculated, which are described briefly in this section. The output tables and graphs produced by the IHA will vary depending on which options are used (see [Viewing and Understanding IHA Outputs](#) for more description).

An important choice that will have to be made is whether to compare two distinct time periods or analyze trends over a single time period. If the hydrologic system you wish to study has experienced an abrupt change such as construction of a dam, the IHA can be used to analyze how the flow regime was affected by computing the hydrologic parameters for two time periods, before and after the impact. For hydrologic systems that have experienced a long-term accumulation of human modifications, the IHA can compute and graph linear regressions to evaluate the trend. As of Version 7.1, it is also possible to compare two different flow datasets. The computations and outputs here are identical to those from a two period analysis, except that two different flow datasets are being compared, as opposed to two different periods in a single flow dataset. See [Setting Up and Managing an Analysis](#) for information on how to set the time periods for these various types of analyses, and [Tables](#) for how output tables differ depending on the type of analysis being conducted.

IHA parameters can be calculated using parametric (mean/standard deviation) or non-parametric (percentile) statistics. For most situations non-parametric statistics are a better choice, because of the skewed (non-normal) nature of many hydrologic datasets (a key assumption of parametric statistics is that the data are normally distributed). But for certain situations, such as flood frequency or average monthly flow volumes, parametric statistics may be preferable. See [Setting Up and Managing An Analysis](#) for information on how to specify non-parametric vs. parametric analysis. See [IHA Parameters](#) and [EFC Parameters](#) for more specifics on how calculations will vary for parametric versus non-parametric analysis, and see [Tables](#) and [Graphs](#) for details on how output tables and graphs will differ.

The hydrologic parameters produced by the IHA are calculated and organized in the output tables by water year. The default water year in the IHA is Oct. 1 - Sept. 30, but the water year can be reset to start on any other day of the year (see [Water Year Definition](#) for more details). Certain parameters can also be calculated for periods shorter than an entire year (see [Shortened Water Years and Seasons](#)). IHA parameters can be calculated for a shortened part of the water year, and EFC parameters other than monthly low flows may be calculated separately for two different seasons, each of which covers only a part of the water year.

When analyzing the change between two time periods, the software enables users to implement the Range of Variability Approach (RVA) described in Richter et al. (1997). See [RVA Analysis](#) for further description. Note that RVA Analysis is only available for IHA parameters, not for the EFC parameters.

As of version 7.1, the IHA can also compute Flow Duration Curves (FDCs). FDCs are computed for all data, and separately for each month, using the same time periods, years, and shortened water years that are used for the other statistics. One additional option is that FDCs can be computed for only selected years in each period. See the section on [Flow Duration Curves](#) for more details.

2.2 IHA Parameters

The 33 IHA parameters are described in Table 1 (see the following page), along with their ecosystem influences. Whether a mean or median value is calculated depends on whether the user has selected parametric or non-parametric analysis. Note that moving averages (1-day to 30-day minimums and maximums) are always calculated as means.

Some important notes regarding the calculation of IHA parameters are as follows:

- When using a shortened water year, IHA parameters are calculated using only the data in the shortened period. Monthly average flows that overlap the boundary of the shortened period will be calculated only for the portion of the month that is in the period. For directions on how to set a shortened water year, see [Setting Up and Managing an Analysis](#).
- For parameter group 2 (extreme water conditions), the 3-, 7-, 30-, and 90-day minimums and maximums are taken from moving averages of the appropriate length calculated for every possible period that is completely within the water year.
- The zero-flow days and base flow index parameters in group 2 are modeled after the suite of flow parameters described by Poff and Ward (1989).
- For parameter group 3 (extreme water conditions), if there are multiple days in the water year with the same flow value, the earliest date is reported.
- For parameter group 4 (high and low pulses), a day is classified as a pulse if it is greater than or less than a specified threshold, which can be set by the user (see [Setting Up and Managing an Analysis](#)). For two period analysis pulse thresholds are calculated using data in the pre-impact period only, while for single period analysis pulse thresholds are calculated using data from the entire period. If a shortened water year is used, the pulse thresholds are computed using data within the shortened water year only. Periods of days which are in the same type of pulse are counted as a distinct pulse event. High and low pulse events that overlap between water years are counted only in the water year in which they begin, and the duration of these events includes the part that occurs in the subsequent water year. Similarly, in cases where a shortened water year is used, only events that start in that shortened water year are included in the statistics, but the entire length of the event is used, even if it ends outside the shortened water year. In some cases a missing water year of data or the end of the dataset may truncate a pulse that is counted in the statistics. When this happens, a [warning](#) is issued in the [Message Report](#), so that the user knows that one event has a truncated duration. Note that events that start on the first day of the dataset or the first day after a missing water year are not counted in the statistics, because it is assumed that these

events actually began in the prior water year that is not in the data.

- Reversals (in parameter group 5) are calculated by dividing the hydrologic record into "rising" and "falling" periods, which correspond to periods in which daily changes in flows are either positive or negative, respectively. Note that a rising or falling period is not ended by a pair of days with constant flow, only by a change of sign in the rate of change. The number of reversals is the number of times that flow switches from one type of period to another. Reversals are analyzed on a water year by water year basis, so the first change in flow of the water year cannot be counted as a reversal, since no rising or falling trend exists before then.

Table 1. Summary of IHA Parameters and their Ecosystem Influences

| IHA Parameter Group | Hydrologic Parameters | Ecosystem Influences |
|--|---|---|
| 1. Magnitude of monthly water conditions | <p>Mean or median value for each calendar month</p> <p>Subtotal 12 parameters</p> | <ul style="list-style-type: none"> • Habitat availability for aquatic organisms • Soil moisture availability for plants • Availability of water for terrestrial animals • Availability of food/cover for fur-bearing mammals • Reliability of water supplies for terrestrial animals • Access by predators to nesting sites • Influences water temperature, oxygen levels, photosynthesis in water column |
| 2. Magnitude and duration of annual extreme water conditions | <p>Annual minima, 1-day mean Annual minima, 3-day means Annual minima, 7-day means Annual minima, 30-day means Annual minima, 90-day means</p> <p>Annual maxima, 1-day mean Annual maxima, 3-day means Annual maxima, 7-day means Annual maxima, 30-day means Annual maxima, 90-day means</p> <p>Number of zero-flow days</p> <p>Base flow index: 7-day minimum flow/mean flow for year</p> <p>Subtotal 12 parameters</p> | <ul style="list-style-type: none"> • Balance of competitive, ruderal, and stress- tolerant organisms • Creation of sites for plant colonization • Structuring of aquatic ecosystems by abiotic vs. biotic factors • Structuring of river channel morphology and physical habitat conditions • Soil moisture stress in plants • Dehydration in animals • Anaerobic stress in plants • Volume of nutrient exchanges between rivers and floodplains • Duration of stressful conditions such as low oxygen and concentrated chemicals in aquatic environments • Distribution of plant communities in lakes, ponds, floodplains • Duration of high flows for waste disposal, aeration of spawning beds in channel sediments |

Table 1, Continued

| | | |
|--|--|--|
| 3. Timing of annual extreme water conditions | Julian date of each annual 1-day maximum Julian date of each annual 1-day minimum <hr/> <i>Subtotal 2 parameters</i> | <ul style="list-style-type: none"> Compatibility with life cycles of organisms Predictability/avoidability of stress for organisms Access to special habitats during reproduction or to avoid predation Spawning cues for migratory fish Evolution of life history strategies, behavioral mechanisms |
| 4. Frequency and duration of high and low pulses | Number of low pulses within each water year Mean or median duration of low pulses (days) Number of high pulses within each water year Mean or median duration of high pulses (days) <hr/> <i>Subtotal 4 parameters</i> | <ul style="list-style-type: none"> Frequency and magnitude of soil moisture stress for plants Frequency and duration of anaerobic stress for plants Availability of floodplain habitats for aquatic organisms Nutrient and organic matter exchanges between river and floodplain Soil mineral availability Access for waterbirds to feeding, resting, reproduction sites Influences bedload transport, channel sediment textures, and duration of substrate disturbance (high pulses) |
| 5. Rate and frequency of water condition changes | Rise rates: Mean or median of all positive differences between consecutive daily values Fall rates: Mean or median of all negative differences between consecutive daily values Number of hydrologic reversals <hr/> <i>Subtotal 3 parameters</i> <hr/> Grand total 33 parameters | <ul style="list-style-type: none"> Drought stress on plants (falling levels) Entrapment of organisms on islands, floodplains (rising levels) Desiccation stress on low-mobility streamedge (varial zone) organisms |

2.3 Environmental Flow Components

2.3.1 Introduction to EFCs

The IHA calculates parameters for five different types of Environment Flow Components (EFCs): low flows, extreme low flows, high flow pulses, small floods, and large floods. This delineation of EFCs is based on the realization by research ecologists that river hydrographs can be divided into a repeating set of hydrographic patterns that are ecologically relevant. It is the full spectrum of flow conditions represented by these five types of flow events that must be maintained in order to sustain riverine ecological integrity. Not only is it essential to maintain adequate flows during low flow periods, but higher flows and floods and also extreme low flow conditions also perform important ecological functions. For more on EFCs, see [EFC Parameters](#) and [EFC Calculation Algorithm](#). The five EFC types are described in more detail below.

Low flows – This is the dominant flow condition in most rivers. In natural rivers, after a rainfall event or snowmelt period has passed and associated surface runoff from the catchment has subsided, the river returns to its base- or low-flow level. These low-flow levels are sustained by groundwater discharge into the river. The seasonally-varying low-flow levels in a river impose a fundamental constraint on a river's aquatic communities because it determines the amount of aquatic habitat available for most of the year. This has a strong influence on the diversity and number of organisms that can live in the river.

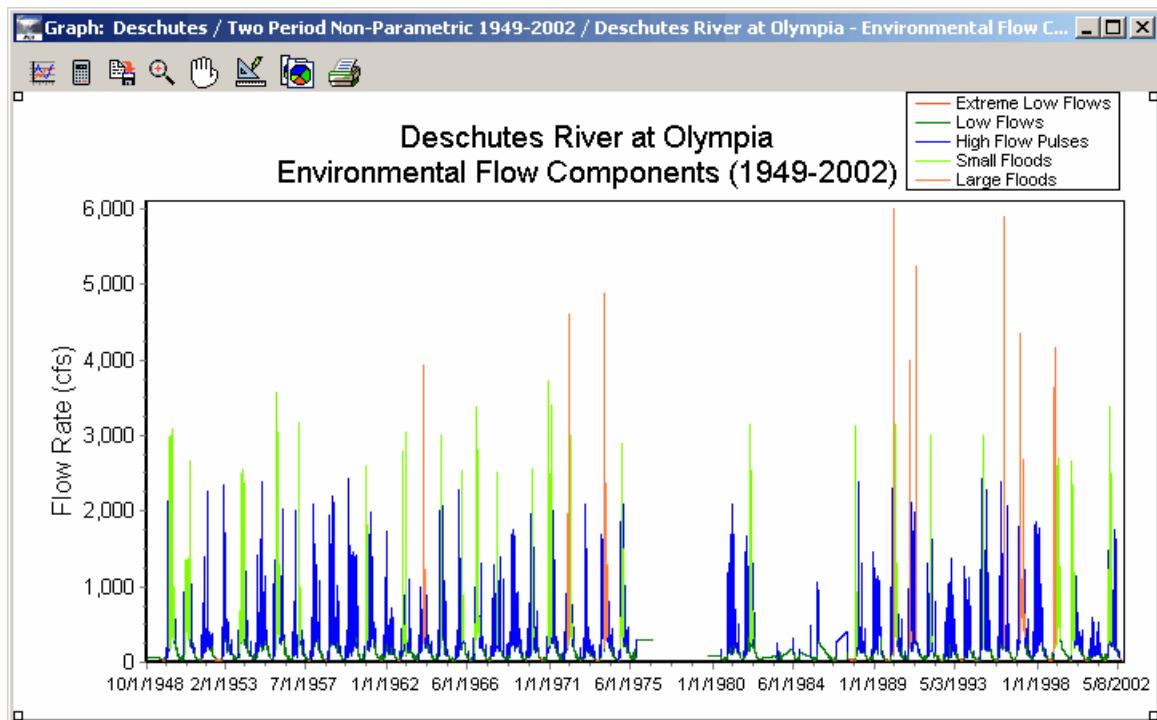
Extreme low flows – During drought periods, rivers drop to very low levels that can be stressful for many organisms, but may provide necessary conditions for other species. Water chemistry, temperature, and dissolved oxygen availability can become highly stressful to many organisms during extreme low flows, to the point that these conditions can cause considerable mortality. On the other hand, extreme low flows may concentrate aquatic prey for some species, or may be necessary to dry out low-lying floodplain areas and enable certain species of plants such as bald cypress to regenerate.

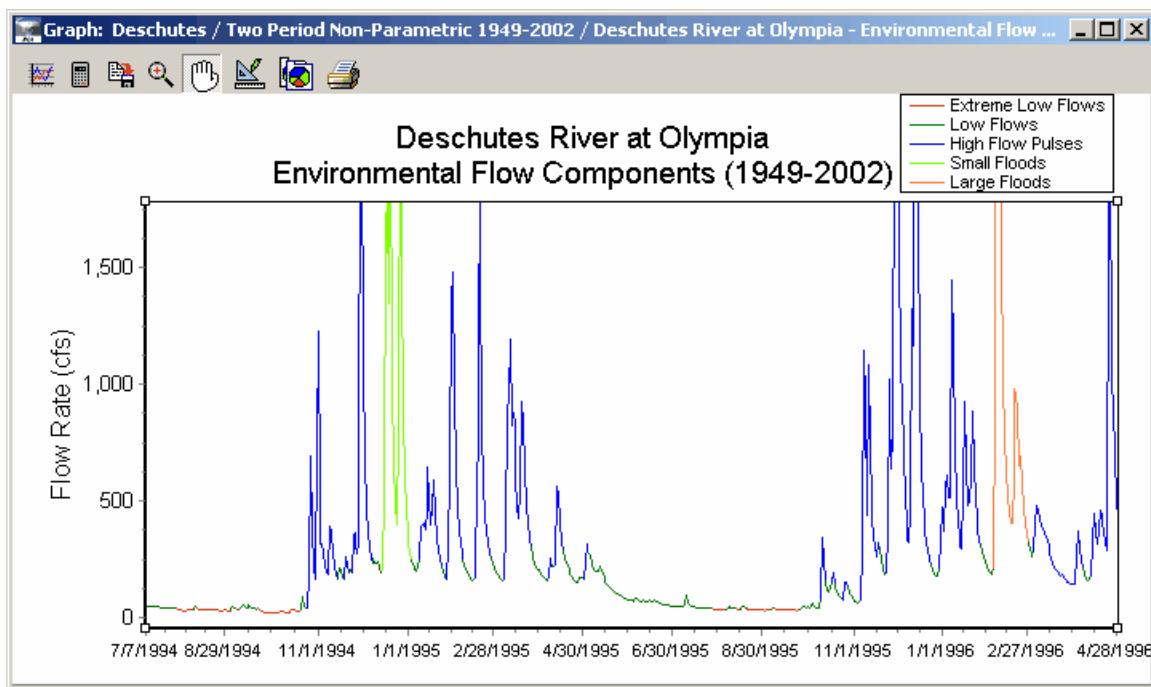
High-flow pulses – During rainstorms or brief periods of snowmelt, a river will rise above its low-flow level. As defined here, high-flow pulses include any water rises that do not overtop the channel banks. These pulses provide important and necessary disruptions in low flows. Even a small or brief flush of fresh water can provide much-needed relief from higher water temperatures or low oxygen conditions that typify low-flow periods, and deliver a nourishing subsidy of organic material or other food to support the aquatic food web. High-flow pulses also provide fish and other mobile creatures with increased access to up- and downstream areas.

Small floods – During floods, fish and other mobile organisms are able to move upstream, downstream, and out into floodplains or flooded wetlands to access additional habitats such as secondary channels, backwaters, sloughs, and shallow flooded areas. These usually inaccessible areas can provide substantial food resources. Shallow flooded areas are typically warmer than the main channel and full of nutrients and insects that fuel rapid growth in aquatic organisms. As used here, a "small flood" includes all river rises that overtop the main channel but does not include more extreme, and less frequent, floods.

Large floods— Extreme floods will typically re-arrange both the biological and physical structure of a river and its floodplain. These large floods can literally flush away many organisms, thereby depleting some populations but in many cases also creating new competitive advantages for some species. Extreme floods may also be important in forming key habitats such as oxbow lakes and floodplain wetlands.

Below are two example graphs of EFCs. The second graph displays a zoomed-in section of the first graph (from July 7, 1994 to April 28, 1996)





2.3.2 EFC Parameters

The 34 [Environmental Flow Component](#) (EFC) parameters computed by the IHA are described in Table 2, along with their ecosystem influences. Note that if two seasons are used, then the number of parameters increases to 56, since all parameters except monthly low flows are duplicated for each season. As with IHA Parameters, means and medians are calculated depending on whether the user has chosen parametric or non-parametric analysis.

Table 2. Summary of Environmental Flow Component (EFC) Parameters and their Ecosystem Influences

| EFC Type | Hydrologic Parameters | Ecosystem Influences |
|----------------------|--|--|
| 1. Monthly low flows | <p>Mean or median values of low flows during each calendar month</p> <hr/> <p><i>Subtotal 12 parameters</i></p> | <ul style="list-style-type: none"> • Provide adequate habitat for aquatic organisms • Maintain suitable water temperatures, dissolved oxygen, and water chemistry • Maintain water table levels in floodplain, soil moisture for plants • Provide drinking water for terrestrial animals • Keep fish and amphibian eggs suspended • Enable fish to move to feeding and spawning areas • Support hyporheic organisms (living in saturated sediments) |
| 2. Extreme low flows | <p>Frequency of extreme low flows during each water year or season</p> <p>Mean or median values of extreme low flow event:</p> <ul style="list-style-type: none"> • Duration (days) • Peak flow (minimum flow during event) • Timing (Julian date of peak flow) <hr/> <p><i>Subtotal 4 parameters</i></p> | <ul style="list-style-type: none"> • Enable recruitment of certain floodplain plant species • Purge invasive, introduced species from aquatic and riparian communities • Concentrate prey into limited areas to benefit predators |

Table 2, Continued

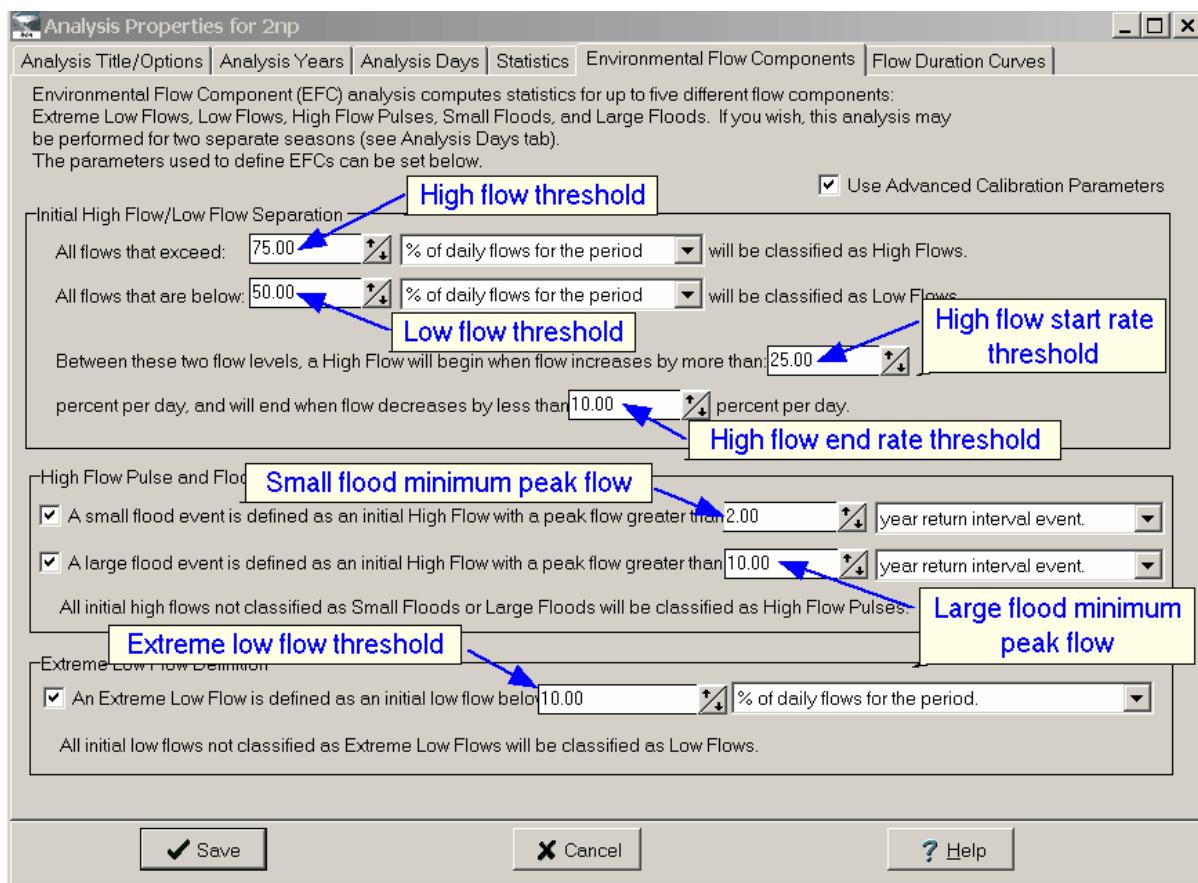
| | | |
|---------------------|---|---|
| 3. High flow pulses | <p>Frequency of high flow pulses during each water year or season</p> <p>Mean or median values of high flow pulse event:</p> <ul style="list-style-type: none"> • Duration (days) • Peak flow (maximum flow during event) • Timing (Julian date of peak flow) • Rise and fall rates <hr/> <p style="text-align: center;"><i>Subtotal 6 parameters</i></p> | <ul style="list-style-type: none"> • Shape physical character of river channel, including pools, riffles • Determine size of streambed substrates (sand, gravel, cobble) • Prevent riparian vegetation from encroaching into channel • Restore normal water quality conditions after prolonged low flows, flushing away waste products and pollutants • Aerate eggs in spawning gravels, prevent siltation • Maintain suitable salinity conditions in estuaries |
| 4. Small floods | <p>Frequency of small floods during each water year or season</p> <p>Mean or median values of small flood event:</p> <ul style="list-style-type: none"> • Duration (days) • Peak flow (maximum flow during event) • Timing (Julian date of peak flow) • Rise and fall rates <hr/> <p style="text-align: center;"><i>Subtotal 6 parameters</i></p> | <p>Applies to small and large floods:</p> <ul style="list-style-type: none"> • Provide migration and spawning cues for fish • Trigger new phase in life cycle (i.e insects) • Enable fish to spawn in floodplain, provide nursery area for juvenile fish • Provide new feeding opportunities for fish, waterfowl • Recharge floodplain water table • Maintain diversity in floodplain forest types through prolonged inundation (i.e. different plant species have different tolerances) • Control distribution and abundance of plants on floodplain • Deposit nutrients on floodplain |

Table 2, Continued

| | | |
|-----------------|---|---|
| 5. Large floods | <p>Frequency of large floods during each water year or season</p> <p>Mean or median values of large flood event:</p> <ul style="list-style-type: none"> • Duration (days) • Peak flow (maximum flow during event) • Timing (Julian date of peak flow) • Rise and fall rates <p><i>Subtotal 6 parameters</i></p> <p>Grand total 34 parameters</p> | <p>Applies to small and large floods:</p> <ul style="list-style-type: none"> • Maintain balance of species in aquatic and riparian communities • Create sites for recruitment of colonizing plants • Shape physical habitats of floodplain • Deposit gravel and cobbles in spawning areas • Flush organic materials (food) and woody debris (habitat structures) into channel • Purge invasive, introduced species from aquatic and riparian communities • Disburse seeds and fruits of riparian plants • Drive lateral movement of river channel, forming new habitats (secondary channels, oxbow lakes) • Provide plant seedlings with prolonged access to soil moisture |
|-----------------|---|---|

2.3.3 EFC Calculation Algorithm

This section describes the algorithm used to define EFCs. The user can adjust the way this algorithm works by resetting the calibration parameters described below (also see [Setting Up and Managing An Analysis](#) and also [Calibrating the EFC Algorithm](#)). Starting with Version 7.1, there is now more flexibility in how the algorithm can be calibrated. The default calibration has been simplified so that the initial separation between high flows and low flows is done using only a single fixed threshold. The default calibration that was used in Version 7.0 can still be used by checking the checkbox for Use Advanced Calibration Parameters (see below):



EFC User Options:

The user initially has to make some choices about how the algorithm works, and then depending on which option is selected, choose the values of the numerical parameters used to calibrate the algorithm.

