ESPADP

PROJECT: Extended Streamflow Prediction,
Analysis, and Display Program

WORK PLAN
March 1993

NOAA/National Weather Service
Office of Hydrology

E S P A D P

Extended Streamflow Prediction, Analysis, and Display Program

WORK PLAN
March 1993

prepared by

Donald P. Laurine
Cara S. McCarthy

Office of Hydrology
Hydrologic Research Laboratory
Silver Spring, Maryland

TABLE OF CONTENTS

APPENDIX A. - - ESPADP System Figures

PROJECT: Extended Streamflow Prediction,
Analysis, and Display Program

ESPADP

WORK PLAN

1. BACKGROUND

1.1 PROGRAM ENVIRONMENT

The National Weather Service (NWS) forecast program is supported through a complex set of models and techniques combined into one system, entitled National Weather Service River Forecast System (NWSRFS). The NWSRFS is a continuous forecasting system which provides real-time predictions of river flows and other variables used in producing river and flood forecasts. The system includes a Calibration System (CS), an Operational Forecast System (OFS), and the Extended Streamflow Prediction (ESP) System (see figure 1.).

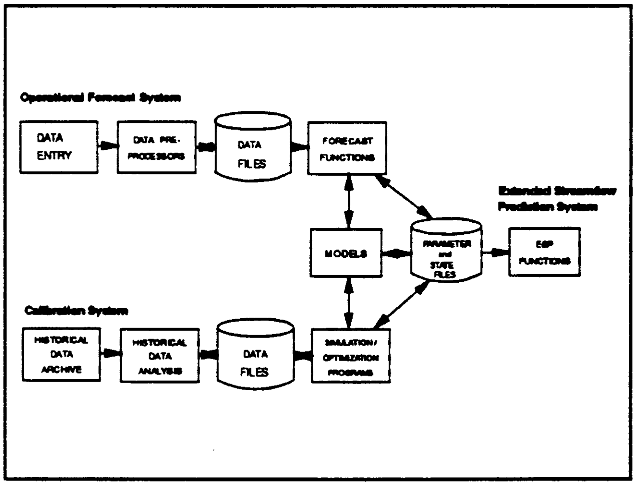

Figure 1. National Weather Service River Forecast System

The Calibration System performs the tasks needed to process historical hydrometeorological data and estimate model parameters for a specific basin. The models simulate snow accumulation and ablation, calculate runoff, distribute runoff over time from within the basin to the basin outlet, and perform channel routing.

The NWSRFS is a modular system that allows the hydrologist to select from a variety of models and configure them in a manner that is descriptive of the basin. All of the models are common to the Calibration, Operational Forecast, and ESP systems. As part of the calibration procedure, the simulated streamflow is statistically and visually compared to the observed streamflow to determine the necessary model parameter adjustments.

After the models have been calibrated for a specific basin, the optimal set of parameters can be combined operationally with real-time hydrometeorological data to forecast streamflow. The Operational Forecast System contains three major components that are needed for operational river forecasting: *Data Entry, Preprocessor, and Forecast.* The Data Entry Component is a set of programs that transfer hydrometeorological data from a variety of sources to the observed data base. The Preprocessor Component reads raw station data, estimates missing data as required, and then uses these data to calculate mean areal time series of precipitation, temperature, and potential evapotranspiration for a particular basin. The processed time series are used by the Forecast Component to perform requested hydrologic and hydraulic simulations. The Forecast Component maintains an account of the current model states. These states describe the hydrologic condition of the basin, including the snow cover, soil moisture, and channel storage. They are needed as starting points for subsequent forecasts.

The Extended Streamflow Prediction System produces probabilistic forecasts of streamflow and other hydrological variables. ESP assumes that historical meteorological data are representative of possible future conditions and uses these as input data to hydrologic models along with the current states of these models obtained from the Forecast Component. A separate streamflow time series is simulated for each year of historical data using the current conditions as the starting point for each simulation. The streamflow time series can be analyzed for peak flows, minimum flows, flow volumes, etc., for any period in the future. A statistical analysis is performed using the values obtained from each year's simulation to produce a probabilistic forecast for the streamflow variable. This analysis can be repeated for different forecast periods and additional streamflow variables of interest. Short-term quantitative forecasts of precipitation and temperature can be blended with the historical time series to take advantage of any skill in short-term meteorological forecasting. In addition, knowledge of the current climatology can be used to weight the years of simulated streamflow based on the similarity between the climatological conditions of each historical year and the current year.

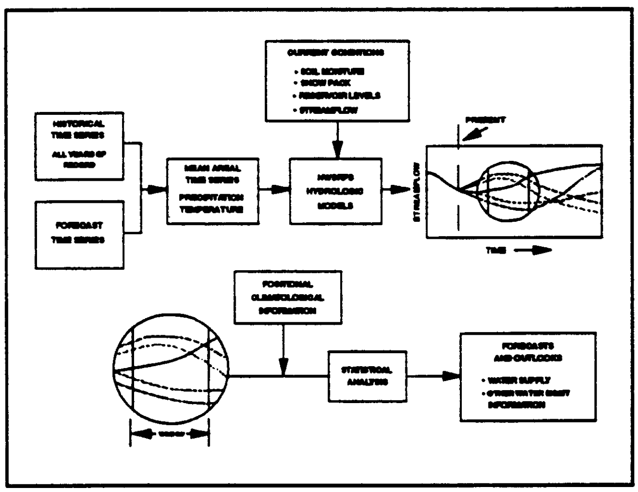
Figure 2. ESP Procedure

ESP allows system flexibility in selection of streamflow variables which can be analyzed, the capability to make forecasts over both short and long time periods, and the ability to incorporate forecast meteorological data into the procedure. Because of ESP's flexibility and conceptual basis, it has many applications, including water supply forecasts, flood control planning, drought analysis, hydropower planning, and navigation forecasts. The ESP probabilistic forecasts provide uncertainty information needed by water managers for risk-based decisions. The streamflow time series generated by ESP can be output as products, so that they can be used in reservoir simulation/optimization models to investigate how operations might be improved. The ESP forecast information is based on our best estimate of current hydrometeorological conditions, as well as an analysis of the local historical climatological variability. The sequence of ESP computations is shown in Figure 2.

1.2 THE CURRENT OPERATIONAL ESP SYSTEM

ESP has been designed as an integrated program within the NWSRFS. It is completely compatible with the OFS and can take advantage of the changing parameters defined for each forecast point. Parameters, rating curve information, and simulated carryover (model states) information are obtained directly from the OFS forecast parameter and carryover files. Information needed for ESP that is not available from the OFS files are defined with the ESP Initialization Program (ESPINIT). ESPINIT is used to define ESP segment information including the location of time series (i.e., temperature, precipitation) on the historical data files and the types of analysis to be performed. ESP segment information is stored on the ESP parameter file. The ESPINIT program is used to redefine, delete, and display this information.

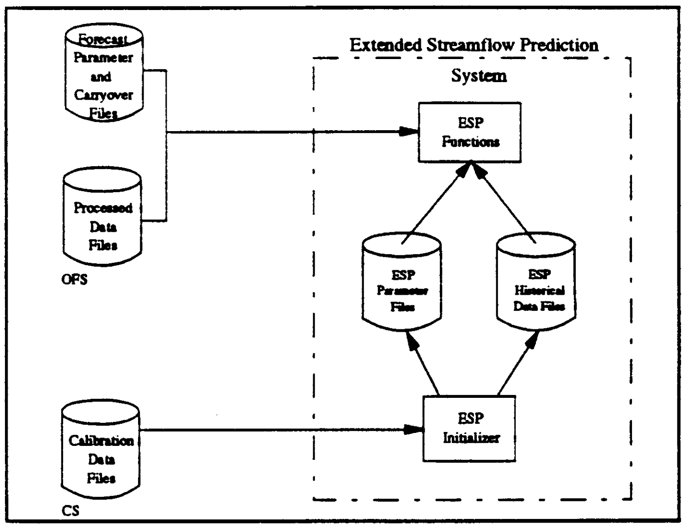

Figure 3. ESP File System

The NWSRFS ESP function accesses the OFS Forecast, Parameter, and the ESP Parameter files to obtain the necessary run information. Historical data is obtained from the ESP historical data files and shorter term meteorological forecast information is accessed from the OFS Processed Data file.