The various choices are:

- (1) Choose between two methods for making the initial split between high flows and low flows. The first method is to select a single flow threshold to distinguish between high flows and low flows. This is the default method. The second method is to use the original EFC method (the default in Version 7.0), which uses four parameters to distinguish between high flows and low flows.

-For the one parameter method (this is available if you don't check the checkbox (Use Advanced Calibration Parameters)), the user will have to select the value of the following parameter:

High flow threshold: All flows greater than this value are classified as high flows, and all flows less than or equal to this threshold are classified as low flows. This parameter can

be specified as a percentile of all daily flows or as a flow value. The default value is the 75th percentile of daily flows.

-For the four parameter method (this is available if you check the checkbox (Use Advanced Calibration Parameters)), the user will have to select the values of the following parameters:

High flow threshold: All flows greater than this threshold are classified as high flows. This parameter can be specified as a percentile of all daily flows or as a flow value. The default value is the 75th percentile of daily flows.

Low flow threshold: All flows less than or equal to this threshold are classified as low flow events. This parameter must always be less than the *high flow threshold*. This parameter can be specified as a percentile of all daily flows or as a flow value. The default value is the 50th percentile of daily flows.

High flow start rate threshold: When flows are between the *high flow* and *low flow thresholds*, this parameter controls the start of high flow events. It also controls whether the ascending limb of an event is restarted from the descending limb. The default value is 25%.

High flow end rate threshold: When flows are between the *high flow* and *low flow thresholds*, this parameter is used to end high flow events during their descending limb. It also controls the transition between the ascending and descending limb of an event. The default value is 10%.

- (2) Choose the number of high flow classes to specify, using the appropriate checkboxes. This can be 1, 2, or 3. If there is one class it will be called high flow pulses. If there are two classes they will be called high flow pulses and either small floods or large floods (the user's choice). If there are 3 classes they will be called high flow pulses, small floods, and large floods.

For 2 or 3 classes, the user must specify one or both of the following 2 parameters:

Small flood minimum peak flow: All high flow events that have a peak flow greater than or equal to this value (and less than the peak flow value for large floods, if there are 3 flow classes) will be assigned to the small flood class. All events with a peak flow less than this value will be assigned to the high flow pulse class. The user has the option to enter this as either a return interval, a flow value, or a percentile of all daily flows. The default value is the 2 year return interval.

Large flood minimum peak flow: All high flow events that have a peak flow greater than or equal to this value will be assigned to the large flood class. All events with a peak flow less than this value will be assigned to the high flow pulse class or the small flood class, depending on whether there are 2 or 3 high flow classes. The user has the option to enter this as either a return interval, a flow value, or a percentile of all daily flows. The default value is the 10 year return interval.

(3) Choose whether to have extreme low flows specified, using the checkbox.

If the user wants to do this, they must specify the following parameter.

Extreme low flow threshold: All low flow days with a flow value less than or equal to this value will be classified as extreme low flows. The user has the option to enter this as a percentile of all daily low flows, as a percentile of all daily flows, or as a flow value. The default value is the 10th percentile of daily low flows.

EFC Algorithm

The algorithm make three passes through the data in order to assign each day to one of the 2-5 EFC types. During the first pass, each day is assigned to one of two initial event types, low flows and high flows. During the second pass, all days that were initially assigned as high flows are re-assigned to 1, 2, or 3 high flow classes (though if only 1 high flow class is desired, then this pass will not do anything). During the third pass, some of the initial low flow days are re-assigned to the extreme low flow class (if the user does not want an extreme low flow class, then this pass is not necessary).

Below is a more detailed description of the algorithm:

-First pass: separation of data into high flow and low flows.

One parameter method (not Advanced Calibration): All days with flow greater than the *high flow threshold* are assigned to the high flow class, and the rest are assigned to the low flow class.

Four parameter method (Advanced Calibration method):

(1) Initialization: The first day of the dataset needs to be initialized as either a high flow or low flow. If it is greater than the *low flow threshold*, then it is classified as a high flow, otherwise it is a low flow. If it is a high flow, then if it is greater than the *high flow threshold*, it is coded as being on the ascending limb, otherwise on the descending limb.

(2) Proceeding sequentially through the rest of the daily values, the following rules are used to differentiate between low flows and high flows, and between the ascending and descending limbs of high flow events.

1. Following a low flow day, the next day is assigned to the ascending limb of a high flow event if the daily flow is greater than the *high flow threshold*, or if flow is greater than the *low flow threshold* and the increase from the previous day is more than *high flow start rate threshold*. Otherwise it continues as a low flow.

2. The ascending limb of a high flow event continues until daily flow decreases by more than the *high flow end rate threshold*, at which time the descending

limb of the event is started.

3. During the descending limb of a high flow event, the ascending limb is restarted if daily flow increases by more than the *high flow start rate threshold*.

4. During the descending limb of a high flow event, the event is ended if the rate of decrease of flow drops below the *high flow end rate threshold* (meaning that the change in flow is between $-1 * \text{high flow end rate threshold}$ and *high flow start rate threshold*), unless the flow is still greater than or equal to the *high flow threshold*, in which case the descending limb continues.

5. The event is always ended if flow drops down to equal to or below the *low flow threshold*, regardless of whether the event is on the ascending or descending limb.

6. After the high flow is ended, a low flow condition resumes.

-Second pass:

After all the initial high flow and low flow events are calculated, the high flow events are divided into 2 or 3 high flow classes. If the user only wants 1 high flow class, then this second pass is not necessary. If there are to be 2 high flow classes, then all events that have a peak flow of greater than or equal to either the *small flood minimum peak flow* and *large flood minimum peak flow* are assigned to the appropriate class, and all other events are assigned to the high flow pulse class. If there are to be 3 high flow classes, then all events that have a peak flow of greater than or equal to the *large flood minimum peak flow* are assigned to the large flood class, all remaining events that have a peak flow greater than or equal to the *small flood minimum peak flow* are assigned to the small flood class, and all others are assigned to the high flow pulse class.

-Third pass:

Days are assigned to the extreme low flow class. If the user does not want this class, then this pass is not necessary. All low flow days that have a flow of less than or equal to the *extreme low flow threshold* are assigned to the extreme low flow class.

Some other important notes regarding the calculation of EFC parameters are as follows:

- For purposes of computing annual output statistics, extreme low flow, high flow pulse, small flood, and large flood events are assigned to the water year in which they peak, but their statistics will be computed using the entire length of the event, even if some of it is outside the water year. The peak of a high flow pulse, small flood, and large flood event is the day with the highest flow value, and the peak of an extreme low flow event is the day with the lowest flow value. If there are multiple peaks with the same flow value, the first one will be used. The timing of an event is the Julian date of the first peak.
- In cases where a flow dataset has one or more water years of missing data, and the Advanced

Calibration method is being used, the initialization procedure described above is rerun after each period of missing data. Note also that the occurrence of missing water years of data means that some EFC events may be truncated either at their beginning or end. Our convention is to count any events in the statistics that are truncated by the end of a water year, but ignore events that are truncated by the beginning of a water year. In either of these situations, a [warning](#) is issued in the [Message Report](#). Be aware that the truncated events that are counted may have errors in flow parameters such as peak flow, duration, timing, and rise and fall rates, due to the fact that not all of the event is present in the flow data. Also, in the rare case that the peak of a high flow event occurs on the last day before a missing year, no fall rate from that event is used to compute annual statistics, since it cannot be calculated.

- The flow values that correspond to the *high flow threshold*, *low flow threshold*, *extreme low flow threshold*, *small flood return interval*, and *large flood return intervals* are displayed at the bottom of the [Scorecard Table](#).
- When using return intervals to identify small and large floods, the return interval is applied using the following procedure. First a list is created of the maximum flood peaks (from the peaks of high flow pulse, small flood, and large flood events) in each year, and then this distribution is used to find the flow value that corresponds to each return interval. So for a 10 year return interval, the software finds the 90th percentile of all the annual maximum flood peaks, and for a 2 year return interval, the software finds the 50th percentile of all the annual maximum flood peaks. All events with peaks greater than the flow value that corresponds to the *Large flood return interval* are classified as large floods, and all events with peaks less than this value but greater than the flow value that corresponds to *Small flood return interval* are classified as small floods.
- For two period analysis (or comparisons of two Hydro Data files), the return intervals for small and large floods and the flow level thresholds used to define extreme low flows and high flow pulses are based on data from the pre-impact period (or the Hydro Data file that represents pre-impact flows). For single period analysis, they are based on data for the entire period of analysis.
- If desired, EFC parameters for high flow pulses, small floods, large floods, and extreme low flows can be calculated separately for two seasons. These seasons can cover two separate parts of the water year, and can overlap. For instructions on specifying the dates of these seasons, see [Setting Up and Managing an Analysis](#). Specifying two separate seasons does not have any affect on the values of the seven calibration parameters described above or on the way the EFC algorithm assigns different days to different EFCs throughout the year. But when the annual statistics are computed, only the events that peak during the appropriate season will be used in the calculation of statistics. As with events that overlap between water years, the statistics will take into account any parts of the event that are outside the specified season.

2.3.4 Calibrating the EFC Algorithm

In order to make best use of the EFC outputs, it is usually necessary to calibrate the parameters used in the [EFC calculation algorithm](#). The most efficient way to calibrate the algorithm is to display the graph of daily flow data coded by EFC type, and then bring up the Analysis

Properties window by clicking on the  button on the graph window. After adjusting the EFC parameters and saving the Analysis Properties, the IHA will automatically rerun the Analysis, and the daily EFC graph will automatically display the results. The EFC daily graph can be evaluated to see if the IHA is providing the proper distinction between high flows and low flows, the desired return interval for floods, or other desired flow characteristics, and the EFC parameters adjusting accordingly. It is also possible to display the values of the various calibration parameters on this graph. Calibration of the EFC algorithm typically occurs in 2 steps, described below:

Step 1: Make sure that the algorithm is splitting the hydrograph properly between low flows and high flows. Only those portions of the hydrograph that are influenced by surface flow (in addition to baseflow) should be classified as high flows. If using the non-Advanced Calibration, this will involve adjusting a single flow parameter, the *high flow threshold*. If using the Advanced Calibration, this could involve adjusting up to four parameters, the *high flow threshold*, the *low flow threshold*, the *high flow start rate threshold*, and the *high flow end rate threshold*. These parameters are contained in the upper box in the Environmental Flow Components tab of the Analysis Properties window (entitled Initial High Flow/Low Flow Separation).

Because it involves only one flow threshold, the non-Advanced Calibration method is simpler to interpret and calibrate, and should work well if it is possible to distinguish between baseflow and runoff-influenced flow using one threshold flow value. But the Advanced Calibration method provides more flexibility in terms of calibration. It is recommended that users experiment with adjusting these various parameters to better understand how their interaction controls the starting and ending of high flow events.

Depending on how the Advanced Calibration method is used, high flows can be characterized in different ways. Because all flows above the *high flow threshold* will be classified as high flows, often events with multiple peaks will be classified as one long event. But between the *high flow threshold* and the *low flow threshold* individual peaks of flow will usually be classified as different events, because when the high flow-low flow classification is governed by the two rate thresholds, each time flow rises and falls it will trigger a separate event. If it is desired that all high flow events be treated this way, then the *high flow threshold* could be increased to a very large value (say the 99th percentile of daily flows).

Which calibration is most useful may depend on the ecological needs of study for which the IHA is being used. If what is ecologically important is when flow is above a certain flow threshold, it will probably make more sense to rely on the *high flow threshold* (and *low flow threshold*) to distinguish between high flow and low flow events. But if individual flow peaks

are better treated as individual events because each peak has some ecological significance, then the second method described in the previous paragraph may be better.

Step 2: Once the hydrograph has been properly split between high flows and low flows, the next step is to calibrate the separation of high flows into high flow pulses, small floods, and large floods, and the separation of the low flows into low flows and extreme low flows. This calibration can be done specifying whether 1, 2 or 3 high flow classes are desired, whether extreme low flows are desired, and by adjusting the *small flood* and *large flood minimum peak flows* and *extreme low flow threshold*. These parameters are contained in the bottom two boxes of the Environmental Flow Components tab of the Analysis Properties window.

Since floods are typically defined as events that overtop the main channel and extend into the floodplain, data on the flow rate that causes such behavior would be useful in calibrating the return interval thresholds. Another type of information that could be useful in calibration would be the flood flow rates that are necessary to perform specific ecological functions. So the EFC algorithm could be calibrated to generate statistics on floods that are necessary for cottonwood recruitment, that promote fish spawning, or that perform other functions. Similar physical and ecological considerations could be used to calibrate the extreme low flows.

2.4 RVA Analysis

When analyzing the change between two time periods (or comparing two Hydro Data files), the IHA software enables users to implement the Range of Variability Approach (RVA) described in Richter et al. (1997). The RVA uses the pre-development natural variation of IHA parameter values as a reference for defining the extent to which natural flow regimes have been altered. The pre-development variation can also be used as a basis for defining initial environmental flow goals. Richter et al (1997) suggest that water managers should strive to keep the distribution of annual values of the IHA parameters as close to the pre-impact distributions as possible. RVA analysis also generates a series of Hydrologic Alteration factors, which quantify the degree of alteration of the 33 IHA flow parameters. Note that RVA analysis is only available for IHA parameters, and not for EFC parameters.

In an RVA analysis, the full range of pre-impact data for each parameter is divided into three different categories. The boundaries between categories are based on either percentile values (for non-parametric analysis) or a number of standard deviations away from the mean (for parametric analysis), which are specified by the user (see [Setting Up and Managing an Analysis](#)). As an example, the default in non-parametric RVA analysis is to place the category boundaries 17 percentiles from the median. This yields an automatic delineation of three categories of equal size: the lowest category contains all values less than or equal to the 33rd percentile; the middle category contains all values falling in the range of the 34th to 67th percentiles; and the highest category contains all values greater than the 67th percentile.

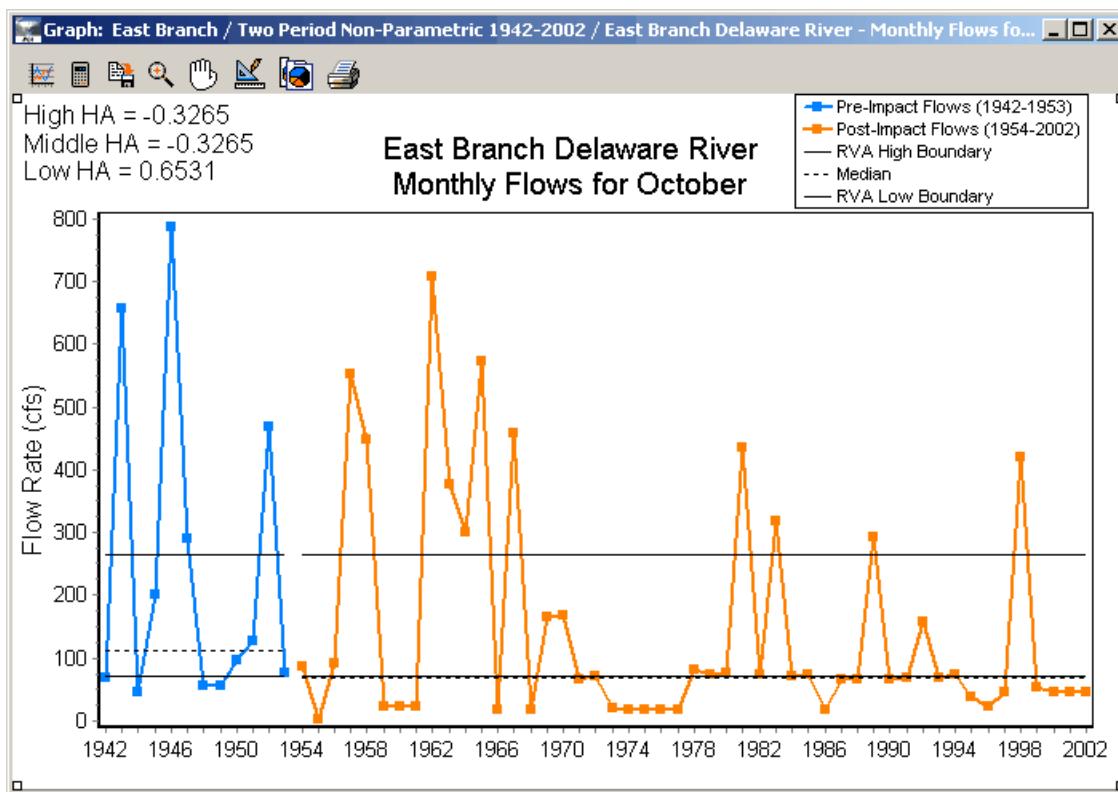
The program then computes the expected frequency with which the "post-impact" values of the IHA parameters should fall within each category (in the non-parametric default, this would be 33% for each of the three categories). The program then computes the frequency with which the "post-impact" annual values of IHA parameters actually fell within each of the three

categories. This expected frequency is equal to the number of values in the category during the pre-impact period multiplied by the ratio of post-impact years to pre-impact years. Finally, a Hydrologic Alteration factor is calculated for each of the three categories as:

$$(\text{observed frequency} - \text{expected frequency}) / \text{expected frequency}$$

A positive Hydrologic Alteration value means that the frequency of values in the category has increased from the pre-impact to the post-impact period (with a maximum value of infinity), while a negative value means that the frequency of values has decreased (with a minimum value of -1). See below for an example graph of RVA category boundaries and Hydrologic Alteration values. Results from RVA analysis are displayed in the [RVA table](#) and can also be displayed in the annual data graphs, the Hydrologic Alteration graph, and the monthly averages graph.

While it is possible to use parametric statistics for RVA analysis and adjust the RVA boundaries, the recommended way to run an RVA analysis is to use the non-parametric defaults. Using the 33rd and 67th percentiles ensures that in most situations an equal number of pre-impact values will fall into each category, which makes the results easier to understand and interpret.



A few further notes on evaluating RVA results are below:

- Annual values that are equal to the category boundaries are always put in the middle category. This means that in some cases using the default settings for non-parametric analysis

will not always yield an equal distribution of annual values between the three categories. In some cases it may be possible to adjust the RVA boundaries to get a more even distribution between categories, but in some cases uneven distributions may be unavoidable.

- The RVA method may also yield non-intuitive results for parameters which have a large number of annual statistics equal to a particular value. For example, the number of zero flow days often has many of its annual values equal to 0, which can mean that both the 33rd and the 67th percentile are also equal to 0.
- There are a few situations where it is impossible to calculate RVA boundaries and/or Hydrologic Alteration factors. If there is one year of pre-impact data or no years of post-impact data, RVA boundaries are not calculated, so in the RVA table these rows along with the expected and observed frequencies and Hydrologic Alteration factors will be blank. When this happens, a [notice](#) is put in the [Message Report](#) listing the parameters for which this is the case. Also, if the denominator in the equation for Hydrologic Alteration (expected frequency) is equal to 0, the Hydrologic Alteration factor is reported as a blank in the RVA Table, to avoid a divide by zero error.
- There are two IHA parameters which may not have annual values in all years (low pulse and high pulse durations). For these parameters, the HA values will be affected not only by the relative distribution of annual values between the three categories, but also by the change in the frequency of events from the pre-impact to the post-impact period. If the frequency of pulse events is greatly reduced from the pre-impact to the post-impact period, it will be possible to get a negative HA for all three categories, a result which should not occur for any other parameters.

For all of these reasons, RVA results should be scrutinized carefully, and different methods for specifying RVA boundaries may need to be tried to get useful results. Problems such as these can usually be diagnosed by examining the category boundaries in the [RVA table](#) and also the annual values in the [Annual Summaries table](#).

2.5 Flow Duration Curves

The IHA will compute Flow Duration Curves (FDCs) separately for each period of analysis (for single and two period analyses) or for each Hydro Data file (for projects that compare two different Hydro Data files). The exact periods, years, and days of data used in these computations are determined by the same settings used to specify years of analysis and days of analysis for the 33 IHA parameters (on the [Analysis Years tab](#) and the [Analysis Days tab](#)). In addition, for the FDCs only, the user can use only selected years of data in each period or Hydro Data file being analyzed. This selection can be done on the [Flow Duration Curves tab](#). Using data from the periods, years, days selected, FDCs will be computed using all the available data (this is called the annual FDC). Also, separate FDCs will be computed for each month, though to simplify the computations, these computations ignore the settings on the

[Analysis Days tab](#) (but use the settings on the [Analysis Years tab](#) and the [Flow Duration Curves tab](#))

FDCs are computed using the following method:

Step 1: Sort (rank) average daily discharges for period of record from the largest value to the smallest value, involving a total of n values.

Step 2: Assign each discharge value a rank (M), starting with 1 for the largest daily discharge value.

Step 3: Calculate exceedance probability (P) as follows:

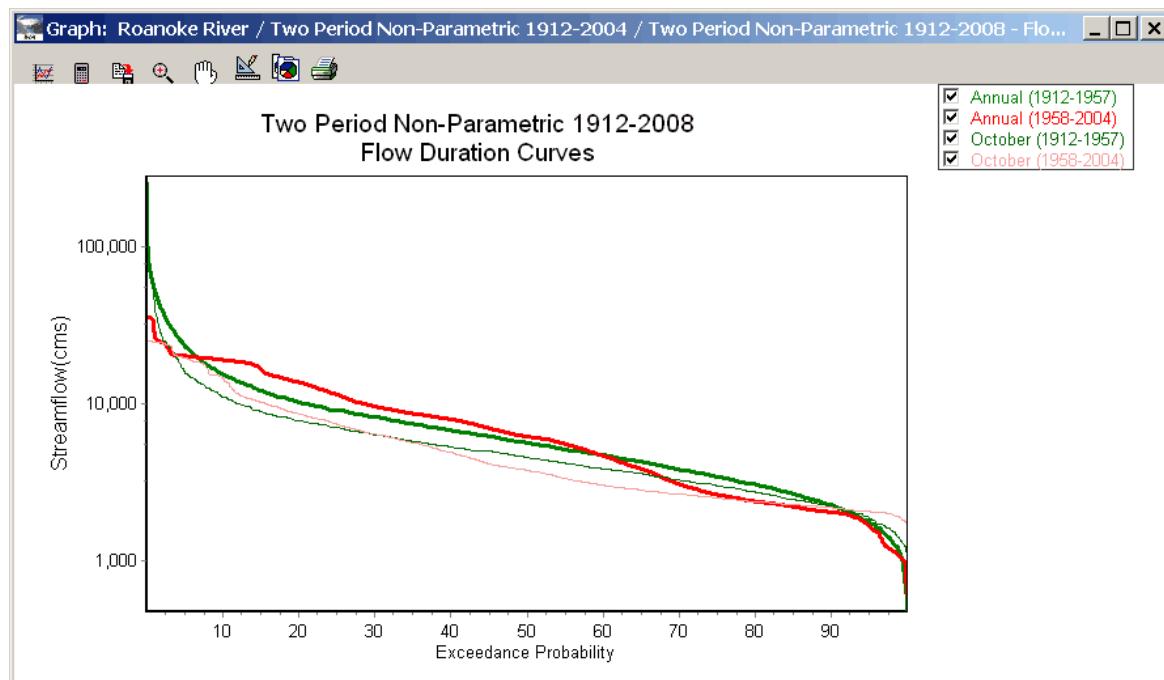
$$P = 100 * [M / (n + 1)]$$

P = the probability that a given flow will be equaled or exceeded (% of time)

M = the ranked position on the listing (dimensionless)

n = the number of events for period of record (dimensionless)

FDC results are then shown in the [Flow Duration Curve Table](#), with flow values (ranked from highest to lowest) and exceedance probabilities for the annual and each monthly FDC. Results can also be displayed graphically (see below for an example graph). Any selection of annual and monthly FDCs can be displayed on the same graph.



3 Setting Up and Running an IHA Analysis

3.1 Introduction to Conducting an Analysis

Setting up and completing an analysis in the IHA involves the following steps:

- (1) Importing hydrologic data. Data can be imported from three different file formats, and then saved as an internal Hydrologic Data file.
- (2) Creating a Project. Each Project is linked to a single Hydrologic Data file, and can be used to create and run multiple Analyses.
- (3) Creating and setting up an Analysis. Each Analysis stores a series of user-settable parameters that define how the hydrologic data will be analyzed. Multiple Analyses can be saved in a single Project.
- (4) Running an Analysis.
- (5) Viewing results. Results are available in table and graph format.

The IHA contains a self-explanatory Wizard to guide you through all these steps. The first time the software is run, the user will have then option of starting the Wizard from the welcome page. It can also be accessed by clicking **IHA | Wizard**.

3.2 Importing Hydrologic Data

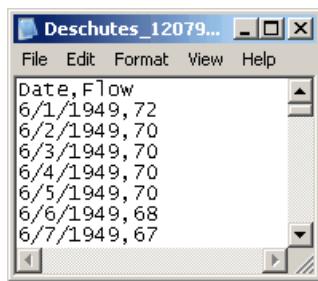
3.2.1 Allowable Hydro Data Formats

The IHA can import daily hydrologic data from three different text file formats:

- (1) Daily streamflow data downloaded from the U.S. Geological Survey (USGS) website. These data are available at <http://nwis.waterdata.usgs.gov/nwis/sw> (click on the link for Daily Data), and can be downloaded as a text file with tab-separated values. The IHA will import data that has any of the available date formats. Note that during the summer of 2006, the USGS changed the format of data available at this website. The IHA will import either the old or the new format. But be aware that while the new format files may contain data other than daily mean discharge, the IHA will only import mean daily discharge data in cubic feet per second (cfs) from these data files, and nothing else. In some cases it is possible to download multiple columns for one station that have mean daily discharge data in cfs. In these cases, the IHA will import the cfs column that is farthest to the right in the file. USGS discharge data for the current water year will usually be provisional, which means that it has not been finalized for publication and could be revised in the future. The IHA will issue a warning if such data exists in the file.
- (2) Data in the .dat file format used by earlier versions of the IHA. This data consists of a

column of data for each water year, with 367 rows in each column. The first row contains the year, and the rest of the rows contain the flow values for each day (or 999999 for days with missing data), in order. The columns can be delimited by a space or a comma, and must be terminated by an end-of-line character. The years must continue in increasing order from left to right, although it is acceptable to have some missing years.

(3) A generic two column format, which consists of a text file where the first column contains the date and the second column contains the flow value. The two columns must be delimited by a comma, space, semi-colon, or tab. The date column can have month, day, and year in any order, i.e. YMD, YDM, MDY, MYD, DMY, or DYM. The year must have four digits, and the month, day, and year must be delimited by either a dash (-), a slash (/), or a dot (.). Dates can also be in the format YYYYMMDD without any delimiter. There can be rows with no data in this file, but the missing data value must be either 999999 or -1. This format will work with or without a single-line column header at the beginning. If a header line exists, a message window will pop during the import process noting that the first line of the file was not read, but the rest of the file should import successfully. An example of a text file in generic two column format is displayed below:



| Date, Flow |
|--------------|
| 6/1/1949, 72 |
| 6/2/1949, 70 |
| 6/3/1949, 70 |
| 6/4/1949, 70 |
| 6/5/1949, 70 |
| 6/6/1949, 68 |
| 6/7/1949, 67 |

While the IHA does not currently import data from Excel format, data saved from Excel into .csv format (a comma-delimited text file) will conform to this generic two column format. Note that in cases where the [Regional and Language Settings](#) on a computer are set to denote decimal places using a comma, comma-delimited text files will not import properly.

While the IHA is primarily designed for analyzing streamflow data expressed in units of flow (cubic feet per second or cubic meters per second), there is no reason why data in different units or groundwater and lake levels expressed as elevations could not be used. When using data in other units, please set all appropriate unit settings to cubic feet per second, but be aware that all outputs will be expressed in the same units as the original input data. A final caveat is that daily data used with this software cannot contain any negative values.

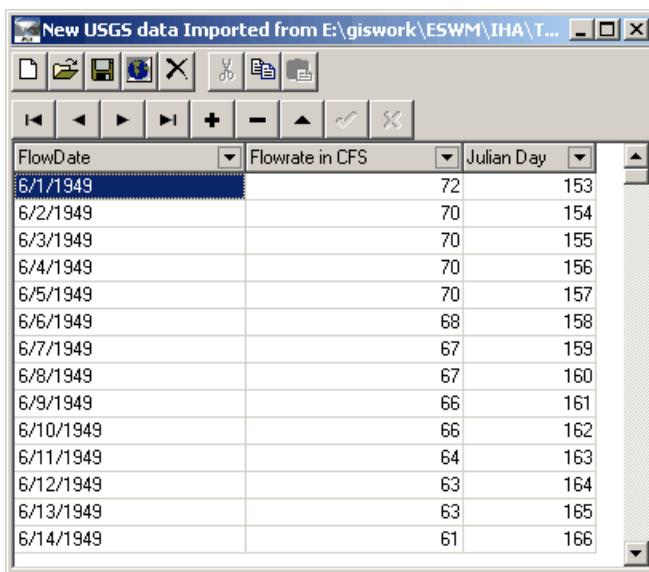
See [Importing and Editing Hydro Data Files](#) for help on importing data in these formats. See [Advice on Importing Particular Datasets](#) for help on importing common types of flow data.

See [Batch Import Capability](#) for a description of how to import and save multiple flow datasets from the same text file.

3.2.2 Importing and Editing Hydro Data Files

To import data into the IHA, click **IHA | Hydrologic Data | Import Data File**. Once pointed towards a file, the IHA will automatically determine which of the three [allowable file types](#) the data correspond to, and then proceed to import the data. If batch processing is necessary, that will also be determined automatically (see [Batch Import Capability](#) for a description of how this works). For data in [.dat file format](#) and [generic two column format](#), the user will be prompted to specify some additional information about the file. For data in .dat file format, the user will need to specify the date of the first flow value in the file. For data in generic two column format, the user will need to specify if a no data value is used in the file (and what that value is) and also the units of flow (cubic feet per second or cubic meters per second). For data in [USGS file format](#) and [.dat file format](#), flow data is assumed to be cubic feet per second, because those are the usual units in which these data are distributed.

Once imported, the data will appear in a Hydro Data File editor such as the one below:



| FlowDate | Flowrate in CFS | Julian Day |
|-----------|-----------------|------------|
| 6/1/1949 | 72 | 153 |
| 6/2/1949 | 70 | 154 |
| 6/3/1949 | 70 | 155 |
| 6/4/1949 | 70 | 156 |
| 6/5/1949 | 70 | 157 |
| 6/6/1949 | 68 | 158 |
| 6/7/1949 | 67 | 159 |
| 6/8/1949 | 67 | 160 |
| 6/9/1949 | 66 | 161 |
| 6/10/1949 | 66 | 162 |
| 6/11/1949 | 64 | 163 |
| 6/12/1949 | 63 | 164 |
| 6/13/1949 | 63 | 165 |
| 6/14/1949 | 61 | 166 |

This editor shows a row for each valid flow value in the imported file, with the calendar date, the flow rate, and the Julian date for each day. There will be no rows for days with missing data, but clicking on **Hydro Data | Review Recorded and Missing Date Ranges** will bring up a summary of the dates of both missing and recorded data. Note that for calculation purposes, the IHA will interpolate flow values for all days without recorded data, which may yield odd results for many of the output parameters for years with numerous interpolated values. For more on this, see [Missing Data and Data Interpolation](#).

After the file is imported, it needs to be saved under a unique name, so that it can be accessed later from a Project. Hydro Data files can be saved, deleted, closed, and exported (to a comma delimited text format) by choosing the appropriate option on the **Hydro Data** dropdown menu, or the corresponding button on the Hydro Data file itself. The **Hydro Data** dropdown menu also shows the number of days recorded in the currently active Hydro Data file, and allows the user to specify the units of flow in the file. Options are also available on this menu to display

Projects that are related to the current Hydro Data file, start a new Project with the current Hydro Data file, and close all Project, graph, and table windows related to the Hydro Data file.

Records can be added to and deleted from the Hydro Data file in the editor window, and the values in the file can also be edited. Any changes that are made to file must be saved or discarded before leaving the Hydro Data editor. Clicking on the column headers will sort the records, and clicking on the triangle to the right of the column header will bring up a custom auto filter which can be used to filter out some records from view. These last two options are for viewing purposes only, and do not affect the saved file.

To re-open an existing Hydro Data file, click on **IHA | Hydrologic Data | Open Existing File**.

The IHA can process up to 500 years of hydrologic data (see [Maximum Numbers of Years in Hydrologic Data](#)).

3.2.3 Advice for Importing Particular Datasets

This section provides step-by-step procedures for converting common types of daily flow data into formats that can be imported directly into the IHA.

Army Corps of Engineers HEC-DSS database files

This conversion procedure uses the HEC-DSS MS Excel add-in tool to extract data from .dss files. This add-in is available on the HEC website: <http://www.hec.usace.army.mil/>. Note that only daily data can be imported into the IHA (.dss files may hold other types of data).

- (1) Open the .dss file using the Excel add-in tool.
- (2) Retrieve regular time series by selection.
- (3) In the catalog, set the date range to the range you wish to import, and import the desired data into Excel.
- (4) Once the data is imported into the spreadsheet, delete the header information above the flow data, and the left (empty) column.
- (5) Save the data out of Excel as a .csv text file.
- (6) Import the .csv file into the IHA.

If there are negative values in the data, the IHA will ignore these when doing the import. Assuming that these values represent days with missing data, converting them to a -1 or a 999999 will make the import cleaner (these are the no data values accepted by the IHA). But it will work either way.

Water Survey of Canada data

These data are available in the internet at <http://www.wsc.ec.gc.ca/hydat/H2O/>. This conversion procedure is for data in the following file format: DATE-DATE FORMAT (CSV). The file should contain only one type of data (flow or stage), so that there is no duplication of calendar dates in the file.

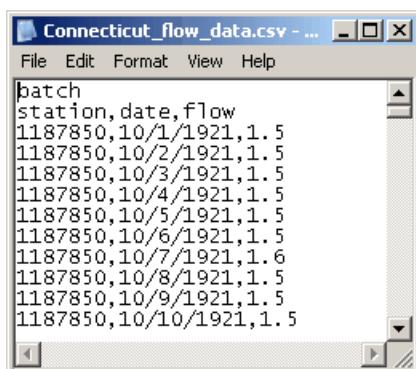
- (1) Open the .csv file in Excel.
- (2) Delete the first, second, and fifth columns of the data (the only columns remaining should be date and flow).
- (3) Make sure that the month, day, and year in the date column are delimited by either a dash (-), a slash (/), or a dot (.). If they are not, do a find and replace to replace the character being used with one of these characters.
- (4) Save the file from Excel as a .csv text file.
- (5) Import the .csv file into the IHA.

3.2.4 Batch Import Capability

In addition to importing flow data from text files containing single datasets, the IHA also has the capability to import data from text files in [USGS file format](#) and [generic two column format](#) that contain more than one dataset. The required format of these files is as follows:

- (1) The USGS website allows one to download flow data from multiple USGS streamflow stations in a single text file. If the IHA is pointed towards one of these files, it will automatically import it just as it does with single station USGS data files, saving each gage record to an individual Hydro Data File. Each Hydro Data File will be automatically named with the appropriate 8-digit USGS station number.
- (2) The IHA will also import text files that are equivalent to generic two column format, but have a third column added to them that contains a station number or other unique name for each dataset. Each Hydro Data File will be automatically named with the unique name in this field. The words or values in this additional column cannot have any spaces in them. For the batch import to work properly, this file must also have the word *batch* entered in the first line of the file, with nothing else on that line. Other than additional column and the batch keyword at the beginning, the file can be identical to any of the allowable [generic two column format](#) files, as far as line delimiters, date formats, no data values, and column headers. Also, it does not matter whether the dates and the gages are in order, i.e. data from the same gage can be in different places in the file, and the rows don't have to be in order by date. The IHA will import the data correctly no matter what order the rows are in.

An example of such a file is below:



| station | date | flow |
|---------|------------|------|
| 1187850 | 10/1/1921 | 1.5 |
| 1187850 | 10/2/1921 | 1.5 |
| 1187850 | 10/3/1921 | 1.5 |
| 1187850 | 10/4/1921 | 1.5 |
| 1187850 | 10/5/1921 | 1.5 |
| 1187850 | 10/6/1921 | 1.5 |
| 1187850 | 10/7/1921 | 1.6 |
| 1187850 | 10/8/1921 | 1.5 |
| 1187850 | 10/9/1921 | 1.5 |
| 1187850 | 10/10/1921 | 1.5 |

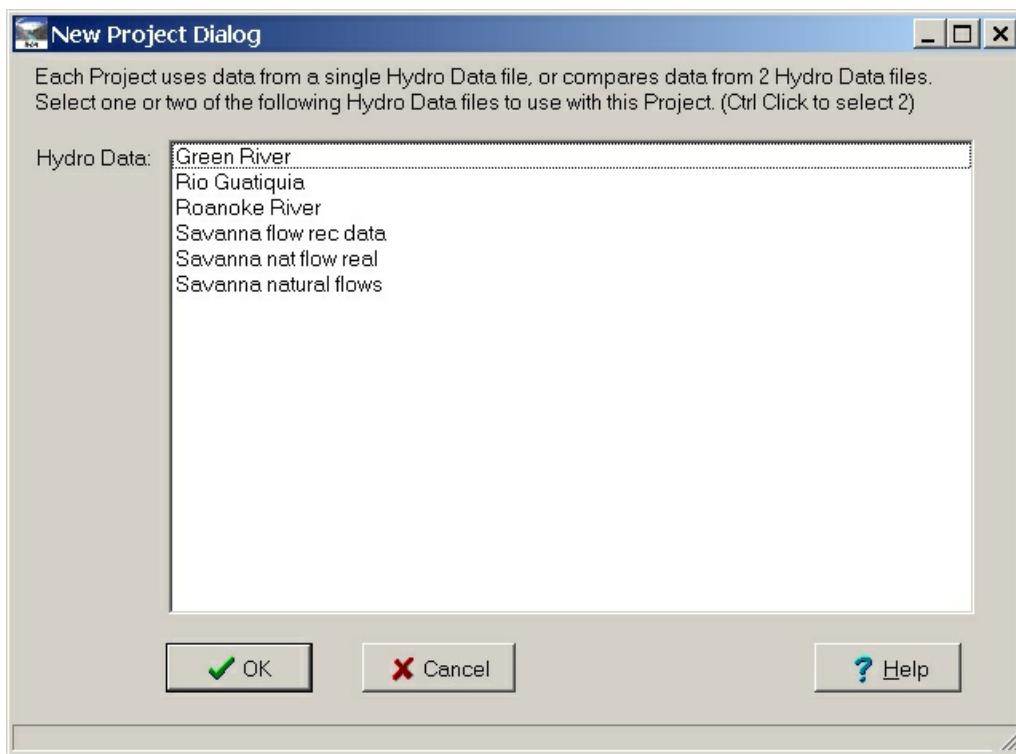
For either of these types of batch files, the IHA will automatically overwrite any existing Hydro Data Files with names identical to the names in the batch file, without prompting the user. For this reason, and also to help keep track of which files have been batch imported, it is recommended that users only conduct batch imports in a new and empty [working directory](#).

3.3 Creating and Managing Projects

3.3.1 Introduction to Projects

Analyses in the IHA are organized in separate Projects. Each Project is linked to a single Hydro Data file, but can contain multiple Analyses. Each Project also has a few settings which can be altered by the user but which will be the same for all Analyses in the Project. Each Analysis contains a series of parameters and settings which allow the user to manage how the IHA will analyze the available Hydro Data file.

To create a new Project, click on **IHA | Project | Start New Project**. This will bring up the following window, which allows the user to select either one or two Hydro Data files to analyze. If one Hydro Data file is selected, you will have the option later on to do either a two period analysis or a single period analysis. If two Hydro Data files are selected, you will be able to use the Project only to compare the two files.