ESP runs in batch mode on the central National Weather Service computer system (NAS9000) in Suitland, Maryland. Submission and output of ESP jobs are restricted to slow communication transmissions. Typical ESP results are presented in a large number of printed pages. Improved graphical output would greatly assist the user in interpreting ESP results. ESP must be rerun to re-specify the historical water years or the analysis window used in the ESP prediction. Computer aided adjustments of the simulated conditional output for model errors does not exist. Users are required to manually calculate these adjustments.

2.0 PROJECT GOAL

The goal of the ESP Analysis and Display Program is to provide greater user confidence and understanding of the ESP process and encourage model implementation. The result will be greater efficiency in producing an extended water resource forecast with increased accuracy.

3.0 PROJECT OBJECTIVES

(1) develop an interactive ESP analysis and display system in a workstation environment;

(2) produce additional tools for analysis of ESP outputs;

(3) provide a method for automatically adjusting the conditional simulated output for model biases;

(4) provide automatic product generation.

4.0 PROJECT ENVIRONMENT

ESPADP is being developed to run in a workstation environment. The system consists of a CPU, monitor, keyboard, and mouse. A graphical user interface (GUI) will be provided to reduce the amount of work required for the user to execute the ESPADP system. The GUI will include graphical objects such as buttons, toggles, pop-up and pull-down menus, scroll bars, sliders, and multiple lists to provide control and ease of data input and program set-up. The user will interface with the GUI through a combination of keyboard and mouse activities (point and click).

5.0 PROJECT TASKS

The project tasks represent the steps required to produce an operational ESP analysis program to run in a workstation environment. Significant changes to the current operational procedures will be dictated. These tasks will be staged in two phases. Phase I will provide a basic program capable of performing all current ESP analysis options with enhanced graphical outputs. Phase II will build on Phase I to provide the enhanced analysis tools and adjustments to improve the accuracy of hydrologic forecast outputs.

Again, these individual task accomplishments work toward creating an enhanced, efficient, and user-friendly ESP analysis program. Many of these tasks are described with accompanying examples. The examples illustrate the functionality of the task(s) and do not necessarily represent the final designs.

Development of the system will remain flexible. However, in the final version, the system must perform and display all existing ESP analysis functions in addition to new enhancements:

-Summary and Frequency Tables
-Exceedance Probability Plot
-Summary Comparison Chart
-Display of Conditional Traces
-Expected Value Plot
-X-Y Time Series Plot with Linear Regression
-Display of Time Series Data.

A specific set of information is required to produce these displays. The user must be able to select the time series and other attributes/parameters to be used in the analysis. The basic role of the user interface is to allow for the designation and redesignation at any time of the time series, parameters, and type of analysis display.

Phase I Tasks

5.1 ***Task 1*** - CREATE AN INTERACTIVE VERSION OF ESP ANALYSIS SYSTEM WITHOUT GRAPHICAL USER INTERFACE (GUI)

The basic component of ESPADP is the code which calculates probabilistic forecasts of flow volumes, peak flows, minimum flows, etc. These procedures and routings must be converted to run in the workstation environment. The initial program will operate on an IBM RISC 6000. The present code is written in FORTRAN and will not be converted to another language. Since the GUI requires a significant amount of resources to create, the initial interactive version will have a text interface.

The run-time options are limited, allowing the user to cycle through the statistical analysis numerous times selecting different analysis forecast windows (period of analysis), parameter outputs, and simple textual display outputs.

This will be the starting platform for developing a GUI for ESPADP. This task has been completed by Cara McCarthy. A schematic of the completed program is shown in Appendix A, figure 1.

5.2 *Task 2* - DEFINE PROGRAM FLOW OF ESPADP

Utilizing the structure of the basic interactive version of ESP analysis which was produced in Task 1, define the flow of the new ESPADP. The definition will incorporate a Graphical User Interface including the design and functionality of the display windows. The key is to keep the design simple but constantly looking toward the direction and capabilities required in the final version. The requirements of the final version were summarized in the introduction to PROJECT TASKS and are more fully explained in the remaining tasks.

The flow design for ESPADP will be an iterative process. The final version may not exist until the project is complete. For the purpose of providing a starting point, we have included a "first-cut" of the flow design (see Appendix A, figure 2). In this design, after the user enters the system, a forecast point is selected, then the attributes are indicated, and lastly an analysis display is chosen.

5.3 *Task 3* - DEFINE/DESIGN INPUT MENUS

Following the program flow diagram, there must be defined a user interface to obtain the necessary information to run the program and display outputs used by ESPADP.

Menus and displays must observe the following rules:

(1) menus must be intuitive, user must understand what is expected of him/her. Help buttons must be available to assist in the interaction;

(2) menus must be consistent between themselves. Windows which look and function similarly, reduce the confusion of the user interface;

(3) menus must be functional but at the same time reduce the amount of key

strokes. This can be accomplished through the use of default values. Do not make the user do anything the computer will do better;

(4) displays which provide output must be able to re-size without the loss of data or display information.

For each of the boxes defined in the ESPADP flow diagram a menu has been designed. Again, these menus are "first-cuts" and represent an initial plan for entering information needed by ESPADP. This starting information and the content of the graphs and tables presented are fixed requirements for ESPADP, yet the arrangement of such input and output is malleable.

All input menus have a *Help* option to describe the functions within the menu.

5.3.1 ESPADP Analysis Selection

This window is used to select and display the output options for the ESP analysis.

Window: This display contains both graphical and text windows. It provides the ability to select a type of analysis and display the output in the form of graphs or tables.

Functions: (1) *Quit* exits the ESPADP program. (2) *TS-Select* displays the forecast point selection menu. (3) *Attributes* displays the attributes selection menu. (4) T*ables* displays the summary or frequency table. (5) *Help*.

There are five options for graphical output display in the ESP analysis program. They are selected through toggle switches. These plots are displayed in the output display window. The *Summary Comparison Plot* will compare the mean, minimum, maximum, and standard deviation of the output variable from each of the time series. This is a graphical output of the summary table. The *Exceedance Probability Plot* is the standard output of the ESP Analysis program. It graphically displays the frequency table information. The *Expected Value Plot* displays the mean for a particular time interval (day, week, month) calculated over all the historical years selected. The standard deviation is also represented. *Conditional Traces Plot* displays the times series for each of the historical traces which have been conditioned for the current states of the hydrologic models. The *X-Y Times Series Plot* displays the linear relationship between the observed and historical time series. The equation for the regression line and a reliability statistic is also displayed. This display is not available in phase I, if either the observed or historical time series are not available.

Information output tables can be selected from the main menu bar. The *Summary and Frequency Tables* produce two windows of information. The first is a summary of the observed, historical, conditional, and adjusted times series information. It provides the mean, maximum and minimum values, and standard deviations of the time series. The second window displays the frequency distribution information for the probabilistic levels defined in the attributes window.

These options and displays will be explained in more detail in later sections of this document.

Format: See Appendix A, figure 3.

5.3.2 ESPADP Forecast Point Selection

This menu will display all the conditional time series which are available to the user and will determine if the selected times series has a corresponding observed and historical time series files. The user is only allowed to select one of the available conditional time series.

Window: Display is a text window. It contains a scrollable box with information about the available conditional time series. The information displayed is the time series name, creation date of the time series, the carryover date from which the time series data were conditioned, the historical years for which hydrologic traces are available, flags indicating the availability of observed and historical time series and number of observed years available..

Functions: The user can click on a line in the scrollable box to select the time series information from which to perform an ESP analysis. There is a menu bar which allows the user the following options: (1) *Quit* exits the ESPADP program, (2) *Close* allows the user to exit this menu and proceed to the next step, (3) *Help*.

Future: In the plan for Phase II, the forecast point will be selected from a graphical schematic of the River Forecast Center area of responsibility.

Format: See Appendix A, figure 4.

5.3.3 ESPADP Select Attributes

This menu defines the common parameters used to control the ESP analysis.

Window: Display is a text window. It contains several boxes of text and/or numbers which define parameters needed to execute ESP analysis. Many of the boxes will come up with values if they have been saved on a previous run. In addition, some default values, obtained from the conditional time series file, will appear in a first-time run.