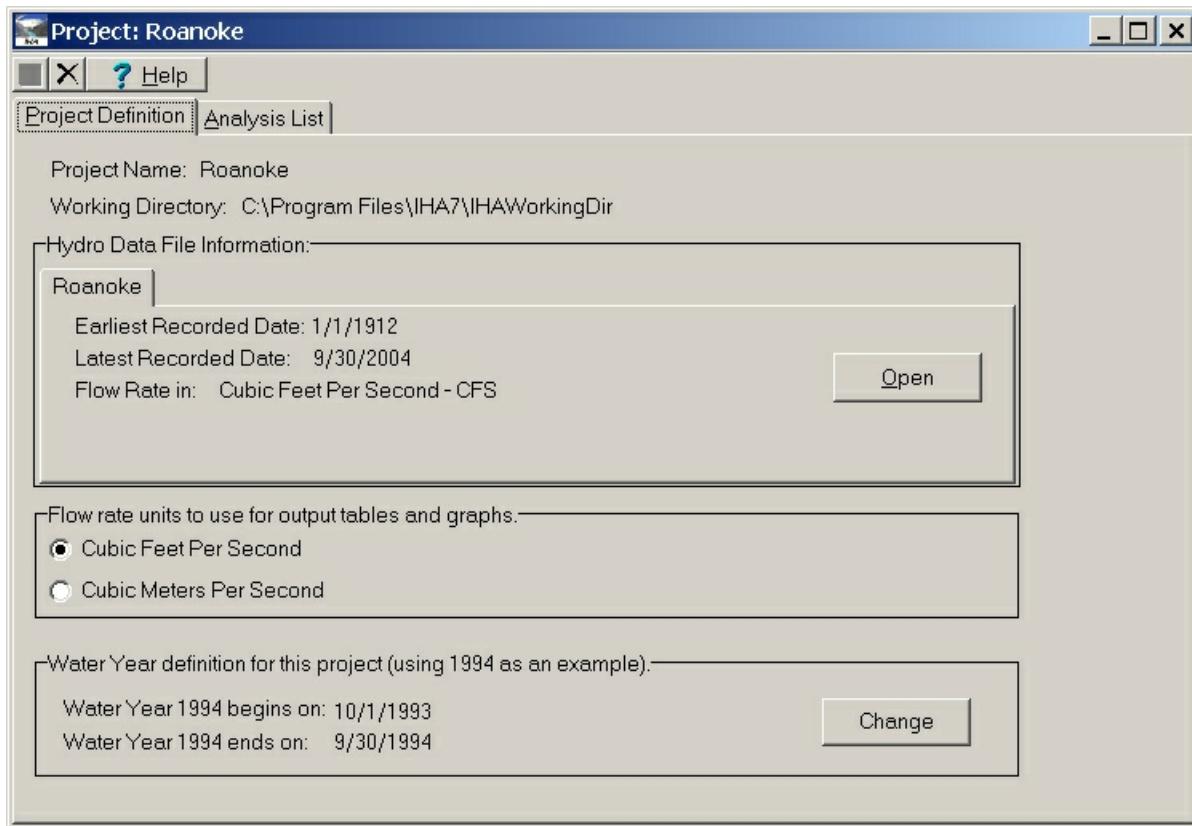
After you select the Hydro Data file to use for this analysis, the Project window will appear. This window has two tabs:

- [Project Definition tab](#)
- [Analysis List tab](#)

The current project can be saved, deleted, and closed from the **Project** dropdown menu, or from the corresponding buttons on the [Project Definition tab](#) of the Project window. Options are also available on the **Project** dropdown menu to open the Hydro Data file which the Project is linked to, and to close all open table and graph windows that are related to either the Project or one of its Analyses.

To re-open an existing Project, click on **IHA | Project | Open Existing Project**.

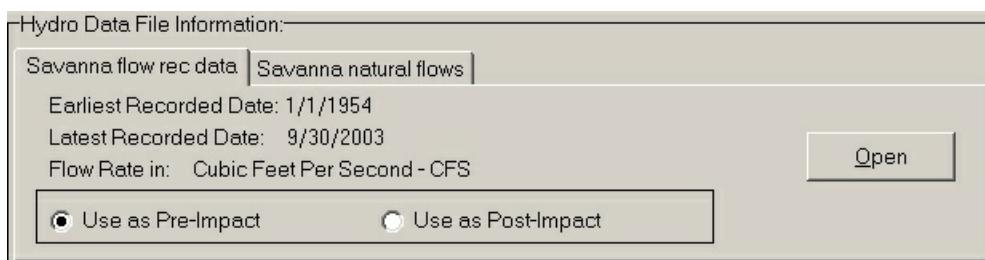
3.3.2 Project Definition Tab



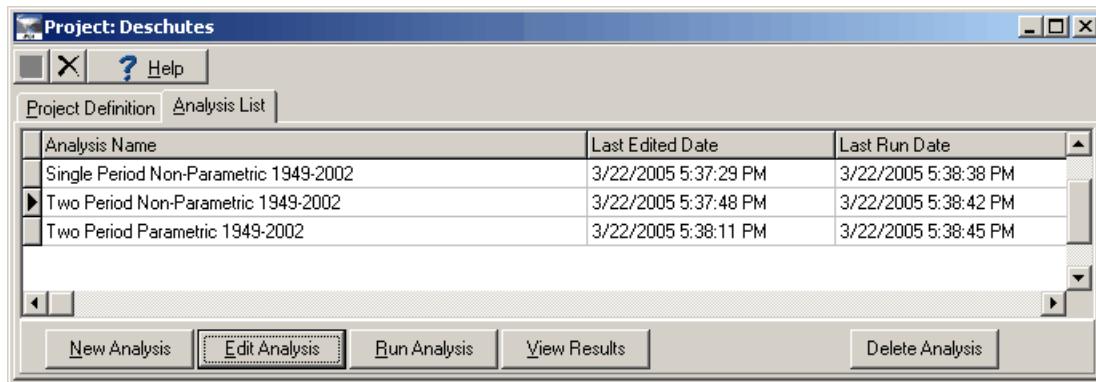
The Project Definitions tab has some settings which are the same for all Analyses in the Project, including the current [working directory](#), some information about the Hydro Data file, the flow rate units to use for output tables and graphs, and the water year definition. If it is necessary to change the water year definition, click on the Change button. For more information on water year definitions, see [Water Year Definition](#).

If your Project is comparing two different Hydro Data files, there will be two tabs in the section entitled Hydro Data File Information, one for each file (see below). Either of the files

can be selected as the pre-impact or the post-impact data. Both Hydro Data files must be in the same flow rate units.



3.3.3 Analysis List Tab



The Analysis List tab shows a list of Analyses that are associated with this Project. Each Analysis has its own name, and the window shows the date and time when each Analysis was last edited and run.

The buttons on this tab can be used to create a new Analysis, and also to edit, run, delete, and view the results of a selected Analysis. For more on these features, see [Setting Up and Managing an Analysis](#), [Running an Analysis](#), and [Viewing and Understanding IHA Outputs](#).

3.4 Setting Up and Managing an Analysis

3.4.1 Introduction to Analyses

Each Analysis contains a series of parameters and settings which allow the user to manage how the IHA will analyze the hydrologic data. A single Project can contain multiple Analyses. A new Analysis can be created by clicking on the **New Analysis** button, which will bring up the following options:



Starting the Wizard will bring up a self-explanatory Wizard which can be used to set up an Analysis. Note that while this is the easiest way to set up an Analysis, it only allows the user to change the basic settings, and the rest of settings will be set as defaults. The Wizard is not available for Projects that are comparing two Hydro Data files. The third option (Copy Existing Analysis) can be used to copy an existing Analysis, giving it a new name. Clicking on the **Edit Analysis** button allows the user to further edit any Analysis first created using these options.

The Set Up Custom Analysis option will bring up the Analysis Properties window, from where the user can alter all available settings. This window has five tabs, which are the:

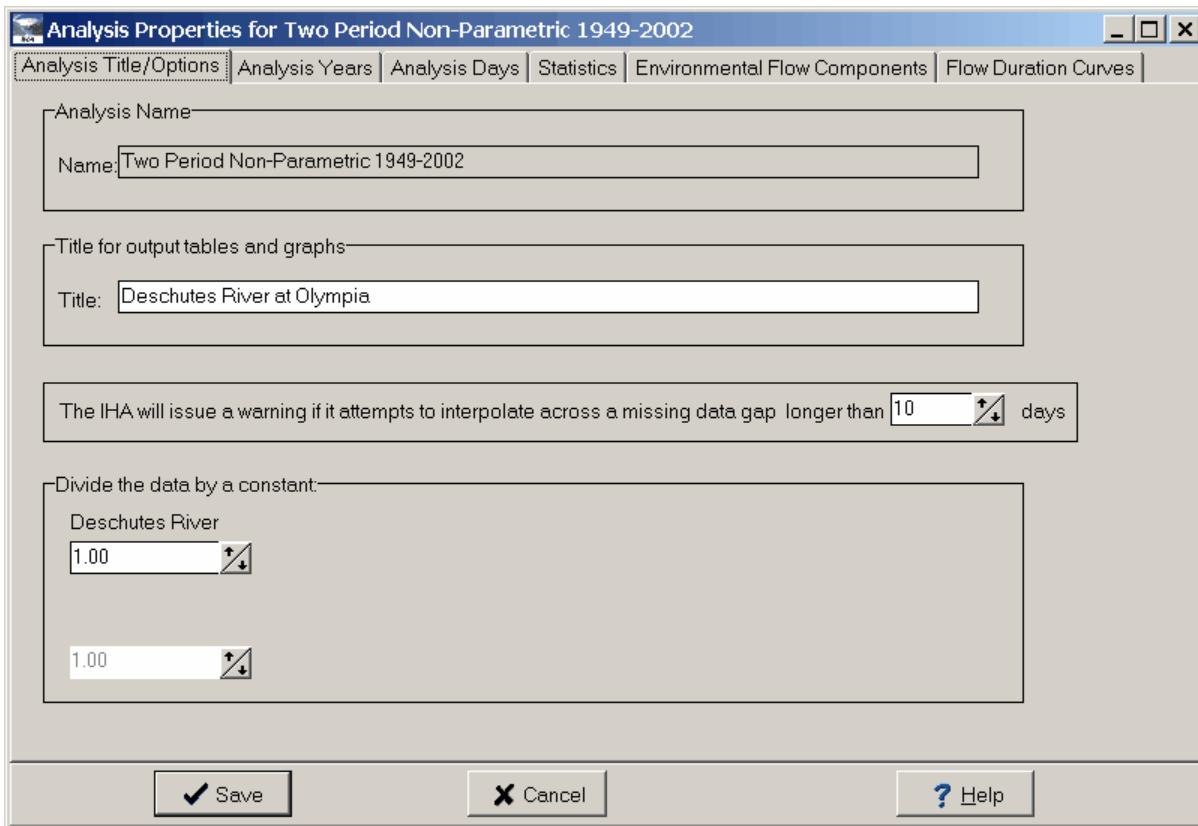
- [Analysis Title/Options tab](#)
- [Analysis Years tab](#)
- [Analysis Days tab](#)
- [Statistics tab](#)
- [Environmental Flow Components tab](#)
- [Flow Duration Curves tab](#)

Once all the options are set, the Analysis can be saved by hitting the Save button.

Editing Analysis Properties with Tables or Graphs Open

It is possible to bring up the Analysis Properties window while table or graph windows are open showing Analysis results. This can be done either by clicking on the  button on an open graph window, or by selecting the appropriate choice from the **Graph** or **Spreadsheet** dropdown menus. But if the Analysis Properties window is brought up in this way, a few of the Analysis settings cannot be edited. The user will not be able to switch between one period and two period analysis, parametric and non-parametric statistics, and one season and two seasons for EFC parameters. This is done so that drastic changes in how the Analysis is conducted cannot be made, since this would affect the accuracy of the data in the open graph or table windows. Other more minor changes in Analysis settings can be made, and after these changes are saved, the values in the graphs and the tables will automatically be recalculated when the user returns to those windows. When appropriate, a warning message will remind the user about which settings cannot be edited, and the relevant sections of the Analysis Properties window will be greyed out.

3.4.2 Analysis Title/Options Tab



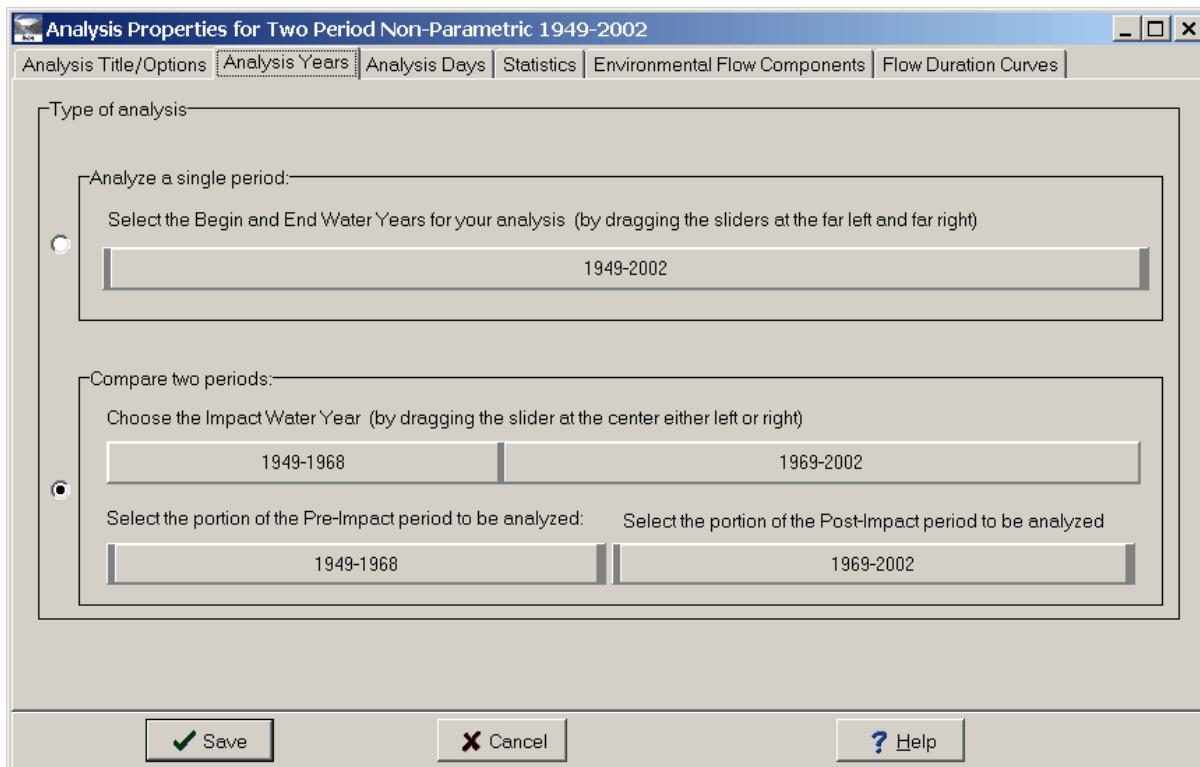
The Analysis Title/Options tab allows the user to set the following:

- Name of the Analysis.
- Default title to use for output tables and graphs.
- The minimum number of consecutive days of interpolated data that will trigger a warning message. This message will appear in the [Message Report](#) to warn the user if there is a large amount of interpolated data in certain years.
- One or two constants to divide the output flow data values by (Normalization Factors). These can be used to "normalize" flow values in the output tables. All flow data are divided by these numbers prior to computing the flow statistics. One factor can be specified per Hydro Data file being analyzed. One use of these normalization factors is that if data from two watersheds with different sizes are being compared, the flow values in each Hydro Data file can be divided by watershed area to make the flow rates comparable. This normalization affects only the outputs expressed in units of flow rate (e.g. cubic feet per second) and also the rise and fall rates.

3.4.3 Analysis Years Tab

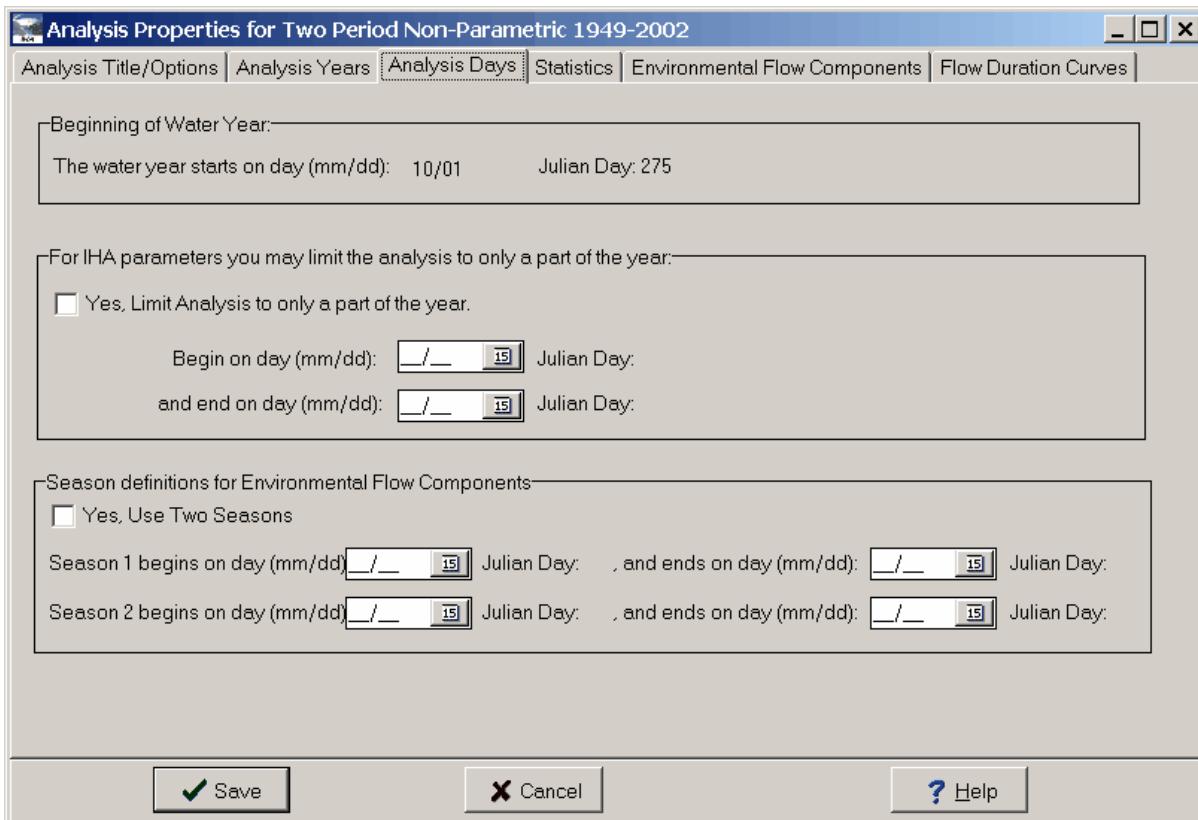
There are two versions of the Analysis Years tab, depending on whether the Project is analyzing one or two Hydro Data files. Below is what will appear if there is only one Hydro

Data file. This tab allows the user to choose between single period and two period analysis, and to set the water years to be used for analysis. It will display the range of years available in the Hydro Data file, and the user can use slider bars to specify which years will be used for analysis. The two Hydro Data file version is similar, with a slider bar for each of the Hydro Data files. Note that the begin and end water year settings cannot correspond to water years that are missing from the Hydro Data file, and the Analysis cannot be saved until this problem is corrected.



If the Analysis Years tab is displayed while a table or graph from the current Analysis is open, it will not be possible to switch between one period and two period analysis (see [Editing Analysis Properties with Tables or Graphs Open](#)).

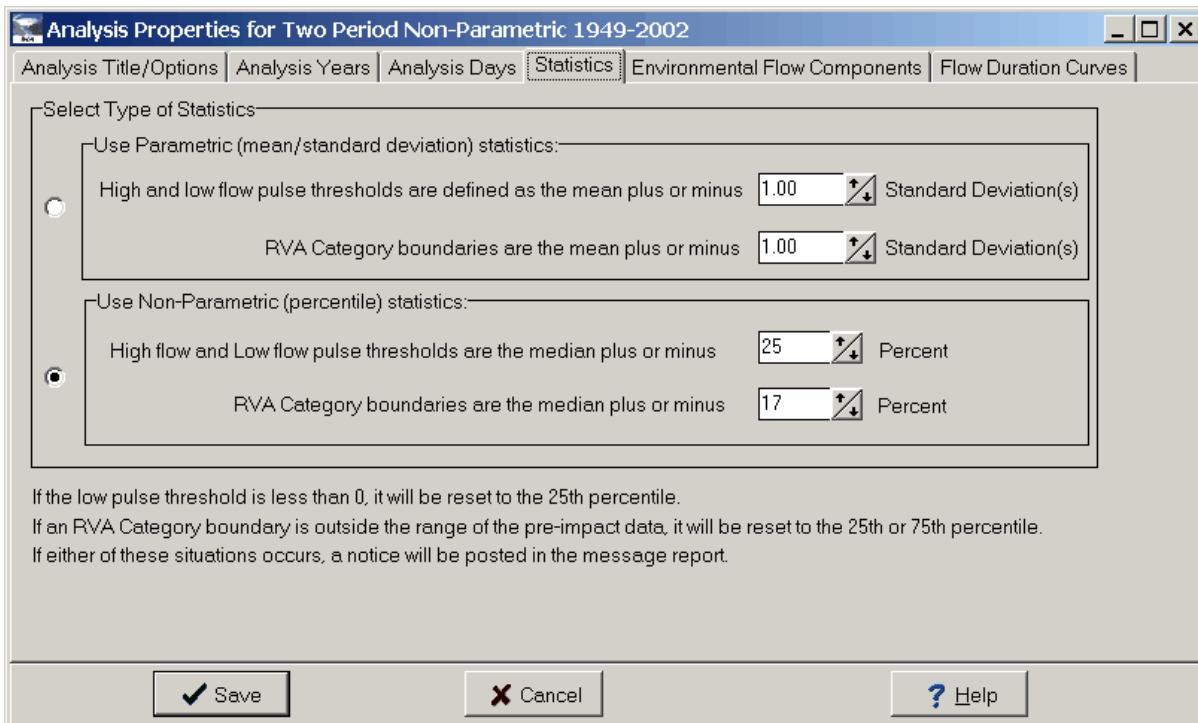
3.4.4 Analysis Days Tab



The Analysis Days tab displays the current [Water Year Definition](#), and also allows the user to limit the time period being used to generate the IHA parameters and define two seasons to be used for non-monthly EFC parameters. See [Shortened Water Years and Seasons](#) for more about this feature.

If the Analysis Days tab is displayed while a table or graph from the current Analysis is open, it will not be possible to switch between one season and two seasons for EFC parameters (see [Editing Analysis Properties with Tables or Graphs Open](#)).