Functions: (1) *Quit* will exit the ESPADP program. (2) *Close* will exit the menu. The values currently displayed in the menu will be used to make the current run of ESPADP. Values are not saved for future runs of ESPADP. (3) *Save* will save parameters of this menu to disk and exit the menu to proceed to the next step. (4) *Help.*

Highlighting an input box is performed using the tab key. In attribute boxes requiring non-numeric input, the user can cycle through selectable options. This avoids the need to spell the option correctly. The following explains the attribute boxes and a method for choosing each attribute: Striking enter button while the *Type of Distribution* box is highlighted will cycle through a list of choices (Empirical, Normal, or Log-Normal). Striking enter button, while the *Analysis Variable* box is highlighted, will cycle through a list of choices (Max Mean Daily Value, Min Mean Daily Value, Mean Daily Value, Cumulative Value, Max Instantaneous Value, Min Instantaneous Value, Number of Days to go Above a Value, Number of Days to go Below a Value, Number of Days Greater than a Value, Number of Days Less than a Value). The *Criterion Value* corresponds to target values needed for several of the analysis variables. The menu will not allow the user to exit until a value is supplied for required variable options. The *ESP Historical Years* represent the period of years for which the ESP traces will be generated. If fewer years are available than defined in this default, the period will default to the available period. The *Analysis Window* defines the period for which statistics will be generated. It is the forecast period. The *Exceedance Probability Levels* are the levels for which probabilistic information is calculated. The limit is currently 10 levels, each of which can have a value from 1 to 99. The *Conditional Adjustment Technique* defines the technique used to adjust the conditional time series for bias between the observed time series and the calibration. (Only one option is currently available, linear regression).

Future: Additional conditional adjustments techniques will be added.

Format: See Appendix A, figure 5.

5.4 ***Task 4*** - CONVERT USRINPUT TO INTERFACE WITH THE GUI

The subroutine USRINPUT provides the user interface for the initial interactive version of ESP analysis program. This task will bring together the old text interface with the new GUI.

5.5 ***Task 5*** - DEFINE/DESIGN THE OUTPUT DISPLAYS

The output analysis windows in ESPADP provide a method for the user to display the results of the probabilistic forecast, make adjustments, and to display additional information about the time series used in the analysis process. The following section describes each of the displays and future enhancements.

5.5.1 ***Task 5a*** - Summary/Frequency Tables

This option presents a summary table indicating the value of a particular output variable within the forecast window. The summary includes information about each historical year. The mean, standard deviation, maximum, and minimum of the output variable values are displayed.

A frequency analysis is performed and the exceedance probabilities are estimated for a defined distribution. The data can be fitted to an empirical, normal, or log-normal distribution. The table presents the exceedance probability values which were requested during set-up.

Window: Display is divided into two windows containing text output.

Functions: There is no interaction with the data required.

Format: See Appendix A, figures 6 and 7.

5.5.2 ***Task 5b*** - Exceedance Probability Plot

The exceedance probability plot is a graphical representation of the frequency table expanded to include probability values for all years available.

Window: Display is a graphical window. It consists of an X-Y plot, with the exceedance probability on the x-axis and analysis variable values on the y-axis. Four times series can be plotted on this graph: Observed, Historical Simulated, Conditional Simulated, and Adjusted Conditional Simulated.

Functions: The user will be allowed to place the cursor anywhere inside the x-y graph and click to display the exact value and the corresponding exceedance probability value. All interactions will automatically update the graphical window.

Future: Should the above functions become difficult to implement, they can be delayed until the future. No additional enhancements are currently expected.

Format: See Appendix A, figure 8.

5.5.3 ***Task 5c*** - Summary Comparison Plot

The summary comparison plot is a synopsis of the summary table.

Window: The display is a graphical window. The basic structure is a typical bar chart. It will display four bars of statistical summaries for each of the time series: observed, historical simulated, conditional simulated, and adjusted conditional simulated.

Future: The user will be allowed to place the cursor on one of the bars and click to display the exact value. Clicking on a control button in the window will allow user to change the comparison of standard deviation to some other level of significance.

Format: See Appendix A, figure 9.

5.5.4 ***Task 5d*** - Plot of Conditional Traces

ESP assumes that each year of historical meteorological data is equally likely to occur in the future. However, the ESP model uses these historical traces in conjunction with the current model states (or carryover) to produce conditional time series traces. Current states represent the simulated conditions of the soil moisture, snow pack, reservoirs, river discharge, etc.

Each yearly conditional simulation starts with the same initial conditions but the values will differ from other simulations over time due to different yearly historical precipitation and temperature. Each simulation for the duration of the forecast is referred to as a trace. The traces comprise the "conditional simulation time series." In this analysis plot, the conditional simulation traces will be plotted over the forecast period.

Window: The display is a graphical window. It is a X-Y plot with the simulated value on the y-axis and time (analysis window) on the x-axis. Each of the conditional times series will be identified with the year it represents. Note: if including all years (labels) provides too much confusion to the plot, a color code will be devised (colored decades, i.e., 70's - blue, 80's red, etc.).

Functions: This is a static display of numerous time series traces.

Future: The user will be able to click on an individual trace and display the year and weight assigned to that year. The user will also be able to change the weight, which will automatically update the analysis (yearly weighting option is planned for phase II).

Format: See Appendix A, figure 10.

5.5.5 ***Task 5e*** - Expected Value Plot

The expected value is the mean for a particular time interval, such as, a day, week, or month of the forecast window calculated over years of data. The data may be either simulated or observed. The plot represents the expected value for the chosen time interval of the forecast window. The standard deviation of each value also is indicated on the graph. Although the values are plotted over time, this diagram does not represent a time series.

Window: The display is a graphical window. This is an x-y plot with the y-axis measuring the value of the parameter and the x-axis will be time.

Functions: *TS-Source* will change the source of the time series between, Observed, Conditional Simulated, or the Adjusted Conditional Simulated.

Future: The user will be able to click on an individual trace and display the time and value of the point within the graph.

Format: See Appendix A, figure 11.

5.5.6 ***Task 5f*** - X-Y Time Series Plot

This analysis option will graph two time series on a x-y plot and compare the linear relationship. Initially, this option will be limited to comparing the historical simulated with the observed time series. The mission of this analysis option is to provide a better understanding of the relationship between the historical simulation and the observed time series. The information obtained will adjust the conditional simulation time series.

The historical simulation time series is compared with the corresponding observed time series, and a regression relationship is developed with the historical time series as the independent variable. The following regression equation is generated:

$$o' = c_1(h.s.) + c_2$$

where o' is the estimated observed value, c_1 and c_2 are the regression coefficients, the slope and the y-intercept respectively and h.s. is the historical simulation value. The regression equation coefficients can be used to develop a "modified conditional" time series. The purpose of developing the modified time series is to correct for bias created during the simulation of the time series. The conditional simulation time series data are entered into the regression equation producing an adjusted conditional simulation time series:

$$a.c.s. = c_1(c.s.) + c_2$$

where a.c.s is the adjusted conditional simulated value and c.s. is the conditional simulation value.

The validity of applying the modification can be determined from the scatter in the plot of the historical versus the observed time series. If the points plotted along the regression line, then the modification that was made to correct for simulation bias probably is accurate and useful.

Window: The display is a graphical window. This is a x-y plot with the x-axis representing the values of observed time series and the y-axis representing the values of historical simulated time series. The related values are plotted along with the regression line. The regression equation is also displayed with the confidence statistic.

Functions: The user will be able to click on an individual value and display the corresponding observed and simulation values and the year they represent.

Future: (1) The user will be allowed to select the type of regression technique to use. (2) This technique will compare any two time series and will be accessed through the TS-display option.

Format: See Appendix A, figure 12.

<u>Phase II Tasks</u>

5.5.7 ***Task 5g*** - Time Series Plot

This option will plot time series data which are available to the ESP function. This will allow only observed and historical simulated time series to be graphed. See the Task 5.5.4 for plotting of the conditional simulated.

Window: The display is a graphical window. This is an x-y plot with the x-axis as time and the y-axis the value of the times series.

Future: The user will be able to click anywhere inside the graph to obtain a value and date.

Format: To Be Determined.

5.6 ***Task 6*** - DEVELOP THE AUTOMATIC CONDITIONAL ADJUSTMENTS USING THE RELATIONSHIP BETWEEN THE OBSERVED AND HISTORICAL TIME SERIES

Techniques are being considered for automatic conditional adjustment and will be developed in the future. A description of one technique is found in the X-Y Time Series Plot (5.5.6), where a regression approach is used as a conditional adjustment.

5.7 *Task 7* - DEVELOP FORECAST POINT SELECTION USING RIVER BASIN MAPS

The initial method of forecast point selection will be from a list of encoded time series names. Using this method, the user will need to have a good knowledge of 5-character basin IDs and will be required to scan large lists for the desired forecast points. To ease the requirements for forecasters, forecast point selection will be made from a graphic schematic of the River Forecast Center area river basin map. Only the forecast points which have been implemented under ESP will be shown. This eliminates the forecaster's need to look through large lists of encoded file names to find the required forecast. For new forecasters, this approach will provide the connectivity of the basin to aide in improving forecaster knowledge of the river systems. There are many considerations to be made during development of this step. For example, the forecaster may want to forecast only the local rather than the total area above a forecast point. This selection process may be used to set-up and execute the ESP trace generation function.

5.8 *Task 8* - DEVELOP A DISPLAY OPTION TO LIST FORECAST POINT SEGMENT INFORMATION

The ESP function uses segment information to define which attributes will be evaluated and which times series will be saved for further analysis. This option will display the information associated with the forecast segment defined for the ESP function.

5.9 *Task 9* - DESIGN/IMPLEMENT AN OUTPUT FOR FORECASTS

The ESPADP system generates plots and tables which represent forecasts for dissemination to water users. However, there is no way to output forecasts so they can be passed along to the water management community. This task will design formats which will provide summaries and individual forecasts in a text format. The user will have the option to use the conditional or the adjusted forecast information.

5.10 *Task 10* - ENHANCE INTERACTION WITH OUTPUT PLOTS

This task will provide **Future** enhancements described in each of the output window descriptions.

5.11 *Task 11* - DEFINE/IMPLEMENT MODERNIZED COMMUNICATIONS OF TIME SERIES

The current method of transferring the conditional time series traces to the RFC is through RJE and the punch stream. In the future, it will be very common to transfer 100+ forecast points which represent files of 200,000 to 300,000 bytes and a possible 13 different data types. These files would be transferred at least once per day. Some RFCs could have over 10,000 forecast points when fully implemented (not all of these would be run every day). Using current communication rates of 9,600 bps, this traffic load would not be possible. This task will be developed under the AWIPS environment.

5.12 *Task 12* - DEFINE HOW TIME SERIES FILES WILL BE MANAGED IN THE FUTURE

The traces are received in files containing multiple years of information for a single hydrologic parameter. They are managed with a descriptive file name using the system directory structure. To handle multiple conditional time series copies an improved management architecture must be created. Some sort of database will be required to maintain and access traces in the future.

5.13 *Task 13* - WHERE SHOULD THE ESP FUNCTION BE EXECUTED ?

It is clear that computer systems are available which will run ESP in the workstation environment. As the number of forecast points increase (the ESP technology expands in usage), turn around for ESP execution on a workstation is still in question. For that matter it may still be in question on a big main frame. How do we maintain multiple copies of software, parameter sets, and input information to insure consistency in forecast output? As we develop the other tasks, we should be considering solutions to this question.

6.0 SPECIAL ESPADP CONSIDERATIONS

The full ESP system is divided into two parts. The ESP function which generates the conditional time series traces is executed in a batch mode on the NWS central computer facility (NAS9000). Output time series traces will be saved and transferred onto the workstation where they will be analyzed by the ESPADP program. Transfer is a multi-step process. During the ESP function execution, time series information is saved onto the ESP file system. The ESP utility program is run to transfer the time series to the River Forecast Centers (RFC) via RJE and its punch stream facility. The time series are stored on a local system until some process transfers them to the workstation (this process differs at each RFC).

Time Series Information

The time series will be identified and stored having the naming convention:

TSID.DTYPE.IDT.(COND/HIST/OBS)

where TSID represents the 5 character identifier, DTYPE is the data type, IDT is the time interval of the data, and (COND/HIST/OBS) indicates if the data is conditionally simulated, historically simulated, or observed.

The time series will be transferred in two different formats. The observed format is:

```
$  IDENTIFIER=dillon obs    DESCRIPTION= dillon res inflow
$  PERIOD OF RECORD= 1/1964 THRU 9/1983
$  SYMBOL FOR MISSING DATA=-999.00  SYMBOL FOR ACCUMULATED DATA=-998.00
$ TYPE=QME    UNITS=CFSD   DIMENSION=L3   DATA TIME INTERVAL=24 HOURS
$  OUTPUT FORMAT=(3A4,2I2,I4,10(F6.0))
SLC FILE 39   QME  L3   CFSD 24   DILLON OBS       DILLON RES INFLOW
 1  1964  9    1983  10   (F6.0)
DILLON OBS    164    1  58.  59.  47.  62.  44.  60.  60.  47.  52.  58.
DILLON OBS    164    2  57.  51.  54.  51.  50.  51.  48.  62.  52.  52.
```

The format for the historical and conditional time series is:

```
PUNCHED TIME SERIES DATA FOR  Inflow    SQME    24-JCSS1
CREATED  11/18/1992-1057.4622
START DATE OF DATA:  11 1 1949  FOR 12  MONTH(S) AND 36 YEAR(S)
FCST PERIOD:  11/ 6/1992-  1/14/1993    MSNG DATA SYMBOL: -999.0
TSTYPE        UNITS        DIMENSION        FMT
HIST          CMSD         L3                (10F8.1)
-999.0   -999.0   -999.0   -999.0   -999.0    38.8     28.2     21.8     17.9
  13.8     12.8     12.2     11.8     11.3     11.1     10.8     10.6     10.5
```

7.0 WORK SCHEDULE

The implementation schedule is separated into two phases. The first phase will provide a basic system with same capabilities as the current batch version. Phase I will end after a GUI has been developed with a basic menu system and some output windows. Phase II will take much longer, providing the enhancements required to produce a fully integrated system with the NWSRFS Interactive Forecast Program being developed in the Office of Hydrology.

Phase I

(1) Task 1 - Create Basic Interactive ESP Analysis System
(2) Task 2 - Define ESPADP Program Flow
(3) Task 3 - Design Basic Input Menus
(4) Task 4 - Convert USRINPUT to GUI
(5) Task 5a-f - Design Output Displays: Basic ESP

Phase II

(6) Task 5g - Design Output Displays: Enhanced Abilities
(7) Task 6 - Automatic Conditional Adjustments
(8) Task 7 - Enhance Forecast Point Selection
(9) Task 8 - List ESP Segment Information
(10) Task 9 - Develop Forecast Output Products
(11) Task 10 - Enhance Interaction With Plots
(12) Task 11 - Modernize Communications
(13) Task 12 - Management of Time Series
(14) Task 13 - Future of ESP Execution

ESPADP Project Review

Milestone Activity	FY 93												FY 94											
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
1. Revise Plan To Accommodate Changed Resources						▲																		
2. Develop Non-graphical Interactive Version of ESP								△																
3. Develop GUI for User Input								△																
4. Incorporate Initial Graphics in Output Display for Phase I											△													
5. Release Initial Version for Field Test													△											
6. Begin Phase II													△	—	—	—								

Legend:

- △ Original Milestone
- ▲ Milestone Accomplished
- □ Milestone Slipped
- ■ Slipped Milestone Accomplished
- —— Ongoing

8.0 REFERENCES

Anderson, E.A. (1973). "National Weather Service River Forecast System - Snow Accumulation and Ablation Model." NOAA Tech. Memo. NWS HYDRO-17, United State Department of Commerce, Silver Spring, MD.

Burnash, R.J.C., Ferral, R.L., and McGuire, R.A. (1973). "A Generalized Streamflow Simulation System - Conceptual Modeling for Digital Computers." United States Department of Commerce, State of California, Department of Water Resources.

Curtis, D.C, and Schaake Jr., J.C. (1979). "The NWS Extended Streamflow Prediction Technique." Paper prepared in the NWS Office of Hydrology, Silver Spring, Maryland.

Day, G.N. (1983). "Extended Streamflow Forecasting Using NWSRFS." Proceedings ASCE Conference on Water Supply -- The Management Challenge.

Day, G.N. and VanBlargan, E.J. (1983). "The Use of Hydrometeorological Data in the NWS Extended Streamflow Prediction Program." Proceedings of the AMS Fifth Conference on Hydrometeorology, October 17-19, Boston, Mass.

Day, G.N., Schaake Jr., J.C., and Ellis, J.H. (1989). "A Direction Toward Improved Streamflow Forecasting in the Western Mountains." Proceedings of Western Snow Conference, April, Fort Collins, Colorado.

Day, G.N., Brazil, E.L., McCarthy, C.S., and Laurine, D.P. (1992). "Verification of the National Weather Service Extended Streamflow Prediction Procedure." Proceedings of AWRA Conference, Reno, NV.

Fread, D.L., Smith, G.F., and Day, G.N. (1991). "The Role of Real-Time Interactive Processing in Support of Water Resources Forecasting in the Modernized Weather Service." NOAA/NWS Hydrologic Research Laboratory, Silver Spring, MD.