3.4.5 Statistics Tab



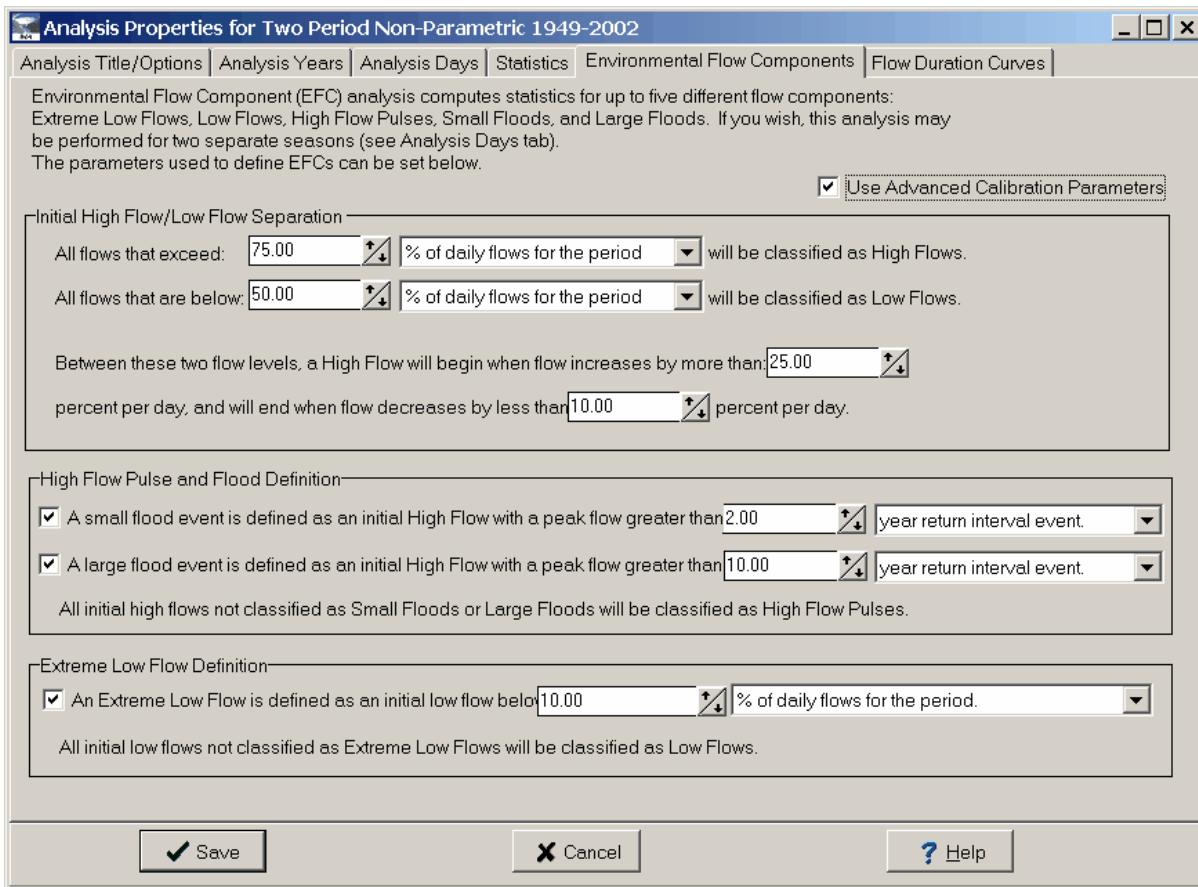
The Statistics tab allows the user to specify whether parametric (mean/standard deviation) or non-parametric (median/percentile) statistics are used for analysis. A key assumption of parametric statistics is that the data are normally distributed. Non-parametric statistics are often useful because of the skewed (non-normal) nature of many hydrologic datasets. See [IHA Parameters](#) and [EFC Parameters](#) for more specifics on how calculations will vary for parametric versus non-parametric analysis. Output tables and graphs will also vary depending on whether parametric and non-parametric analysis is used, see [Tables](#) and [Graphs](#) for details.

If the Statistics tab is displayed while a table or graph from the current Analysis is open, it will not be possible to switch between parametric and non-parametric analysis (see [Editing Analysis Properties with Tables or Graphs Open](#)).

The definitions of high and low pulse thresholds and RVA category boundaries can also be set here. The exact values of the pulse thresholds are displayed in the [Scorecard Table](#) and [RVA Table](#). The exact values of the RVA boundaries are displayed in the [RVA Table](#). For further description of how the RVA category boundaries are used, see [RVA Analysis](#).

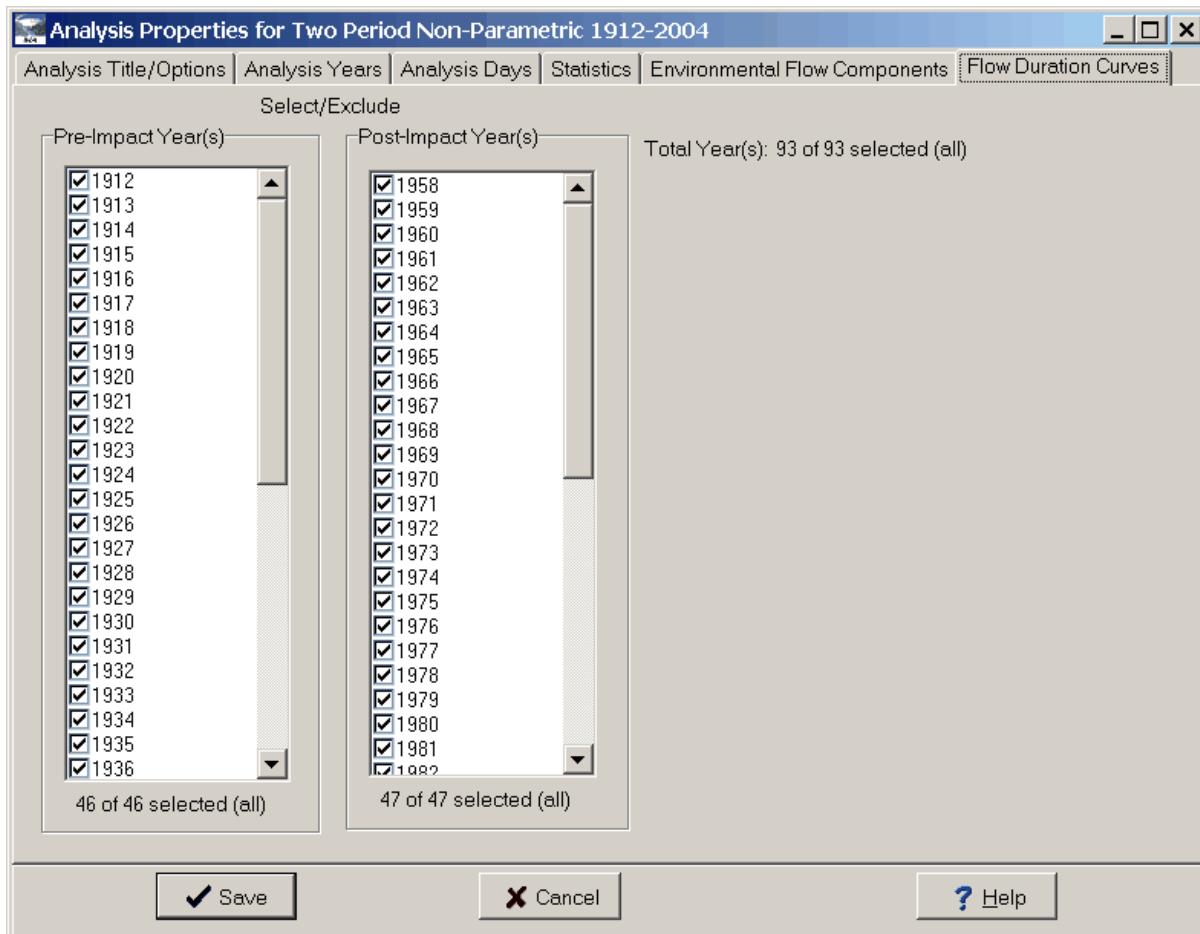
Note that if the low pulse threshold is less than 0, it will be reset to the 25th percentile, and if an RVA category boundary is outside the range of the pre-impact data (as can happen often when using standard deviations in parametric analysis), it will be reset to the 25th or 75th percentile. If either of these situations occurs, a [notice](#) will be posted in the [Message Report](#).

3.4.6 Environmental Flow Components Tab



The Environmental Flow Components tab allows the user to reset the parameters used in the algorithm that defines [Environmental Flow Components](#), in order to [calibrate the EFC algorithm](#). For two period analysis, the recurrence intervals for small and large floods and the flow level thresholds used to define extreme low flows and high flow pulses are based on data from the pre-impact period. For single period analysis, they are based on data for the entire period of analysis.

3.4.7 Flow Duration Curves Tab



The Flow Duration Curves tab allows the user to select out individual years in each period or Hydro Data file to be analyzed, beyond the settings in the [Analysis Years tab](#) and the [Analysis Days tab](#). In order to select or deselect multiple years, click on one year, then use shift-click to select a block of years and to toggle all those years on or off. The IHA has a limit of 100 excluded (deselected) years. If it is necessary to exclude more than that, then this should be done by adjusting slider bars on the Analysis Years tab.

3.5 Running an Analysis

3.5.1 Running an Analysis

Running an Analysis will cause the IHA to perform a series of calculations on your hydrologic data. Once an Analysis is saved, it can be run by clicking on the **Run Analysis** button on the second tab of the Project window while the Analysis is selected. The Analysis list shows the

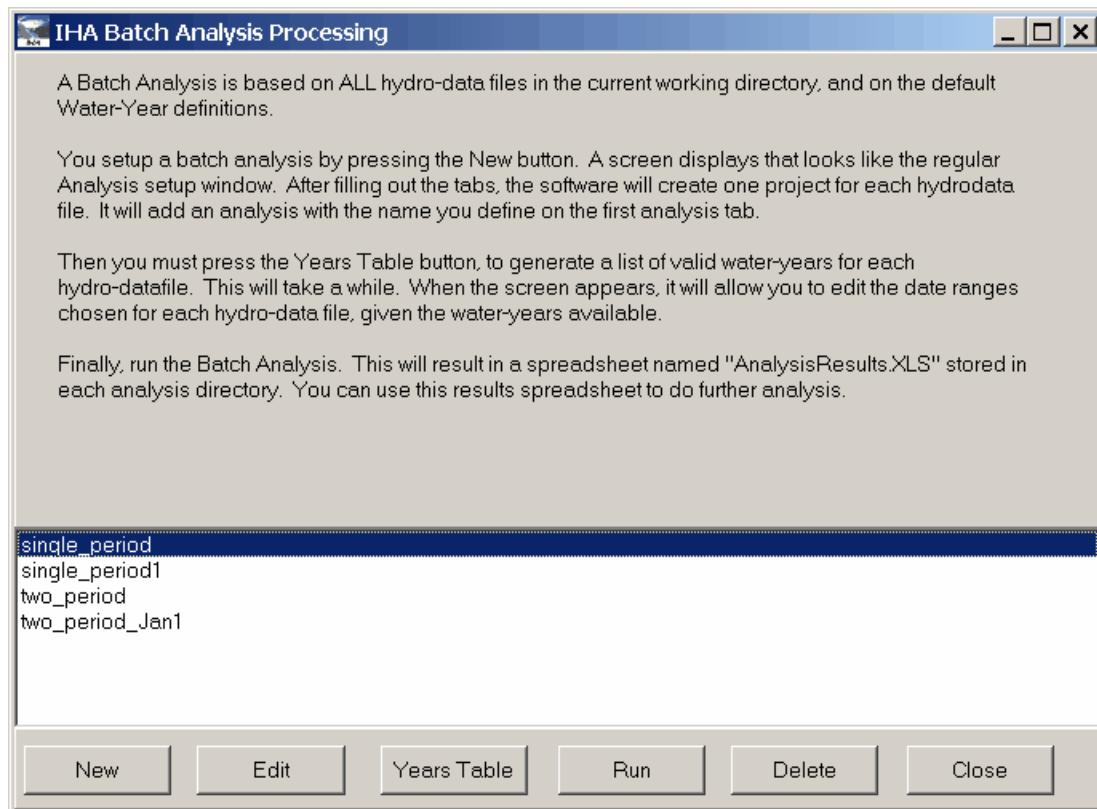
last date and time that the Analysis was run. If the **Run Analysis** button has not been clicked on, selecting any of the options from the **View Results** button will also automatically run the Analysis.

Note that if after running an Analysis, the user makes any changes to the Hydro Data file, the parameters on the [Project Definition tab](#) of the Project window, or any of the Analysis settings or parameters, the Analysis will automatically be rerun whenever the user tries to view any results of the Analysis. This will occur if the user makes a selection from the **View Results** button, or clicks on a table or graph window that was left open while the Analysis settings were being changed. This latter recalculation is done to ensure that there will never be any data in an open table or graph that is not consistent with the current Analysis settings. This feature also allows the user to quickly switch between the Analysis Properties window and the tables and graphs, which can be useful when [Calibrating the EFC Algorithm](#) or adjusting other Analysis settings based on the results.

3.5.2 Batch Analysis

IHA Analyses can also be run in a batch mode. The window described below will create an identical Analysis for each of a number of Hydro Data files. These Analyses will differ only in the years analyzed. Note that when a Batch Analysis is set up and run, it will create and run a separate Analysis for each of the Hydro Data files in the current [working directory](#), deleting any existing results. So it is best to create specialized working directories for conducting Batch Analyses. Batch analysis can only be conducted for one Hydro Data file analyses, not for comparisons of two Hydro Data files.

Batch processing can be initiated by clicking **IHA | Batch Processing**. This will bring up the following window:



The buttons on this window can be used to create, edit, run, and delete a Batch Analysis, and set up the years to be used in each individual Analysis.

The New button brings up a slightly modified version of the Analysis Properties window, which can be used to set up the Batch Analysis in the same way as single Analyses are set up. The only big difference from the normal Analysis Properties window is that the only choices on the Analysis Years tab are whether the Analysis is single period or two period. The exact years to be used are set up differently (see below). Another small difference is that the water year can be set up on the Water Years tab, since there is no Project window available for Batch Analyses. Also, for Flow Duration Curves, it is not possible to use selected years during each period.

The Edit button allows one to edit the properties of an already created Batch Analysis.

The Years Table button brings up the window shown below, which can be used to set up the years used for each individual Analysis. The first four columns, which can't be altered by the user, display the names of all Hydro Data files in the current working directory, and the lowest, middle, and highest years in each Hydro Data file. The right four columns are used to set the years used in each Analysis. The first time the Years Table button is clicked, default values are created for the years used for each Hydro Data file. These can then be altered by either typing in values, or copying and pasting from another application such as Excel. The IHA will check to make sure that the values entered are valid and in the proper order. For a two period analysis, all four of these columns must be filled. For a single period analysis, only the first two are used.

| Years Table for Batch: two_period | | | | | | | | |
|-----------------------------------|----------|-------------|-------------|--------------|---------------|-------------|---------------|-------------|
| Edit | | | | | | | | |
| | A | B | C | D | E | F | G | H |
| 1 | HDF Name | Lowest Year | Middle Year | Highest Year | Per1BeginYear | Per1EndYear | Per2BeginYear | Per2EndYear |
| 2 | | | | | | | | |
| 3 | 1034500 | 1903 | 1953 | 2003 | 1903 | 1952 | 1953 | 2003 |
| 4 | 1042500 | 1904 | 1953 | 2003 | 1904 | 1952 | 1953 | 2003 |
| 5 | 1049500 | 1890 | 1946 | 2003 | 1890 | 1945 | 1946 | 2003 |
| 6 | 1053500 | 1905 | 1954 | 2003 | 1905 | 1953 | 1954 | 2003 |
| 7 | 1054500 | 1900 | 1951 | 2003 | 1900 | 1950 | 1951 | 2003 |
| 8 | 1064000 | 1902 | 1951 | 2000 | 1902 | 1950 | 1951 | 2000 |
| 9 | 1187300 | 1996 | 1996 | 1996 | 1996 | 1996 | 1996 | 1996 |
| 10 | | | | | | | | |

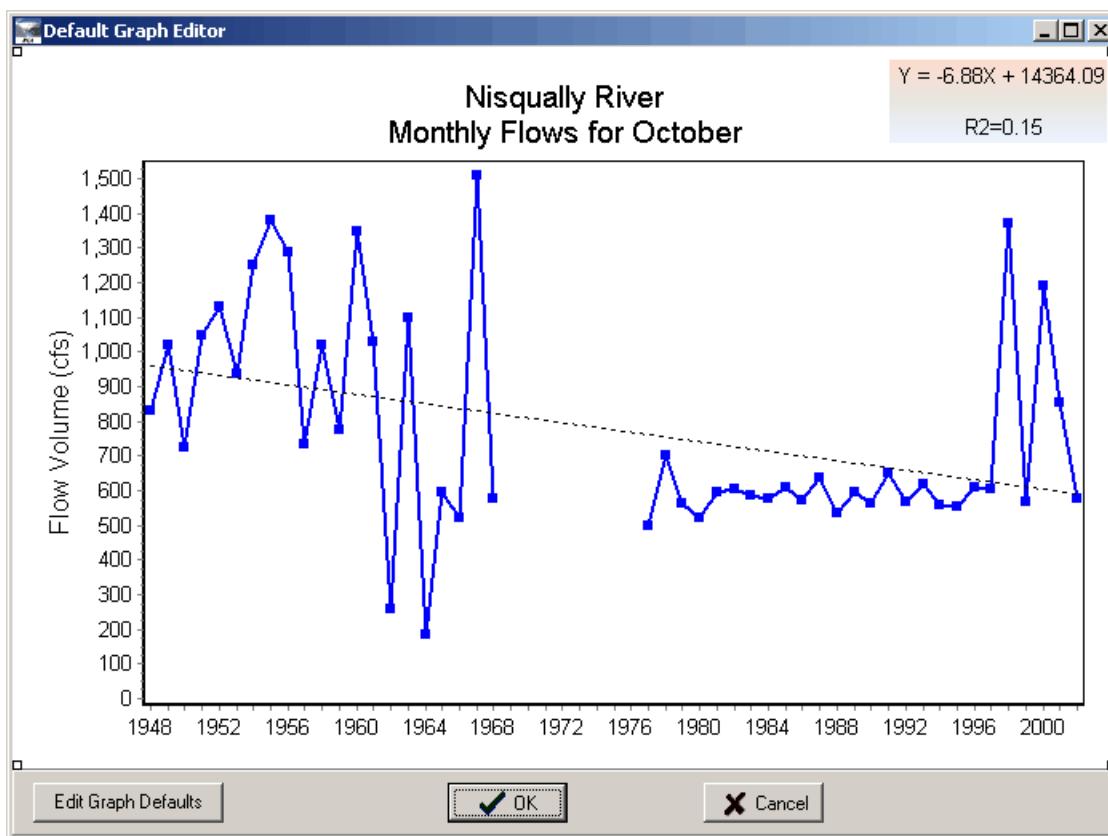
The Run button will run the selected Batch Analysis for each of Hydro Data files listed. Batch processing results are stored as follows: A Project is created for each Hydro Data file in the working directory, and an Analysis is created in each Project directory for each of the Batch Analyses. Results from each Analysis will be saved in an Excel spreadsheet called AnalysisResults.xls, which is stored in the relevant Analysis directory. A window will also be displayed that lists the Analyses completed and any problems encountered. For a large number

of Hydro Data files, be aware that batch processing can be time-consuming. Results of Projects created through batch processing can also be viewed individually in the same way as normal results are viewed.

3.6 Other Features

3.6.1 Graph Default Settings

In order to reduce the need to edit each individual graph, many of which have very similar features, the IHA allows the user to edit the characteristics of a default set of graphs, whose settings are then used to populate all subsequent graphs that are created in any Project. These default graphs can be accessed by clicking on **Options | Graph Default Layout**. There are separate default graphs for the single period annual data graphs, two period annual data graphs (with separate defaults for graphs with RVA lines and variance lines), monthly average graph, hydrologic alteration graph, flow duration curves, and daily data graphs (with separate defaults for daily data with and without Environmental Flow Components). An example default graph is shown below.



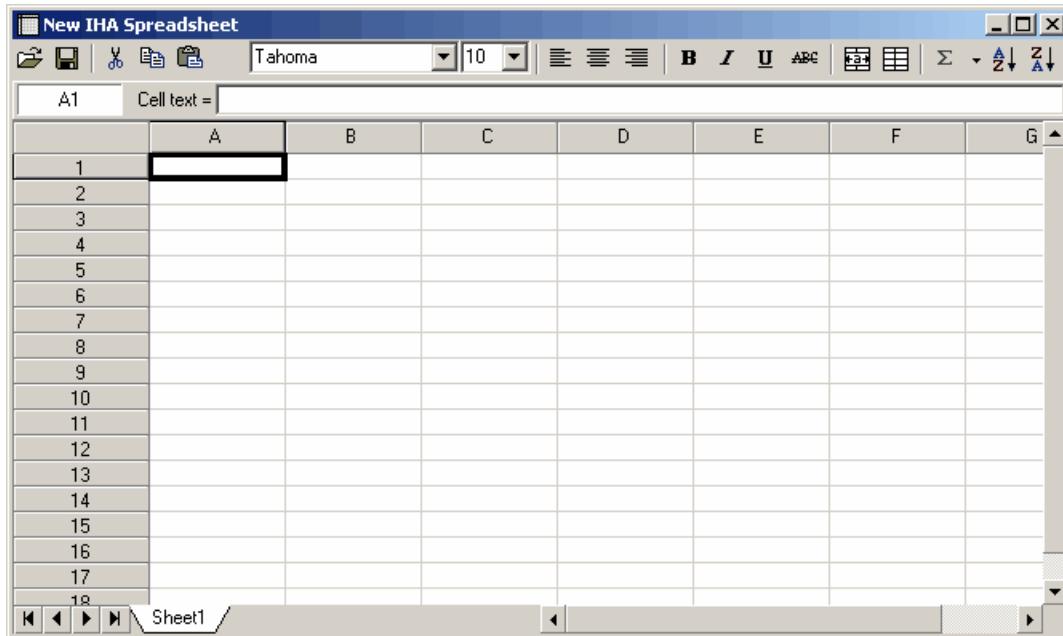
These default graphs can be edited just like the normal graphs (see [Editing and Working with IHA Graphs](#)), and once they are saved any new graphs of the same type created in any Analysis will use all the same features (fonts, colors, line symbols, etc.) of the default graphs. If you

wish to revert back to the original default graph contained in the software, hit cancel in response to the pop-up window that asks whether you want to start fresh for a particular default graph.