Laurine, D.P. (1992). "WARFS Demonstration Project: Denver Water Evaluation of ESP Information in Reservoir Operations." Presented at the Colorado River Forecast Service (CRFS) Federal Interagency meeting, January 1992, Salt Lake City, Utah.

Laurine, D.P. and Brazil, L.E. (1993). "Pilot Project Results from a Probability Based Long Range Water Management/Supply Forecast." To be presented at the Federal Interagency Workshop: Hydrologic Modeling Demands for the 1990's, June 6-9, Fort Collins, Colorado.

Monro, J.C, and Anderson, E.A. (1974). "National Weather Service River Forecasting System." Journal Hydraulics Division, ASCE, 100(HY5):621-630.

Twedt, T.M., Schaake Jr., J.C., and Peck, E.L. (1977). "National Weather Service Extended Streamflow Prediction." Proceedings of Western Snow Conference, April 19-21, Albuquerque, New Mexico.

Schaake Jr., J.C. (1987). "Building a New Age of Hydrologic Modeling on the Strength of the Past." Paper prepared in the NWS Office of Hydrology, Silver Spring, Maryland.

Schaake Jr., J.C. (1990). "Water Resource Forecasting." Proceedings from a National Research Council Colloquium on Managing Water Resources Under Conditions of Climate Uncertainty, November, Silver Spring, MD.

Appendix A

ESPADP System Figures

Extended Streamflow Prediction (ESP)
Interactive Analysis Program
(Initial Workstation Program)

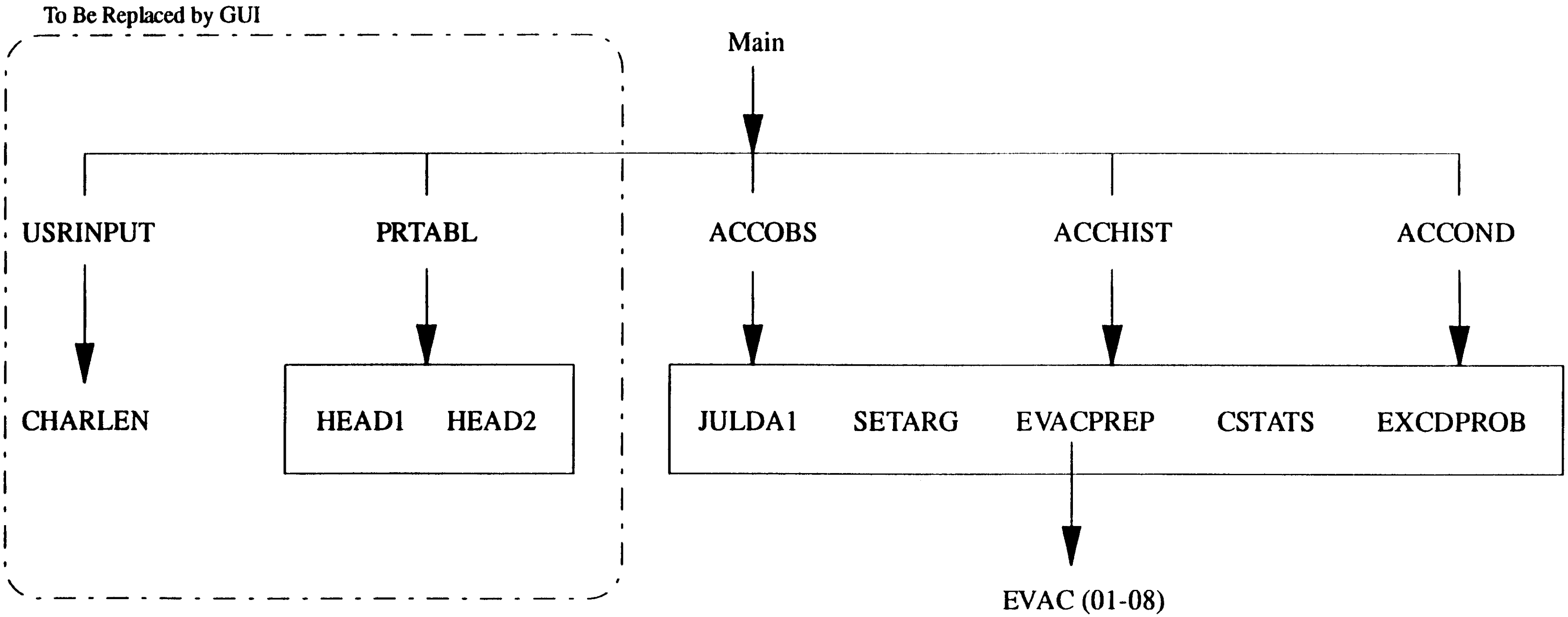

figure 1. - - ESP Basic Program Flow Diagram

ESPADP Flow Diagram

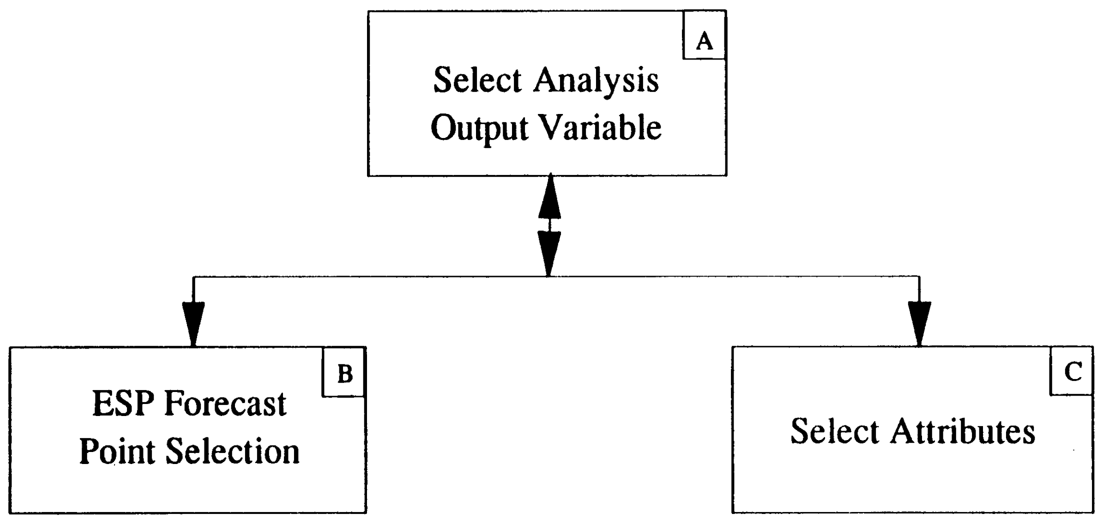

figure 2. - - ESPADP Flow Diagram

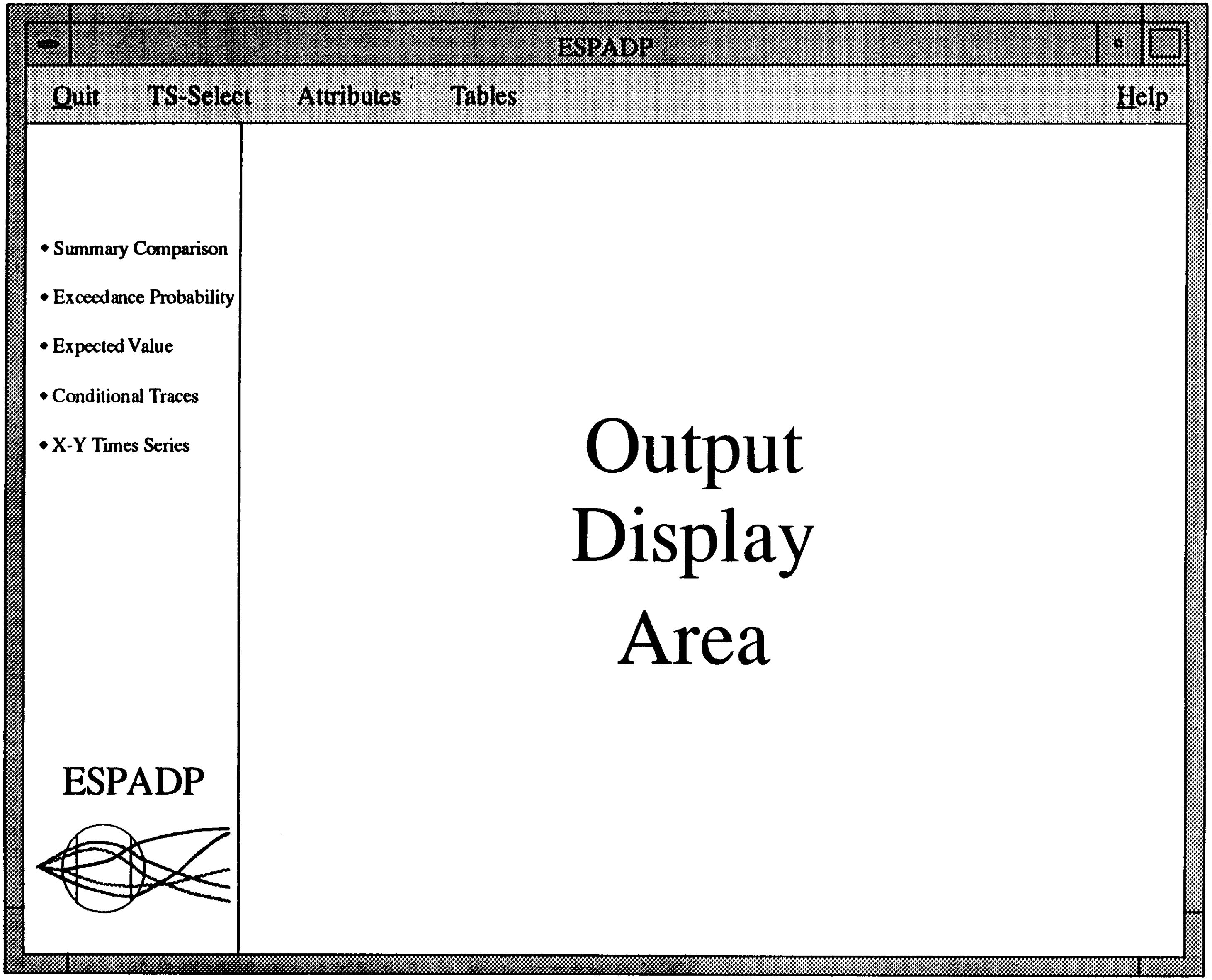