3.6.2 Spreadsheet Tools

An additional feature of the IHA is its spreadsheet capabilities, which provide the ability to open and save spreadsheets in Microsoft Excel format and also do basic spreadsheet operations inside the IHA. A blank spreadsheet like the one below can be created by clicking on **IHA | Spreadsheet | New**. This spreadsheet replicates the basic functionality of Excel spreadsheets, including cell formulas and built-in functions and operators, but it does not have Excel's more advanced capabilities. Once data is entered into this spreadsheet, it can be saved in Microsoft Excel format by clicking on **Spreadsheet | Save** or by hitting the save button. The saved spreadsheet can be then be viewed either in Excel or in the IHA directly (by clicking on **IHA | Spreadsheet | Open**).

Note that results tables in the IHA are now displayed in this same spreadsheet format (see [Tables](#)).

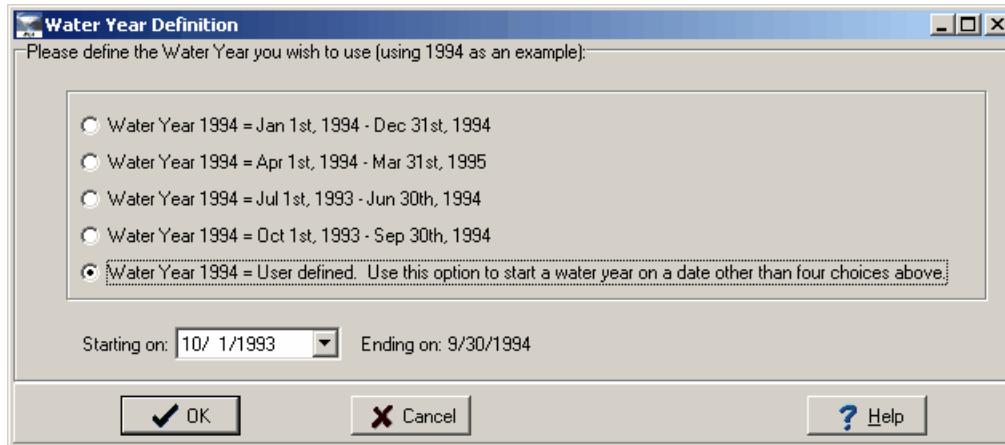


3.6.3 Water Year Definition

The hydrologic statistics produced by the IHA are calculated and organized in the output tables by water year. A water year is a 12-month period that does not necessarily correspond to the calendar year. The default water year in the IHA is Oct. 1 - Sept. 30, but the water year can be

reset to start on any other day of the year if desired. Note that certain analysis can also be conducted for periods shorter than 12 months. See [Shortened Water Years and Seasons](#) for instructions on how to use periods shorter than an entire year for some calculations.

The water year can be reset in two different places in the IHA. First, the default water year can be altered by clicking on **Options | Water Year Definitions Default**. The water year stored here is the default water year that will be used for each new Project. Second, the water year can be altered for individual Projects. This option is available on the first tab of the Project window. Selecting either of these options will bring up the following window:



Water years in this window are displayed using 1994 as an example. The radio buttons can be used to select the beginning of the water year. The first four radio buttons allow the user to select the beginning date of each quarter of the calendar year, and the last radio button can be used to select any other date.

A couple more notes on water year definition are as follows:

- While a water year can start on any day of the year, if it is started on a day other than the first of the month, the monthly average flow and EFC monthly low flow parameters for the first month of the year will only be calculated using the period of the month that is at the beginning of the current water year. This is to avoid calculating these parameters for two disconnected periods during the year.
- If the water year definition for a Project is changed after Analyses have been created, it is possible that some of the settings on the Analysis Years and Analysis Days tabs of the Analysis Properties will become invalid. If this happens, the user will be notified the next time an Analysis is run, and the Analysis Properties window will be displayed so the needed changes can be made. Sometimes the IHA will make these changes automatically, and sometimes it will display a warning message notifying the user where the problem is.

3.6.4 Working Directory

The IHA software stores all of the data and information associated with saved Hydro Data files, Projects, and output tables and graphs in a single directory, called the working directory. The default working directory is the same directory that the IHA is installed in, and under normal use there should be no need to ever change this directory. But if the user does wish to control where the IHA stores its data, the working directory can be reset by clicking on **Options | Set Working Directory**, and selecting another directory. Note that the only Hydro Data files and Projects that will be accessible to the user are those that are saved in the current working directory. The current working directory is also displayed in Project Definition tab of the Project window.

The working directory contains two subdirectories named HydroData and Projects, which contain all the data and other information that is currently saved. If it is necessary to transfer IHA data from one computer, hard-drive, or directory to another, this can be done by copying these two subdirectories directly. Each Project directory also contains subdirectories for each individual Project and for each Analysis with each Project.

4 Viewing and Understanding IHA Outputs

4.1 Introduction to Viewing Results

Outputs from the IHA are available in two formats, as tables and graphs. Outputs may be viewed by clicking on the **View Results** button on the second tab of the Project window, while the appropriate Analysis is selected, which will bring up the following options:



New tables and graphs can be displayed by selecting either View Tables or New Graph. Any currently open graphs can be accessed through the View Open Graphs list, and any saved graphs are available under the View Saved Graphs choice. For more information on table and graph outputs, see [Tables](#) and [Graphs](#). The graphs can be edited, either by altering a default graph that is used to as the basis for all subsequent graphs, or by editing individual graphs. See [Editing and Working With IHA Graphs](#) for details.

Note that selecting any of the options from the **View Results** button will automatically run the Analysis, if it has not been previously run or if any changes have been made to the Hydro Data file, the parameters on the [Project Definition tab](#) of the Project window, or any of the Analysis settings or parameters. This is done to ensure that there will never be any data in an open table or graph that is not consistent with the current Analysis settings.

4.2 Tables

4.2.1 Introduction to Tables

The output tables generated by the IHA vary depending on whether the Analysis is run with one or two periods and with parametric or non-parametric statistics. Table 3 shows the tables that are available for each type of analysis. The information available within different tables will also vary depending on the type of analysis conducted (see the description of individual tables for more details). The results tables are displayed in separate pages in a [spreadsheet](#), which can be displayed by choosing the View Tables option from the **View Results** button. This spreadsheet can be viewed inside the IHA and also saved in Excel format by hitting the save button.

Table 3. Output Tables Generated by the IHA.

| | | Tables are available for the following types of analyses: | | | | |
|---|------------|---|---------------------------|-----------------------|---------------------------|-----------------------|
| | | Spreadsheet Page | Two Period Non-Parametric | Two Period Parametric | One Period Non-Parametric | One Period Parametric |
| Annual Summaries Table | ann | | Yes | Yes | Yes | Yes |
| Scorecard Table | sco | | Yes | Yes | Yes | Yes |
| RVA Table | rva | | Yes | Yes | | |
| Box-and-Whisker Table | baw | | Yes | Yes | | |
| Regression Table | lsq | | | | Yes | Yes |
| Percentile Table | pct | | Yes | | Yes | |
| EFC Daily Table | daily efcs | | Yes | Yes | Yes | Yes |
| Flow Duration Curve Table | fdc | | Yes | Yes | Yes | Yes |
| Message Report | msg | | Yes | Yes | Yes | Yes |

Below is an example spreadsheet of IHA table results.

| Spreadsheet: Roanoke River / Two Period Non-Parametric 1912-2004 | | | | | | | | | | | |
|--|------|---------|----------|----------|---------|----------|-------|-------|-------|-------|-------|
| Cell text = IHA Annual Summary Statistics | | | | | | | | | | | |
| IHA Annual Summary Statistics | | | | | | | | | | | |
| Two Period Non-Parametric 1912-2008 | | | | | | | | | | | |
| 1 | Year | October | November | December | January | February | March | April | May | June | July |
| 2 | 1912 | 9060 | 9060 | 9060 | 6620 | 9500 | 21400 | 9845 | 9280 | 4290 | 10400 |
| 3 | 1913 | 2620 | 3090 | 3250 | 5140 | 4260 | 9060 | 7010 | 4260 | 13300 | 8630 |
| 4 | 1914 | 3740 | 4430 | 5870 | 7400 | 11650 | 11400 | 8210 | 4780 | 14430 | 10400 |
| 5 | 1915 | 2460 | 2460 | 10900 | 14700 | 10900 | 8210 | 6620 | 4430 | 12750 | 8950 |
| 6 | 1916 | 6080 | 3160 | 3630 | 8130 | 8130 | 5700 | 4800 | 4290 | 14400 | 10400 |
| 7 | 1917 | 2930 | 2660 | 3160 | 8570 | 7280 | 15900 | 7280 | 5700 | 13300 | 8630 |
| 8 | 1918 | 2270 | 2615 | 1620 | 4430 | 10900 | 7010 | 13300 | 8630 | 14400 | 10400 |
| 9 | 1919 | 2040 | 4085 | 8630 | 9960 | 7400 | 9960 | 7400 | 10400 | 14400 | 10400 |
| 10 | 1920 | 3090 | 2770 | 3410 | 3740 | 8210 | 8630 | 9280 | 4780 | 12750 | 8950 |
| 11 | 1921 | 2270 | 3215 | 12500 | 10000 | 11750 | 8000 | 7310 | 6280 | 14400 | 10400 |
| 12 | 1922 | 1620 | 3540 | 3700 | 4860 | 14150 | 17200 | 7080 | 9500 | 14400 | 10400 |
| 13 | 1923 | 3540 | 2930 | 4180 | 9000 | 12750 | 17200 | 8150 | 5380 | 14400 | 10400 |
| 14 | 1924 | 2760 | 3440 | 5030 | 10000 | 6500 | 9520 | 11850 | 15600 | 14400 | 10400 |
| 15 | 1925 | 5380 | 4525 | 6500 | 16800 | 10000 | 6900 | 5205 | 5740 | 14400 | 10400 |
| 16 | 1926 | 2270 | 3230 | 4040 | 5740 | 11600 | 6900 | 6120 | 3440 | 14400 | 10400 |
| 17 | 1927 | 1620 | 3360 | 4690 | 5030 | 8150 | 7720 | 8590 | 3740 | 14400 | 10400 |
| 18 | 1928 | 5030 | 3230 | 10000 | 6900 | 8590 | 6900 | 7935 | 5740 | 14400 | 10400 |
| 19 | 1929 | 5030 | 4360 | 4360 | 5030 | 7510 | 14400 | 8590 | 8590 | 14400 | 10400 |
| 20 | 1930 | 6480 | 8650 | 7320 | 7970 | 7970 | 5680 | 5480 | 3800 | 14400 | 10400 |
| 21 | 1931 | 859 | 2105 | 2370 | 4050 | 2935 | 4260 | 8000 | 6390 | 14400 | 10400 |
| 22 | 1932 | 1280 | 1485 | 2710 | 5300 | 6390 | 8150 | 7500 | 4810 | 14400 | 10400 |

The first time a results spreadsheet is viewed, the Message Report is displayed on top, so that the user can see any messages and warnings from the Analysis.

When a spreadsheet containing output tables from an Analysis is displayed, the options on the **Spreadsheet** dropdown menu can be used to display the current Analysis Properties window, the current Project window, the Hydro Data file that was used for the Analysis, and any graphs that are related to this Analysis.

Note that if the Analysis Properties window is brought up while a spreadsheet is being displayed, certain settings of the Analysis cannot be altered (see [Editing Analysis Properties with Tables or Graphs Open](#)). If any changes are made to the Analysis Properties, the values in the spreadsheet will automatically be recalculated when the user returns to that window. This is done to ensure that there will never be any data in an open table that is not consistent with the current Analysis settings.

Below are a couple more notes about IHA results tables:

- IHA results are displayed with four significant digits.
- Usually, at least a few of the cells in some of these tables will be blank. This occurs when no valid data existed to calculate the parameter or statistic held in that cell.
- If two seasons are used when calculating EFCs, the number of rows and columns in each table will be increased in order to display individual parameter values for two seasons instead of one.

4.2.2 Annual Summaries Table

This table displays all the [IHA](#) and [EFC](#) parameter values for each individual water year that has been included in the time periods selected for analysis. Each column shows one parameter, and each row corresponds to one year. Note that if your input flow data has any water years which have no valid flow values, these years will not have rows in this table.

If non-parametric statistics were used, the values in this table are medians for each water year of the relevant sub-annual data. So for example: for October flows, the value in this table is the median of all daily flows during October in the water year; for high pulse durations, the value in this table is the median of the durations of all high pulse events in the water year; etc.

If parametric statistics are used, the values in this table are means rather than medians.

For comparisons of two Hydro Data files, all the water years for the file that is selected as pre-impact will be shown first (at the top), followed by all the years for the file used as post-impact.

4.2.3 Scorecard Table

This table shows a variety of statistics for the pre-impact and post-impact periods (or for the two Hydro Data files being compared), for each hydrologic parameter. These statistics are calculated from the annual values in the [Annual Summaries Table](#). The statistics will vary depending on whether the analysis was run with parametric or non-parametric statistics. For single period analysis, fewer columns will be shown in the table, since there is not pre-impact and post-impact periods.

The Scorecard Table also shows the high and low pulse thresholds (under the section for Parameter Group #4), and the flow values that correspond to the five [EFC calibration](#) parameters (below all of the EFC data).

Non-Parametric Scorecard Table

The header panel contains a number of parameters that apply only to the period of analysis as a whole. These are:

- Normalization Factor. This is the normalization factor entered in Analysis Title/Options Tab. All output flow values have been divided by this factor (except the Non-Normalized Mean Flow below). If two Hydro Data files are being used, each can have a different normalization factor, and both will be displayed here.
- Mean annual flow
- Non-Normalized Mean Flow
- Annual Coefficient of Variation. This is calculated as the standard deviation of all the daily flow values, divided by the mean annual flow.
- Flow predictability. Predictability ranges in value from 0 to 1 and is composed of two additive components: constancy (C), a measure of temporal invariance, and contingency (M), a measure of periodicity. The predictability of a stream with very constant flow will be mostly due to C, while the predictability of a stream with highly variable flow with a fixed periodicity will be mostly due to M.
- Flow constancy / flow predictability. $C / (C+M)$.
- Maximum proportion of floods that occur during any common 60 day period in all years during the period of record. Floods are defined as any flows above the high pulse threshold. See the [Statistics tab](#) of the Analysis Properties window to set this threshold.
- Length of flood-free season. This is the length in days of the longest period common to all water years where flows are at or below the high pulse threshold in every year.

These parameters are modeled after a suite of parameters described by Poff and Ward (1989). The flow predictability, constancy, and contingency measures are originally from Colwell (1974). If a [shortened water year](#) is used for IHA parameters, the parameters in the header panel will be calculated only for that shortened period.

The rest of the data in the table consists of a series of columns which display statistics for each hydrologic parameter. The columns displayed for two period analysis are as follows:

Columns 1 and 2 display the median (i.e. the 50th percentile) for each of the two periods.

Columns 3 and 4 display the coefficients of dispersion (CD) for each period. This is defined as $= (75\text{th percentile} - 25\text{th percentile}) / 50\text{th percentile}$.

Columns 5 and 6 show the deviation of the post-impact period from the pre-impact. This is defined as Deviation Factor $= |(\text{Post-impact value}) - (\text{Pre-impact value})| / (\text{Pre-impact value})$. This deviation is shown both for the median and for the coefficient of dispersion.

Columns 7 and 8 calculate a "significance count" for the deviation values. To calculate this, the software program randomly shuffles all years of input data and recalculates (fictitious) pre- and post-impact medians and CDs 1000 times. The significance count is the fraction of trials for which the deviation values for the medians or CDs were greater than for the real case. So a low significance count (minimum value is 0) means that the difference between the pre- and post-impact periods is highly significant, and a high significance count (maximum value is 1) means that there is little difference between the pre- and post-impact periods. The significance count can be interpreted similarly to a p-value in parametric statistics.

It is important to understand that in some infrequent situations this algorithm may generate very low significance counts when there is very little apparent difference between the pre- and post-impact periods. This can occur when the deviation factor between the pre- and post-impact periods is zero or very small, and the overall distribution contains a large number of values right at or very near the center of the distribution. In this situation a low significance count actually means that the lack of difference between the two periods is highly significant, in a statistical sense, because randomly rearranging the data rarely yield a larger deviation factor than the original data.

It is also important to understand that significance counts may differ slightly each time the IHA is run for the same dataset, since a new set of randomized cases is generated each time.

For single period analysis, only columns 1 and 3 are displayed, showing data for the single period.

Parametric Scorecard Table

The header panel is identical for the parametric version of this table.

The columns in the main body of the table are slightly different, and are organized as follows:

Columns 1 and 2 are the means for each period

Columns 3 and 4 are the coefficients of variation, defined as (standard deviation) / mean.

Column 5 gives the magnitude of the change in mean values from the pre-impact to the post-impact period, called the deviation factor.

Column 6 expresses this change as a percentage.

Columns 7 and 8 give the magnitude and percentage change in the coefficients of variation.

For each IHA parameter group, the absolute values of the percentage change in the deviation factors of the mean and coefficient of variation are averaged. These means are shown at the bottoms of the respective column, and offer an at-a-glance summary of the impact on each parameter group.

As with the non-parametric version of the table, for single period analysis, only columns 1 and 3 are displayed, showing data for the single period.

4.2.4 RVA Table

This table shows the results that are used for [RVA Analysis](#), which is done for IHA parameters only. Results are shown either for the pre-impact and post-impact periods, or for the two Hydro Data files being compared. These statistics are calculated from the annual values in the [Annual Summaries Table](#). The RVA Table also shows the high and low pulse thresholds (under the section for Parameter Group #4)

The first section of this table gives the following information on each of the hydrologic parameters:

Columns 1-2 show the median or mean and coefficient of dispersion ((75th percentile - 25th percentile) / 50th percentile) or coefficient of variation ((standard deviation) / mean), for the pre-impact period. What is shown in these columns depends on whether parametric or non-parametric statistics are used.

Columns 3-4 show the minimum and maximum for each parameter during the pre-impact period.

Columns 5-8 give the same information as Columns 1-4 for the post-impact period.

Columns 9-10 give the low and high RVA category boundaries. These values are calculated according to the settings in the [Statistics](#) tab of the Set Up Analysis window.

Column 11 gives the Hydrologic Alteration factor for the middle RVA category.

The second section of the table compares the distributions of data in each of the three RVA categories. Expected and observed frequencies and the Hydrologic Alteration factor are shown separately for each of the three RVA categories.

See [RVA Analysis](#) for a description of how expected and observed frequencies and Hydrologic Alteration factors are calculated.

4.2.5 Box-and-Whisker Table

This table contains five values for each hydrologic parameter, for the pre-impact and post-impact periods (or for the two Hydro Data files being compared). These statistics are calculated from the annual values in the [Annual Summaries Table](#). For non-parametric analysis, it shows the median, 25th and 75th percentile values, and minimum and maximum values. For parametric analysis, it shows the mean, the mean plus and minus 1 standard deviation, and minimum and maximum values. Note that for the parametric analysis, the mean plus or minus 1 standard deviation may end up being greater than the minimum or maximum value or even negative, depending on how the data is distributed.

These values are for use in creating box-and-whisker plots.

4.2.6 Regression Table

This table shows complete results from a linear regression on each hydrologic parameter during the period of record (for single period analysis only). These statistics are calculated from the annual values in the [Annual Summaries Table](#). The table shows the following for each parameter:

Columns 1 and 2 show the slope and y-intercept of the least-squares fit regression line.

Column 3 shows sigma (standard error of the predicted y-value for each x in the regression). This is the standard deviation of the residuals of the regression.

Column 4 shows the correlation coefficient.

Column 5 shows the P-value for the slope of the regression line.

Column 6 shows the F statistic for the regression line.

Column 7 shows the R^2 for the regression line.

4.2.7 Percentile Table

This table shows the details of the percentile statistics. Results are shown either for the pre-impact and post-impact periods, or for the two Hydro Data files being compared. These statistics are calculated from the annual values in the [Annual Summaries Table](#). For two period analysis, there are 12 columns. The first five columns show the 10th, 25th, 50th, 75th, and 90th percentile values for the pre-impact period. The sixth column has the coefficient of dispersion, calculated as $(75\text{th percentile} - 25\text{th percentile}) / 50\text{th percentile}$. The last six columns give the analogous values for the post-impact period. For single period analysis, only six columns are shown, showing the analogous values for the entire period.

4.2.8 EFC Daily Table

This table shows the [Environmental Flow Component](#) (EFC) event types that are assigned to each day of flow. It has five columns, which show the calendar date, the volume of flow, a code for the EFC type (0 = extreme low flow, 1 = low flow, 2 = high flow pulse, 3 = small flood, 4 = large flood), the EFC type, and whether or not the row contains real or interpolated flow data. Note that if your input flow data has any water years which have no valid flow values, these years will not have rows in this table.

4.2.9 Flow Duration Curve Table

This table shows results for [Flow Duration Curves](#) (FDCs). For each period being analyzed or Hydro Data file being compared, there are 26 columns, showing the flow values (ranked from highest to lowest) and exceedance probability, for all the data (the annual FDC) and for each month (monthly FDCs). So for one period analysis, there are 26 columns, and for a two period analysis and a comparison of two Hydro Data files, there are 52 columns.

The specific years and days of data used for the annual FDCs are according to the settings on the [Analysis Years tab](#), the [Analysis Days tab](#), and the [Flow Duration Curves tab](#). To simplify computations, the data used for the monthly FDCs are according to the settings on the [Analysis Years tab](#) and [Flow Duration Curves tab](#) only. So specifying a shortened water year on the [Analysis Days tab](#) will only affect the annual FDC, not the monthly FDCs.

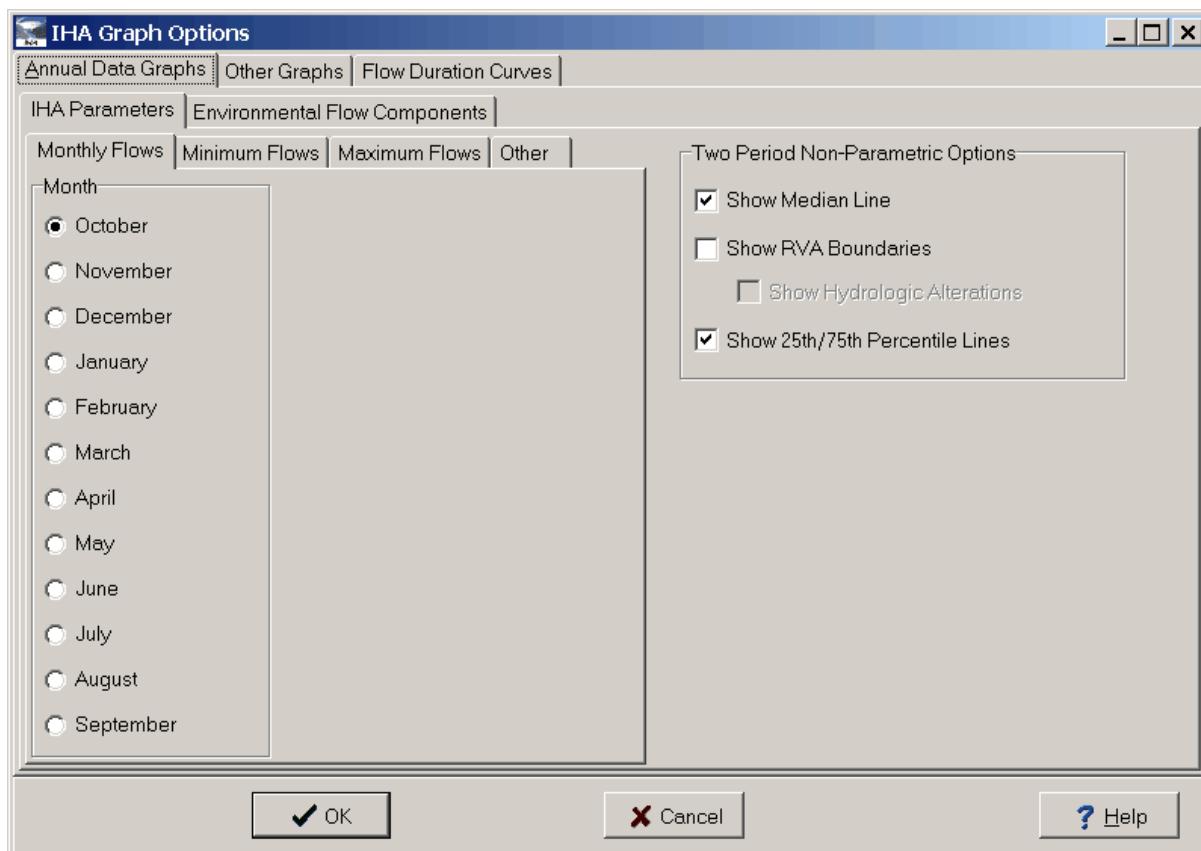
4.2.10 Message Report

This report shows any message and warnings generated while running your Analysis. Please read this report carefully, because there may be important warnings about possible problems with your results. See [Warning Messages](#) for a description of all the possible warnings.

4.3 Graphs

4.3.1 Introduction to Graphs

Choosing the View Graphs option from the **View Results** will bring up the IHA Graph Options window below, which can be used to select the type of graph to be displayed and also alter some of the basic features on the graph. Some of the options displayed on these windows will vary depending on whether your analysis is one period or two period and parametric or non-parametric. Choosing the View Saved Graphs option from the **View Results** button will bring up a list of saved graphs. For more on graphs, see [Summary of IHA Graphs](#) and [Editing and Working with IHA Graphs](#).



4.3.2 Summary of IHA Graphs

Tables 4 and 5 below show all the available graphs and the features that can be added to each graph.

Table 4. Graph Characteristics, for Two Period Analysis.

| Graph Type | Parameters That Can be Displayed | Additional Display Options |
|----------------------------------|---|---|
| IHA Parameters Annual Data | 33 standard parameters | <ul style="list-style-type: none"> • Mean or median lines • Variance lines (25th or 75th percentiles or mean plus or minus 1 SD) • RVA category boundaries, with or without Hydrologic Alteration values for each category |
| EFC Parameters Annual Data | 34 standard parameters | <ul style="list-style-type: none"> • Mean or median lines • Variance lines (25th or 75th percentiles or mean plus or minus 1 SD) |
| Hydrologic Alteration | Hydrologic Alteration values for three RVA categories | <ul style="list-style-type: none"> • Can display values for all categories or just the category with the greatest alteration |
| Monthly Averages | Monthly average flow for pre-impact and post-impact periods | <ul style="list-style-type: none"> • Can show RVA category boundaries |
| Daily Data | All daily flow values | <ul style="list-style-type: none"> • Can show daily values with different colors depending on EFC type • Can display EFC calibration parameter values on graph |
| Flow Duration Curves | Annual and monthly flow duration curves, for each period | <ul style="list-style-type: none"> • Can display any number of FDCs on the same graph. |

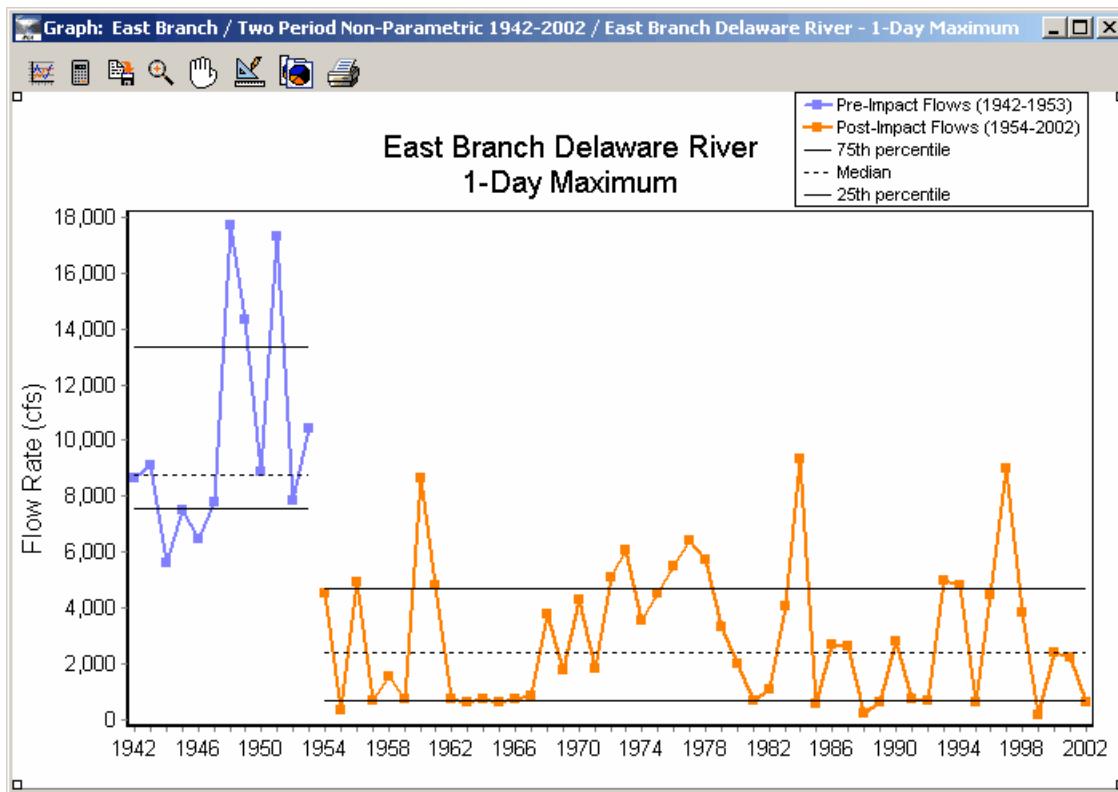
Table 5. Graph Characteristics, for Single Period Analysis.

| Graph Type | Parameters That Can be Displayed | Additional Display Options |
|----------------------------------|--|--|
| IHA Parameters Annual Data | 33 standard parameters | <ul style="list-style-type: none"> • Least-squares best fit line • Regression parameters |
| EFC Parameters Annual Data | 34 standard parameters | <ul style="list-style-type: none"> • Least-squares best fit line • Regression parameters |
| Daily Data | All daily flow values | <ul style="list-style-type: none"> • Can show daily values with different colors depending on EFC type • Can display EFC calibration parameter values on graph |
| Flow Duration Curves | Annual and monthly flow duration curves. | <ul style="list-style-type: none"> • Can display any number of FDCs on the same graph. |

4.3.3 Editing and Working with IHA Graphs

Once a graph is displayed, its characteristics can be edited by double-clicking on the graph window (or for [Default Graphs](#), hitting the Edit Graph Defaults button). This will bring up a

[Chart Editor](#) which allows the user to edit many different graph characteristics. The Chart Editor has its own separate help system, which can be accessed by hitting F1 or the help button while the Chart Editor is visible. See [Summary of IHA graphs](#) for a listing of all graphs available in the IHA. Below is an example graph.



A series of buttons are available at the upper left of each graph window, which do the following:

 Brings up the [IHA Graph Options](#) window. From here the user can switch to a different graph, or make changes in the additional features that are displayed on the graph (mean or median lines, variances lines, etc.).

 Brings up the [Analysis Properties](#) window. This allows the user to edit the parameters and settings for the Analysis, but note that there are some settings which cannot be altered while a graph window is open (see [Editing Analysis Properties with Tables or Graphs Open](#)). If any changes are made to the Analysis Properties, the values in the graphs will automatically be recalculated when the user returns to that window. This is done to ensure that there will never be any data in an open graph that is not consistent with the current Analysis settings.

 Saves the graph under unique name. After being saved and closed, the graph can be viewed again by choosing the View Saved Graphs option from the **View Results** button. Saved graphs are specific to each analysis, so your saved graph will only be available if the appropriate analysis is selected. All saved graphs will continue to be accessible even if the

Analysis settings have been altered and the Analysis re-run. Note that this is the only way to save edited features on a graph, if the graph is closed without saving, all changes will be lost.

 Enables zoom capability. This feature is particularly useful when viewing the daily data graphs. After enabling zoom capability by clicking on this button, click and hold the mouse button and then draw a box over any area of the graph to zoom into that section of the graph. To zoom back out to the full extent of the graph, click directly on the zoom button again.

 Enables scroll capability. This feature is particularly useful when viewing the daily data graphs. To scroll in any direction (after the enable scroll button has been selected), click and hold the mouse button and then move the hand in the desired direction.

 Brings up the [Chart Editor](#), which allows you to edit many different features of the graph. One particularly useful feature of the Chart Editor is the ability to re-draw the y-axis using a log scale. This can be done by clicking on the Chart tab in the Chart Editor, then the Axis tab below that, and then clicking the checkbox labeled Logarithmic (for the left axis). Note that if there are negative values on the y-axis, this option will not work, because it is impossible to calculate logarithms for negative values. Also, after the y-axis has been reset to a log scale, this scale will be retained even if the graph window is switched to a different graph through the IHA Graph Options window.

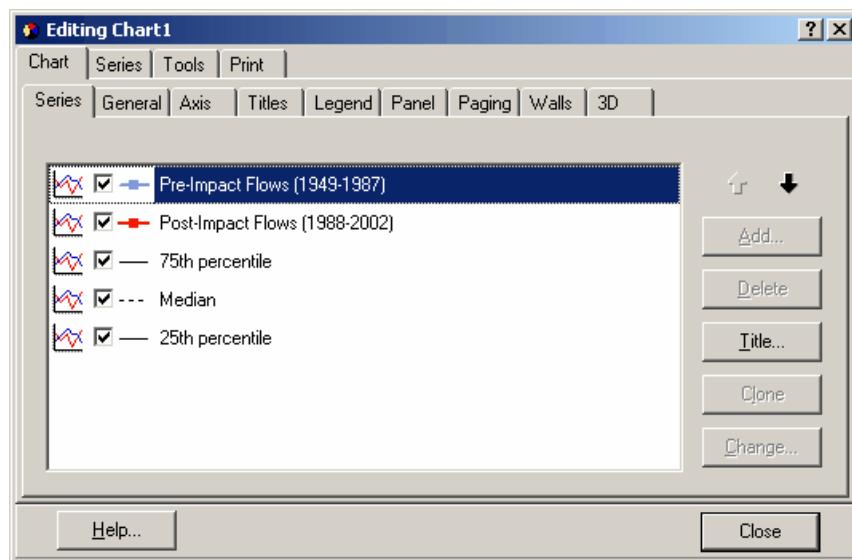
 Copies the graph onto your computer's clipboard.

 Prints the graph.

Many of these options are also available on the **Graph** dropdown menu. It is also possible from this menu to display the current Analysis Properties window, the current Project window, the Hydro Data file that was used for the Analysis, and the tables and any graphs that are related to this Analysis.

4.3.4 Chart Editor

The Chart Editor can be used to edit many different features of a graph, including the graph title, axis labels and title, colors and line types, text sizes and fonts, legend characteristics, and much more. The main Chart Editor window is displayed below. The Chart Editor has its own separate help system, which can be accessed by hitting F1 or the help button while the Chart Editor is visible.



5 Technical Notes

5.1 Introduction to Technical Notes

This section has some information that may be of interest to some IHA users. The following issues are covered here:

- [Calculation of empirical percentiles](#)
- [Julian dates and methods for calculating statistics for timing variables](#)
- [Handling of missing data values and data interpolation](#)
- [Ability to conduct analysis for shortened water years or two separate seasons](#)
- [Maximum number of years in Hydro Data files](#)
- [Using the .par file as metadata for an IHA Analysis](#)
- [Issues with large flow values](#)
- [Warning messages](#)
- [Bug-tracking feature](#)
- [Regional and language settings](#)
- [DOS Command line start-up](#)

5.2 Empirical Percentiles

There is a problematic aspect to calculating non-parametric (percentile) statistics. There appears to be no general agreement on how to compute empirical percentiles for a finite data set. We have chosen to use the algorithm in the International Mathematical and Statistical Libraries (IMSL). You should be aware that some common statistical packages (notably those in the Excel spreadsheet) use a different algorithm, and so will often produce different results for the same set of data.

5.3 Julian Dates and Statistics for Timing Variables

In order to quantify the timings of maximum and minimum flows and EFC events, the IHA uses the concept of Julian dates. Julian dates represent calendar dates by integer values, which start with 1 on January 1 and end with 366 on December 31. Note that although the number of calendar days varies slightly in each year, depending on whether or not it is a leap year, the starting and ending Julian dates in each year are always 1 and 366. In the IHA the difference between leap years and non-leap years is that leap years have a Julian date for Feb. 29, which is 60, while non-leap years skip from Julian date 59 (Feb. 28) to Julian date 61 (Mar. 1). This ensures that each calendar date is represented by the same Julian date in each year.

Users should be aware that this method of defining Julian dates does differ from definitions used elsewhere, which usually assign a Julian date of 1 to January 1, 4713 B.C., and then increment the date by 1 for each day thereafter, without restarting the count at the beginning of each year.

Leap years are all years that are divisible by 4 (i.e. 1996, 2000 etc.), except centurial years that are not evenly divisible by 400 (i.e. 1700, 1800, 1900, 2100).

Calculating Statistics for Timing Variables

Calculating means, medians, and other statistics for the IHA's timing parameters (the dates of minimum and maximum flows and EFC events) presents some methodological problems, because of the difficulties of calculating statistics for any periodic variable (a date or time of day, an angle). For instance, the arithmetic average of December 31 and January 2 (Julian Days 366 and 2) is day 184, which falls in July! The intuitive meaning of "average", however, requires a result of January 1. The methods for calculating statistics for the IHA's timing parameters are described below. The user should be warned that while these calculation methods work reasonably well, in some cases the results generated by these methods are not ideal. Because in some cases the calculation of statistics for timing related variables may produce peculiar and non-intuitive results, users should carefully review all the statistics for timing parameters before using them in any analysis. These algorithms are unchanged from earlier versions of the software, but improvement of these calculations is planned for future versions of the software.

In order to deal with the difficulties of calculating statistics for timing variables, the IHA often uses a "circular method" for timing statistics. This method puts all the dates in question into quarterly bins, which are 1-91, 92-183, 184-275, and 276-366 (depending on the situation, these bins are applied to either Julian dates or dates of the water year). If the second or third quarter has the greatest frequency of dates, the statistic is computed in the usual way. If the largest number of dates is in the first quarter, 366 is temporarily subtracted from all dates in the fourth quarter prior to computing the statistic, and if the result is less than 0 then 366 is added back onto it. If the largest number of dates is in the fourth quarter, 366 is temporarily added to all dates in the first quarter prior to computing the statistic, and if the result is greater than 366 then 366 is subtracted from it. This method produces reasonable results in situations where the timing values are clustered at some point in the year, although for variables where there is an even distribution throughout the year, calculation of such statistics is unavoidably arbitrary.

There are a couple of warnings which can be generated in the [Message Report](#) because of calculation of these statistics. If more than 10% of the data falls in the quarter six months away from the dominant quarter, a [warning](#) is generated. Here data are widely scattered throughout the year, meaning that statistics calculated using the "circular method" may not be too meaningful. A second [warning](#) is also generated for parametric analysis if the standard deviation calculated using the "circular method" is greater than 180, indicating a similar situation.

All of the statistics calculated by the IHA are listed below, with a brief description of how they are calculated:

- Timing of EFC events in the [Annual Summaries Table](#) and [Annual Data graphs](#): Calculated by applying the "circular method" to the water year dates of the individual events. Results are then converted to Julian dates for display in the table and graph.

- Minimum and maximums of annual values in the [RVA Table](#) and [Box-and-Whisker Table](#): Calculated using the Julian dates in the [Annual Summaries Table](#), without using the "circular method", i.e. the value nearest to 366 is the maximum and the value nearest 1 is the minimum.
- Regression statistics in the [Regression Table](#) and [Annual Data graphs](#): Calculated using the Julian dates in the [Annual Summaries Table](#), without using the "circular method". This means that in cases where timing variables are clustered around the beginning/end of the calendar year, the regression lines will not be of much use in determining the trend over time.

-Non-parametric statistics:

- Medians and percentiles in the [Box-and-Whisker Table](#), [Percentile Table](#), [RVA Table](#), [Scorecard Table](#) and [Annual Data graphs](#): Calculated by applying the "circular method" to the Julian dates in the [Annual Summaries Table](#).
- Coefficients of dispersion and $(75-25)/50$ in the [Percentile Table](#), [RVA Table](#), and [Scorecard Table](#): Calculated by (1) taking the absolute value of the difference between the 75th and 25th percentiles (these are calculated as described above), (2) taking the minimum of this absolute value or $(366 - \text{this absolute value})$, and (3) dividing the result by 366. What this calculation effectively does is to take the absolute value of the shortest distance between the 75th and 25th percentile dates, even if that distance crosses the calendar year boundary, and normalizes that value by 366.
- Deviation factors and significance counts in the [Scorecard Table](#): Deviation factors for medians are calculated by (1) taking the absolute value of the difference between the post-impact and pre-impact values, (2) taking the minimum of this absolute value or $(366 - \text{this absolute value})$, and (3) dividing the result by 183. What this effectively does is take the absolute value of the shortest distance between median dates for the two periods, even if it crosses the calendar year boundary, and normalizes that by 183. The deviation factors for the coefficients of dispersion are calculated in the same manner as for non-timing parameters. The significance counts and the deviation factors for the randomized trials are calculated in the same manner as for the actual case.
- RVA boundaries in the [RVA Table](#) and [Annual Data graphs](#): Calculated using the Julian dates in the [Annual Summaries Table](#), without using the "circular method". This means that for the purposes of calculating percentiles and expected and observed values, the top of the high RVA category is 366, and the bottom of the low RVA category is 1.

-Parametric statistics:

- Means in the [Box-and-Whisker Table](#), [RVA Table](#), [Scorecard Table](#), and [Annual Data graphs](#): Calculated by applying the "circular method" to the Julian dates in the [Annual Summaries Table](#).
- Coefficients of variation in the [RVA Table](#) and [Scorecard Table](#): Calculated as standard deviation / 366. The standard deviation is calculated by applying the "circular method" to the Julian dates in the [Annual Summaries Table](#).

- Deviation factors in the [Scorecard Table](#): The difference between the means is set to the absolute value of the shortest distance between the mean dates for the two periods, even if it crosses the calendar year boundary. The percent change in means is this difference / 183. The magnitude and percent difference for the coefficients of variation are calculated in the same manner as for non-timing parameters.
- Means plus and minus one standard deviation in the [Box-and-Whisker Table](#) and [Annual Data graphs](#): Means and standard deviations are calculated using the "circular method". If the mean plus or minus one standard deviation is outside the range of 0 to 366, it is adjusted as follows. If the value is greater than 366, then 366 is subtracted from it, and if it is less than 0, then 366 is added to it.
- RVA boundaries in the [RVA Table](#) and [Annual Data graphs](#): The initial calculation is done in the same way as the mean plus or minus one standard deviation described above. But instead of checking that the value is in the range of 0 - 366, the check is if the boundaries are within the range of the pre-impact values, with the value nearest to 0 being considered the low value, and the value nearest 366 being considered the high value. If the RVA boundary is outside this range, it is replaced by the 25th or 75th percentile, calculated as described further above for non-parametric RVA boundaries. *This method will sometimes produce RVA boundaries that are very close together, or even a high boundary that is below the low boundary, so the results need to be checked carefully. Until this is fixed in the next version of the software, we recommend that users use non-parametric RVA boundaries only for timing statistics.* As with non-parametric analysis, for purposes of calculating expected and observed values, the top of the high RVA category is 366, and the bottom of the low RVA category is 1.

5.4 Missing Data and Data Interpolation

Hydrologic records often have some days with missing data, which can cause problems for the calculation of some hydrologic parameters, such as rise and fall rates. For this reason, the IHA estimates a flow value for days with missing data by linear interpolation. Interpolated values will be generated for all days with missing data that are in water years that have at least one valid flow value. This means that water years with no valid flow data will be skipped during any analysis, and as such will not appear in the [Annual Summaries Table](#) or the [EFC Daily Table](#). Interpolated flow values will appear in the [EFC Daily Table](#), but will be identified in the fifth column of that table. The interpolation algorithm will interpolate across water year boundaries. If the adjacent water year is missing, the last good datum is duplicated to the year boundary. Any water years with no valid flow data will be excluded from analysis in the IHA (i.e. flow values will not be interpolated).