figure 3. - - ESPADP Analysis and Display

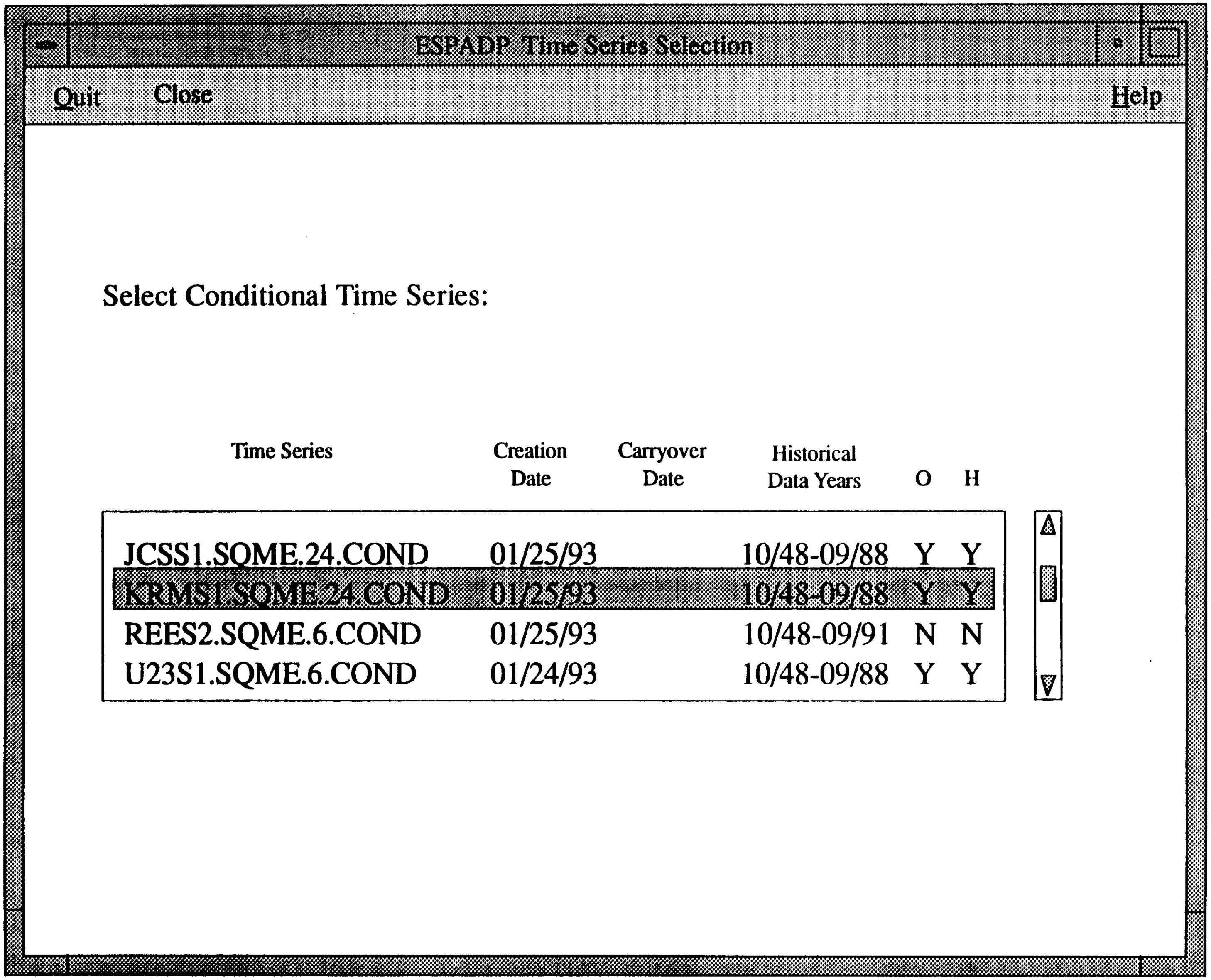

figure 4. - - Forecast Point Selection

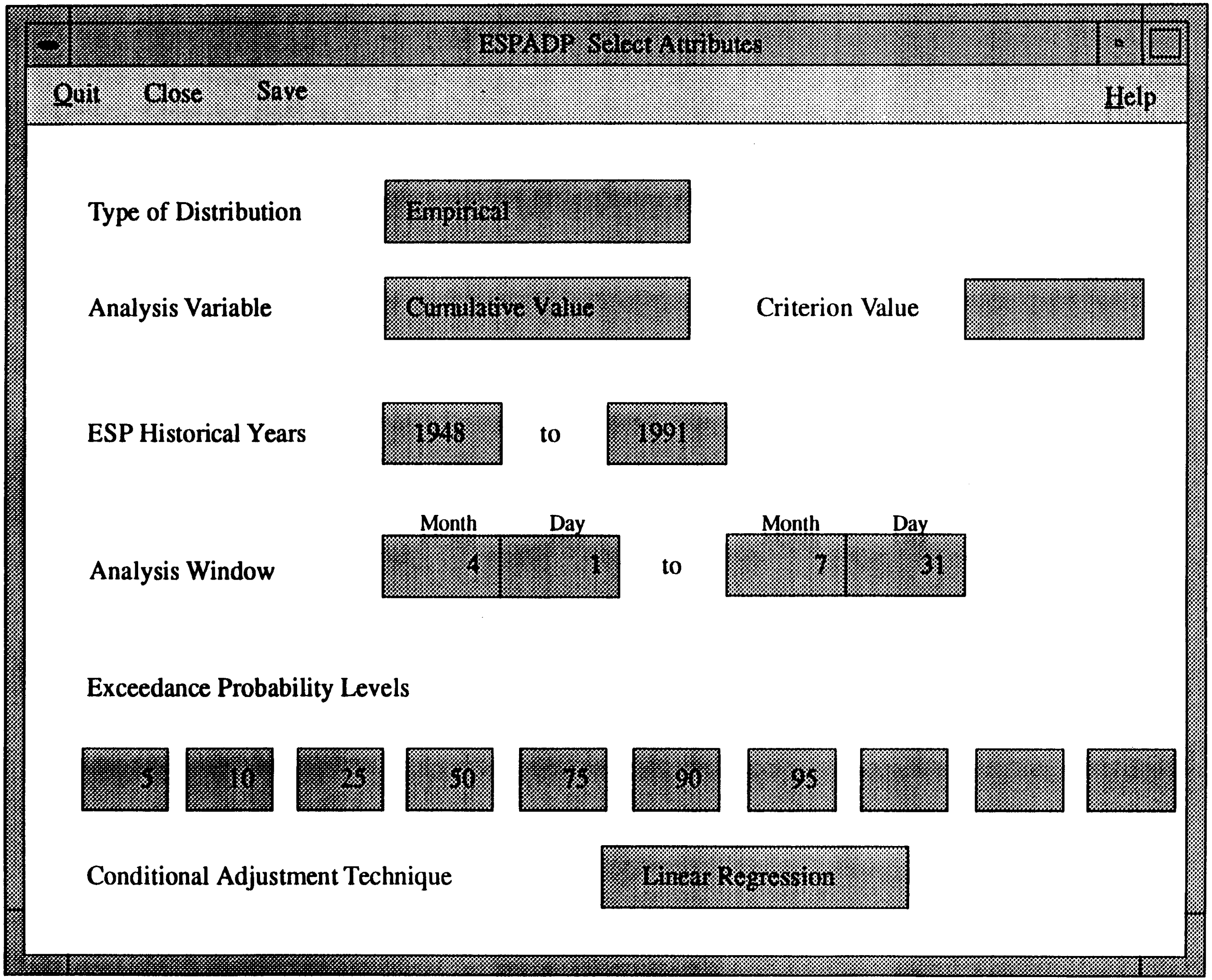

figure 5. - - Select Attributes

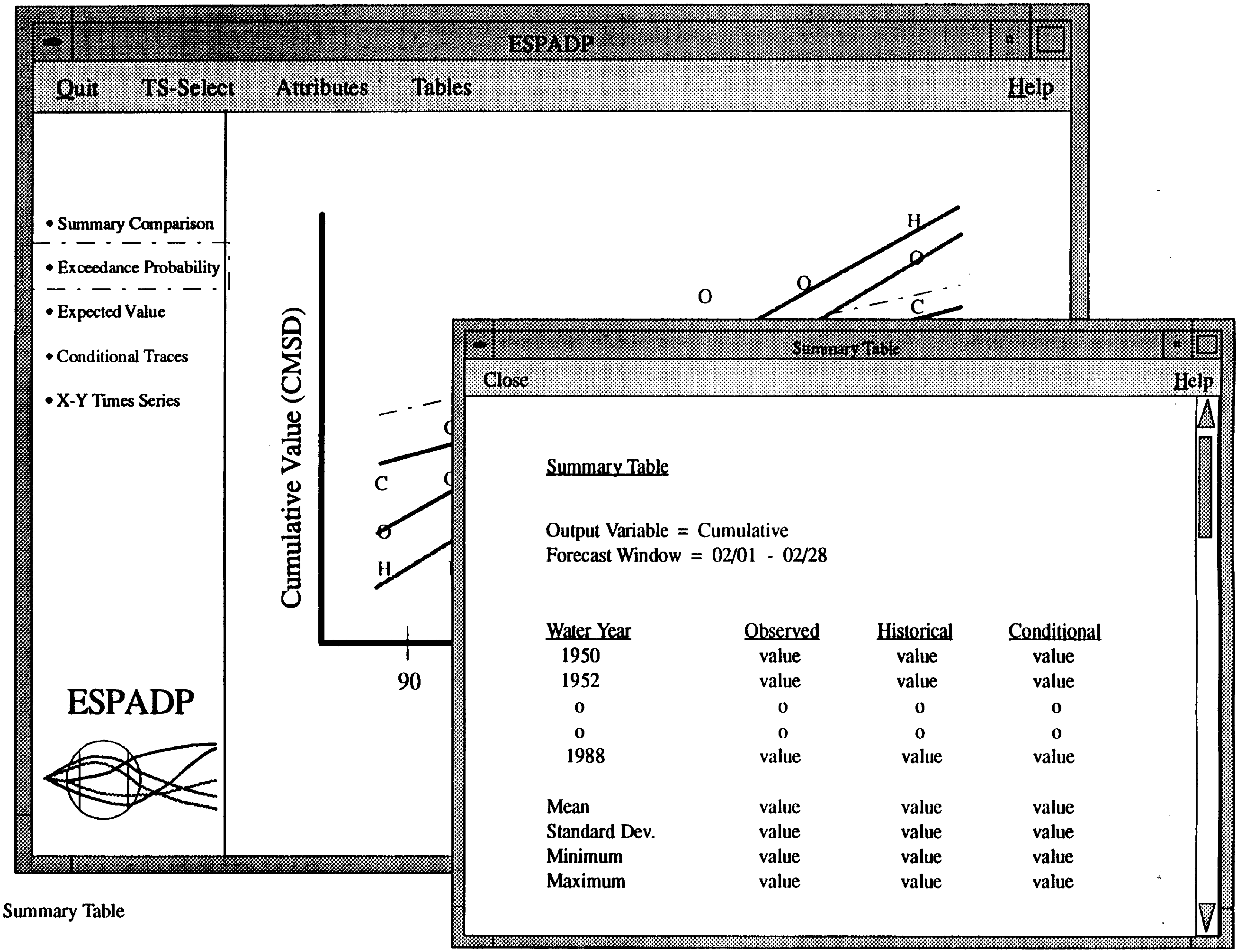

figure 6. - - Summary Table