In years with very large gaps in the data, the many interpolated values can lead to odd results for rise/fall rates, pulses, and other parameters. If your data has such problems, the graphical output should be examined carefully before you place confidence in the results. The IHA is set up to issue a [warning](#) if there is a consecutive block of missing data greater than a user-defined length, which will appear in the [Message Report](#). The default length used to generate this

warning is 10 days, but see [Setting Up and Managing an Analysis](#) for how to alter this default. Specific [warnings](#) will also be issued identifying water years in which more than 30 values are interpolated.

When viewing your flow data in the Hydrologic Data file editor, selecting **Hydro Data | Review Recorded and Missing Date Ranges** will bring up a summary of the dates of both missing and recorded data. Long periods of interpolated data can also usually be easily discerned in the daily data graph, since they will be straight lines. Examining this graph is also a useful way to inspect your data for outliers, gaps, incorrect data entries, and other anomalies in the data.

Because water years without any valid flow values are excluded from all calculations, there are some special issues having to do with high and low pulse events and EFC events that begin or end immediately after or before a water year that is entirely missing data. For events that begin on the first day of a water year after an entire missing water year, the pulse or EFC event is assumed to have started in the previous water year and will be ignored. Events that include the last day of a water year prior to an entire water year of missing data will be included in the statistics for that water year, but a [warning](#) is issued to warn the user that these events may have been truncated. Identical rules are applied to pulses and events that apparently extend beyond the beginning or end of shortened water years and seasons.

5.5 Shortened Water Years and Seasons

For certain hydrologic parameters, the IHA can be set to do its calculations for periods other than the entire water year.

First, [IHA parameters](#) can be calculated only for a shortened part of the water year, which can start and end on any Julian date in the current water year (see [Setting Up and Managing an Analysis](#) for how to set this). The parameters in the header panel of the [Scorecard Table](#) will also be calculated for this shortened period. The only restrictions on how these dates are set is that the beginning date must occur earlier in the water year than the ending date, meaning that proceeding sequentially from the begin date to the end date does not cross the water year boundary. Note that if the shortened water starts or ends in the middle of a month, the monthly flows will only be calculated for the portion of the month that is inside the shortened period. The only parameters that will be calculated using data outside the shortened water year are the high and low pulses, whose duration may include additional days outside the year if the event begins inside the shortened water year but extends beyond it.

Second, [EFC parameters](#) other than monthly low flows may be calculated separately for two different seasons, each of which covers only a part of the water year. Seasons are set by specifying the beginning and ending dates of each season (see [Setting Up and Managing an Analysis](#) for how to set this). As with the shortened water year, the beginning date for each season must occur earlier in the water year than the ending date for the same season, so that a season does not cross the water year boundary. Specifying two separate seasons does not affect the way the EFC algorithm assigns different days to different EFCs throughout the year, but when the annual statistics are computed, only the events that peak during the appropriate

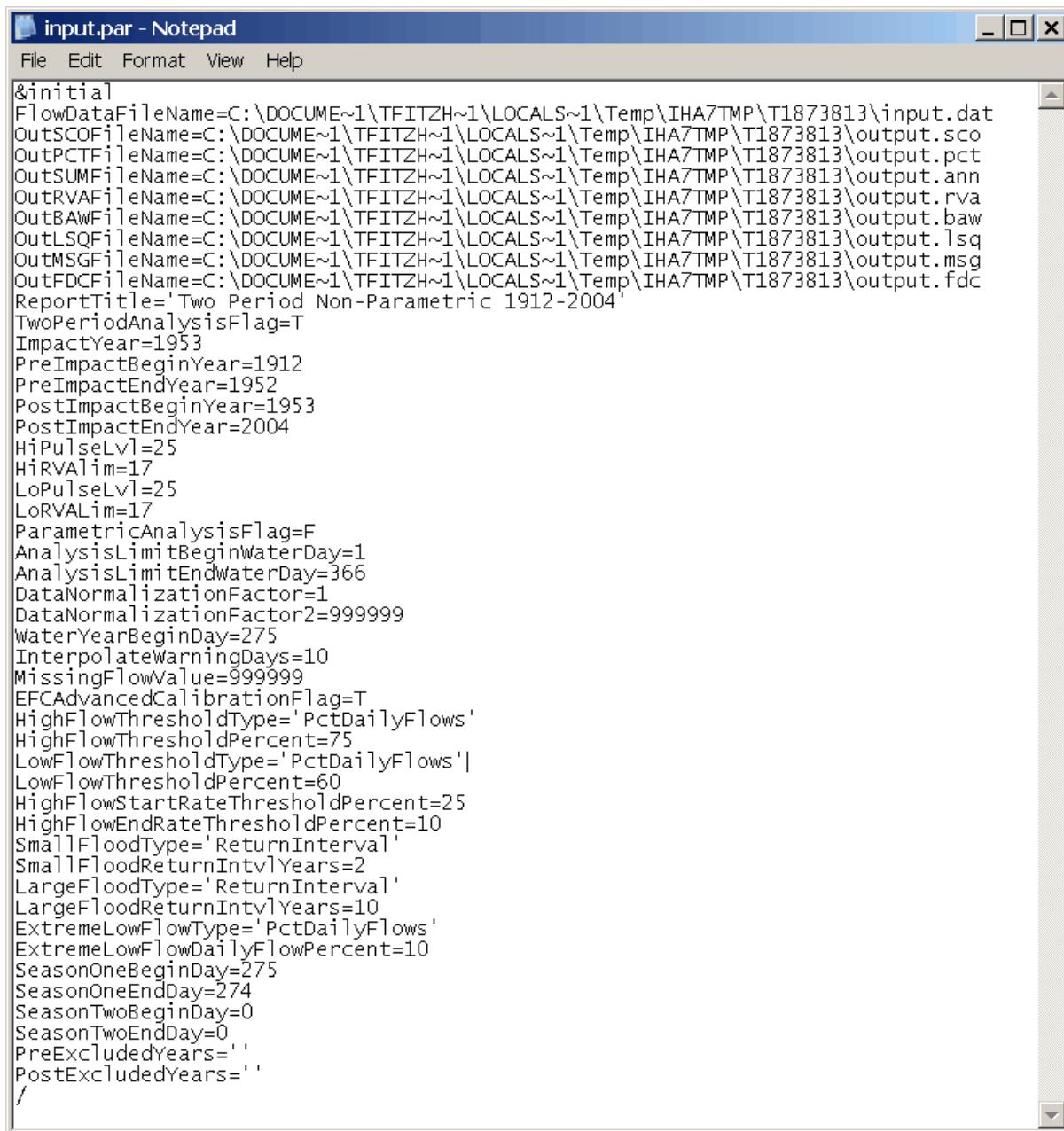
season will be used in the calculation of statistics. As with events that overlap between water years, the statistics will take into account any parts of the event that are outside the specified season. Monthly low flow statistics are not affected by using two seasons.

5.6 Maximum Number of Years of Hydrologic Data

Because of memory limitations in the software, the maximum numbers of years of hydrologic data that can be processed is 500. Note that this limit applies to the number of years in the Hydro Data file, so limiting the period of analysis for a Hydro Data file larger than this may not solve the problem.

5.7 Metadata for an IHA Analysis

In some cases it may be useful to have a text file that provides metadata on all the different parameters and settings used for an IHA Analysis, which can be saved or sent to others to document how an Analysis was conducted. There is a text file called the parameter file that is available for each Analysis which can be used for this purpose. To find the file for a particular Analysis, go to the [working directory](#) for the Analysis. In that directory, look in the Projects subdirectory, then in the subdirectory with the name of the relevant Project, and then in the subdirectory with the name of the relevant Analysis. Assuming the Analysis has been run, there will be a text file called input.par. An example of this file is displayed below. This file contains all of the possible variables, but not all of these variables will be present for every analysis.



```

input.par - Notepad
File Edit Format View Help

&initial
FlowDataFileName=C:\DOCUME~1\TFITZH~1\LOCALS~1\Temp\IHA7TMP\T1873813\input.dat
OutSCOFFileName=C:\DOCUME~1\TFITZH~1\LOCALS~1\Temp\IHA7TMP\T1873813\output.sco
OutPCTFileName=C:\DOCUME~1\TFITZH~1\LOCALS~1\Temp\IHA7TMP\T1873813\output.pct
OutSUMFileName=C:\DOCUME~1\TFITZH~1\LOCALS~1\Temp\IHA7TMP\T1873813\output.ann
OutRVAFileName=C:\DOCUME~1\TFITZH~1\LOCALS~1\Temp\IHA7TMP\T1873813\output.rva
OutBAWFileName=C:\DOCUME~1\TFITZH~1\LOCALS~1\Temp\IHA7TMP\T1873813\output.baw
OutLSQFileName=C:\DOCUME~1\TFITZH~1\LOCALS~1\Temp\IHA7TMP\T1873813\output.lsq
OutMSGFileName=C:\DOCUME~1\TFITZH~1\LOCALS~1\Temp\IHA7TMP\T1873813\output.msg
OutFDCFileName=C:\DOCUME~1\TFITZH~1\LOCALS~1\Temp\IHA7TMP\T1873813\output.fdc
ReportTitle='Two Period Non-Parametric 1912-2004'
TwoPeriodAnalysisFlag=T
ImpactYear=1953
PreImpactBeginYear=1912
PreImpactEndYear=1952
PostImpactBeginYear=1953
PostImpactEndYear=2004
HiPulseLvl=25
HiRVALim=17
LoPulseLvl=25
LoRVALim=17
ParametricAnalysisFlag=F
AnalysisLimitBeginWaterDay=1
AnalysisLimitEndWaterDay=366
DataNormalizationFactor=1
DataNormalizationFactor2=999999
WaterYearBeginDay=275
InterpolateWarningDays=10
MissingFlowValue=999999
EFCAdvancedCalibrationFlag=T
HighFlowThresholdType='PctDailyFlows'
HighFlowThresholdPercent=75
LowFlowThresholdType='PctDailyFlows'
LowFlowThresholdPercent=60
HighFlowStartRateThresholdPercent=25
HighFlowEndRateThresholdPercent=10
SmallFloodType='ReturnInterval'
SmallFloodReturnIntvYears=2
LargeFloodType='ReturnInterval'
LargeFloodReturnIntvYears=10
ExtremeLowFlowType='PctDailyFlows'
ExtremeLowFlowDailyFlowPercent=10
SeasonOneBeginDay=275
SeasonOneEndDay=274
SeasonTwoBeginDay=0
SeasonTwoEndDay=0
PreExcludedYears=''
PostExcludedYears=''
/

```

The lines in the file before the BigTitle variable can usually be ignored, these refer to temporary files which the IHA stores while running an Analysis. Descriptions of the rest of the values in the file are as follows. All of these variables are set in the various tabs of the [Analysis Properties window](#).

ReportTitle='Two Period Non-Parametric 1912-2004': Denotes the default title to be displayed on tables on graphs.

TwoPeriodAnalysisFlag=T: Specifies whether one period or two period analysis is being conducted (T or F).

ImpactYear=1953: The impact year. For two period analysis, this is set to be equal to PostImpactBeginYear.

PreImpactBeginYear=1912: For two period analysis, this is the beginning year of the pre-impact period. For single period analysis, this will be the first year of the period to be analyzed.

PreImpactEndYear=1952: For two period analysis, this is the end year of the pre-impact period. For single period analysis, this will be the last year of the period to be analyzed.

PostImpactBeginYear=1953: For two period analysis, this is the beginning year of the post-impact period.

PostImpactEndYear=2004: For two period analysis, this is the end year of the post-impact period.

HiPulseLvl=25: The high pulse threshold, either in percentiles (non-parametric analysis) or number of standard deviations (parametric analysis).

HiRVALim=17: The lower boundary of the high RVA category, either in percentiles (non-parametric analysis) or number of standard deviations (parametric analysis). This will be set but not used for single period analysis.

LoPulseLvl=25: The low pulse threshold, either in percentiles (non-parametric analysis) or number of standard deviations (parametric analysis).

LoRVALim=17: The upper boundary of the low RVA category, either in percentiles (non-parametric analysis) or number of standard deviations (parametric analysis). This will be set but not used for single period analysis.

ParametricAnalysisFlag=F: Whether parametric (T) or non-parametric analysis (F)

AnalysisLimitBeginWaterDay=1: First day of the water year. This is expressed as the date of the water year, and is only different from 1 if a shortened water year is being used for IHA parameters.

AnalysisLimitEndWaterDay=366: Last day of the water year. This is expressed as the date of the water year, and is only different from 366 if a shortened water year is being used for IHA parameters.

DataNormalizationFactor=1: Constant by which all flow data in the first Hydro Data file is divided.

DataNormalizationFactor2=999999: Constant by which all flow data in the second Hydro Data file is divided (only available for a two Hydro Data file analysis).

WaterYearBeginDay=275: Julian date of the first day of the water year.

InterpolateWarningDays=10: Number of days of missing data required to trigger a warning message.

MissingFlowValue=999999: Value for no data used in input data file.

EFCAdvancedCalibrationFlag=T: Use advanced calibration method for EFC algorithm (T or F).

HighFlowThresholdType='PctDailyFlows': Method used to specify the *high flow threshold* in the EFC algorithm (can be 'PctDailyFlows' or 'FlowRate').

When using 'PctDailyFlows' - HighFlowThresholdPercent=75: Percentile used.

When using 'FlowRate' - HighFlowThresholdFlowRate=750: Flow value used.

LowFlowThresholdType='PctDailyFlows' Method used to specify the *low flow threshold* in the EFC algorithm (can be 'PctDailyFlows' or 'FlowRate').

When using 'PctDailyFlows' - LowFlowThresholdPercent=60: Percentile used.

When using 'FlowRate' - LowFlowThresholdFlowRate=600: Flow value used.

HighFlowStartRateThresholdPercent=25: *High flow start rate threshold* used in the EFC algorithm.

HighFlowEndRateThresholdPercent=10: *High flow end rate threshold* used in the EFC algorithm.

SmallFloodType='ReturnInterval': Method used to specify the *small flood minimum peak flow* used in the EFC algorithm (can be 'ReturnInterval', 'Flow Rate', or 'PctDailyFlows').

When using 'ReturnInterval' - SmallFloodReturnIntvlYears=2: Return interval used.

When using 'Flow Rate' - SmallFloodFlowRate=2000: Flow rate used.

When using 'PctDailyFlows' - SmallFloodPercent=95: Percentile used.

LargeFloodType='ReturnInterval': Method used to specify the *large flood minimum peak flow* used in the EFC algorithm (can be 'ReturnInterval', 'Flow Rate', or 'PctDailyFlows').

When using 'ReturnInterval' - SmallFloodReturnIntvlYears=10: Return interval used.

When using 'Flow Rate' - SmallFloodFlowRate=10000: Flow rate used.

When using 'PctDailyFlows' - SmallFloodPercent=98: Percentile used.

ExtremeLowFlowType='PctDailyFlows': Method used to specify the *extreme low flow threshold* in the EFC algorithm (can be 'PctDailyFlows', 'PctAllLowFlows', or 'FlowRate').

When using 'PctDailyFlows' - ExtremeLowFlowDailyFlowPercent=10: Percentile used.

When using 'PctAllLowFlows' - ExtremeLowFlowLowFlowsPercent=10: Percentile used.

When using 'FlowRate' - ExtremeLowFlowFlowRate=22: Flow rate used.

SeasonOneBeginDay=275: Julian date of the first day used for EFC calculations. Will only be different from WaterYearBeginDay if two seasons are used for EFC parameters.

SeasonOneEndDay=274: Julian date of the last day used for EFC calculations. Will only be different from WaterYearBeginDay -1 if two seasons are used for EFC parameters.

SeasonTwoBeginDay=0: Julian date of the first day of the EFC second season. Will only be different from 0 if two seasons are used for EFC parameters.

SeasonTwoEndDay=0: Julian date of the last day of the EFC second season. Will only be different from 0 if two seasons are used for EFC parameters.

PreExcludedYears='': Years excluded from analysis for purposes of computing Flow Duration Curves for pre-impact period.

PostExcludedYears='': Years excluded from analysis for purposes of computing Flow Duration Curves for post-impact period.

5.8 Issues with Large Flow Values

In its internal calculations, the IHA represents no data values with the number 999999. Because of this, it is possible that using the IHA with flow datasets that have flow values in the same magnitude as this number will yield some calculation errors. So if any daily flows are near to 1,000,000, the entire flow dataset should be converted to another unit or divided by a factor so that the flow values are smaller.

This issue is a legacy of the FORTRAN code written for early versions of the IHA, and will be corrected in the next version of the software.

5.9 Warning Messages

Below is a description of all the warning messages that may appear in the [Message Report](#).

When comparing two Hydro Data files, certain messages may indicate the name of the Hydro Data file.

Message: An EFC flood or high flow pulse event has been truncated by missing year 1956.
This event is used to compute annual statistics, but its length has been truncated.

Message: An EFC extreme low flow event has been truncated by missing year 1956. This event is used to compute annual statistics, but its length has been truncated.

Message: An EFC flood or high flow pulse event has been truncated at the end of the dataset.
This event is used to compute annual statistics, but its length has been truncated.

Message: An EFC extreme low flow event has been truncated at the end of the dataset. This event is used to compute annual statistics, but its length has been truncated.

These messages are to warn the user that the end of an EFC event that is included in the EFC

statistics has been truncated by a missing water year of data or by the end of the dataset. Statistics for such events may have errors because part of the event is missing from the flow dataset.

Message: An EFC flood or high flow pulse event has been truncated at the beginning of the dataset. This event is not used to compute annual statistics.

Message: An EFC extreme low flow event has been truncated at the beginning of the dataset. This event is not used to compute annual statistics.

Message: An EFC flood or high flow pulse event has been truncated at the beginning by missing year 1972. This event is not used to compute annual statistics.

Message: An EFC extreme low flow event has been truncated at the beginning by missing year 1972. This event is not used to compute annual statistics.

These messages are to warn the user that an EFC event has been ignored in the annual statistics because it started on the first day at the beginning of the dataset or on the first day after a missing year. Such events are assumed to have started prior to the first day of the water year (in the previous water year), so our convention is to exclude them from the annual statistics.

Message: A high pulse has been truncated by missing year 1956

Message: A low pulse has been truncated by missing year 1956

This message is to warn the user that the end of a high or low pulse that is included in the statistics has been truncated by a missing water year of data. Statistics for such events may have errors because part of the event is missing from the flow dataset.

Message: Dates of extreme flows are widely distributed throughout the year. Use statistics with caution.

This message refers to the timing of annual 1-day maximum and minimum flows and EFC events, and is triggered when the annual data values appear to be widely scattered throughout the calendar year. For specifics on when this warning is generated, see the [Calculating Statistics for Timing Variables](#).

Message: The lower RVA limit is outside the range of variability of parameter High pulse duration. The 25th percentile level will be used.

Message: The upper RVA limit is outside the range of variability of parameter Low pulse count. The 75th percentile level will be used

These messages appear when one of the RVA boundaries is outside the range of the data, and indicate that this value has been replaced with the relevant percentile value.

Message: The parametric low pulse level is <0. It will be replaced by the 25th percentile value.

For parametric analysis, this appears when the low pulse level is set at less than 0, and indicates that it has been replaced by the 25th percentile.

Message: There is not enough pre-impact data to calculate RVA limits for parameter April.

This appears in certain situations when RVA boundaries cannot be calculated. This happens when there is only one year of pre-impact data, or when there is no post-impact data.

Message: WARNING: Some of the Colwell parameters are based on fewer than twenty years of data

This warns the user when the Colwell Parameters (flow predictability, constancy, and contingency) reported at the beginning of the [Scorecard Table](#) are based on fewer than 20 years of data.

Message: WARNING: variance of a mean date is > 180 days.

This appears when the standard deviation calculated for a timing statistics is greater than 180. For more on when this warning is generated, see the [Calculating Statistics for Timing Variables](#).

Message: 61 daily values have been interpolated in year 1977.

This warning appears for water years where there are numerous days of missing data. This warning only occurs for water years where 30 or more days of data have been interpolated. See [Missing Data and Data Interpolation](#) for a description of the procedures used when there are missing data in the Hydro Data file.

Message: The longest period of missing data is 61 days. Interpolating across this gap may cause anomalies in the statistics. Please use them with caution.

This message reports the longest period of missing data in the Hydro Data file, and appears gap of missing data longer than the threshold value set in [Analysis Title/Options tab](#) of the Analysis Properties window.

5.10 Bug-Tracking Feature

The IHA has a bug-tracking feature that will help the developers further improve the code in the future. In the case of an Access Violation or other problem with the code, a window will pop up that gives you the option to email a bug report with some information attached to it that will help the software developer diagnose the problem. Before sending the email, it would also be useful if the user could quickly type in the circumstances that caused the error. Note that occasionally this window will pop up in the case of a warning that does not necessarily

indicate a bug, in which case you can just ignore it by clicking OK.

5.11 Regional and Language Settings

Because different parts of the world use different characters to denote decimal places (usually either a period or a comma), the IHA software will display numbers according to the Windows Regional and Language settings for the computer. It is possible to view or change these settings under the Windows Control Panel, under Regional Language Options. When importing data from a text file, the IHA will also expect decimal places to be denoted according to these same settings. But note that if the language settings are set to denote decimal places as commas, comma-delimited text files will not import properly.

Version 7.1 has a Spanish language help system and user manual. The IHA will automatically use the English language help system unless the user's computer has Spanish language settings. The language choice can also be set manually using the menu option **Options -> Set Language**.

Future versions of the IHA will have a Chinese language help system and manual, and also have an option to switch the language used on all software windows to either Spanish or Chinese.

5.12 DOS Command Line Start-Up

The IHA can be started up from the DOS prompt by typing iha7.exe on the command line when located in directory where the IHA is installed. The file IHA7.exe must be present in the directory for this to work. IHA can also switch working directories and open up a specific project when started from the DOS prompt.

There are two options available when using command line startup:

WorkDir= This sets the IHA working directory. If not specified, IHA will open in the same working directory that was in use the last time the software was used.

Proj= This tells IHA to open up a specific project after it starts, which has to be located in the working directory as specified above.

An example of use of both of these options is below:

IHA7.exe WorkDir=c:\mynewtestsub Proj="EAST BRANCH"

Double quotes are necessary when there are spaces in the name of the working directory or project.

6 Endnotes

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