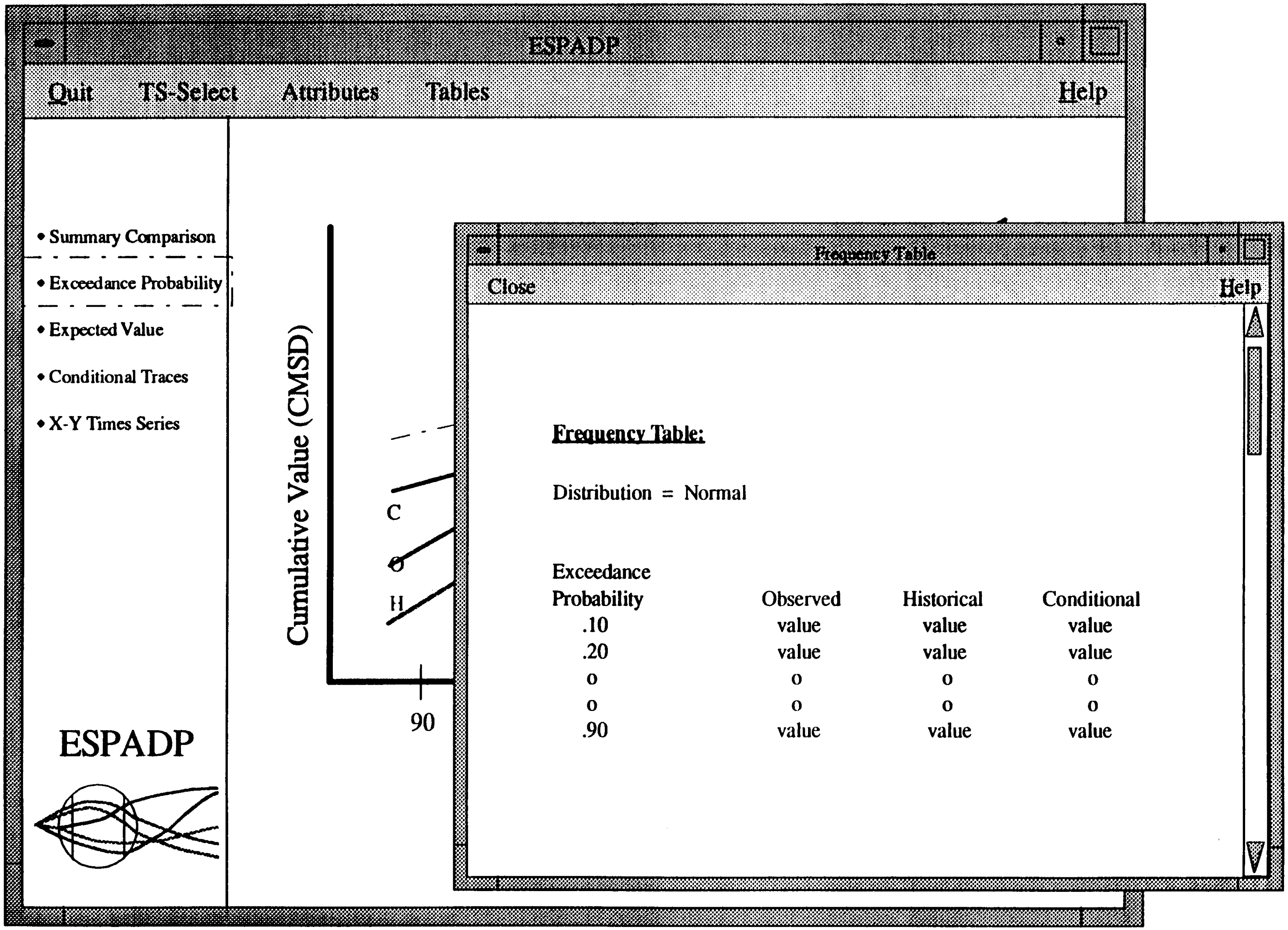

figure 7. - - Frequency Table

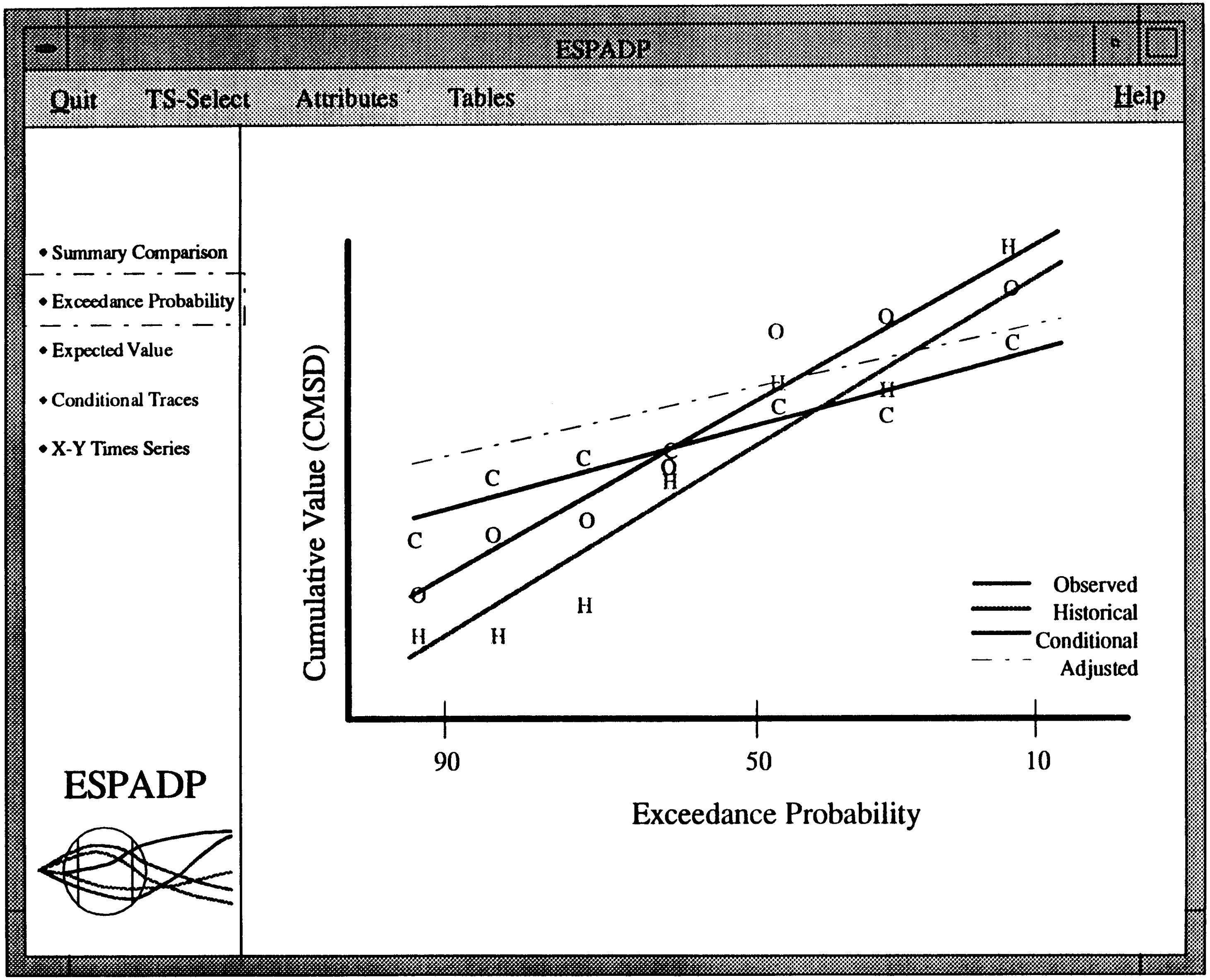

figure 8. - - Exceedance Probability Plot

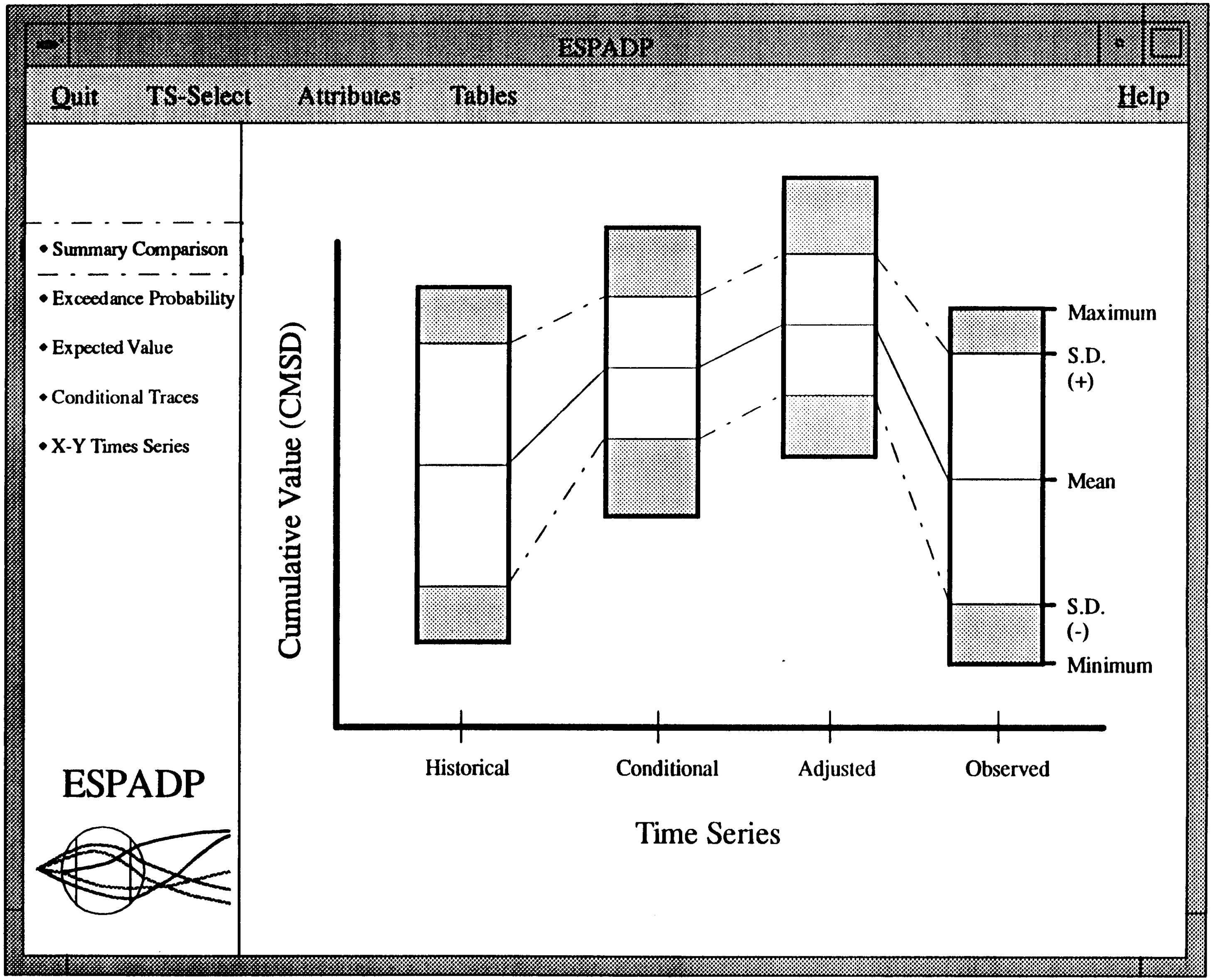

figure 9. - - Summary Comparison Plot

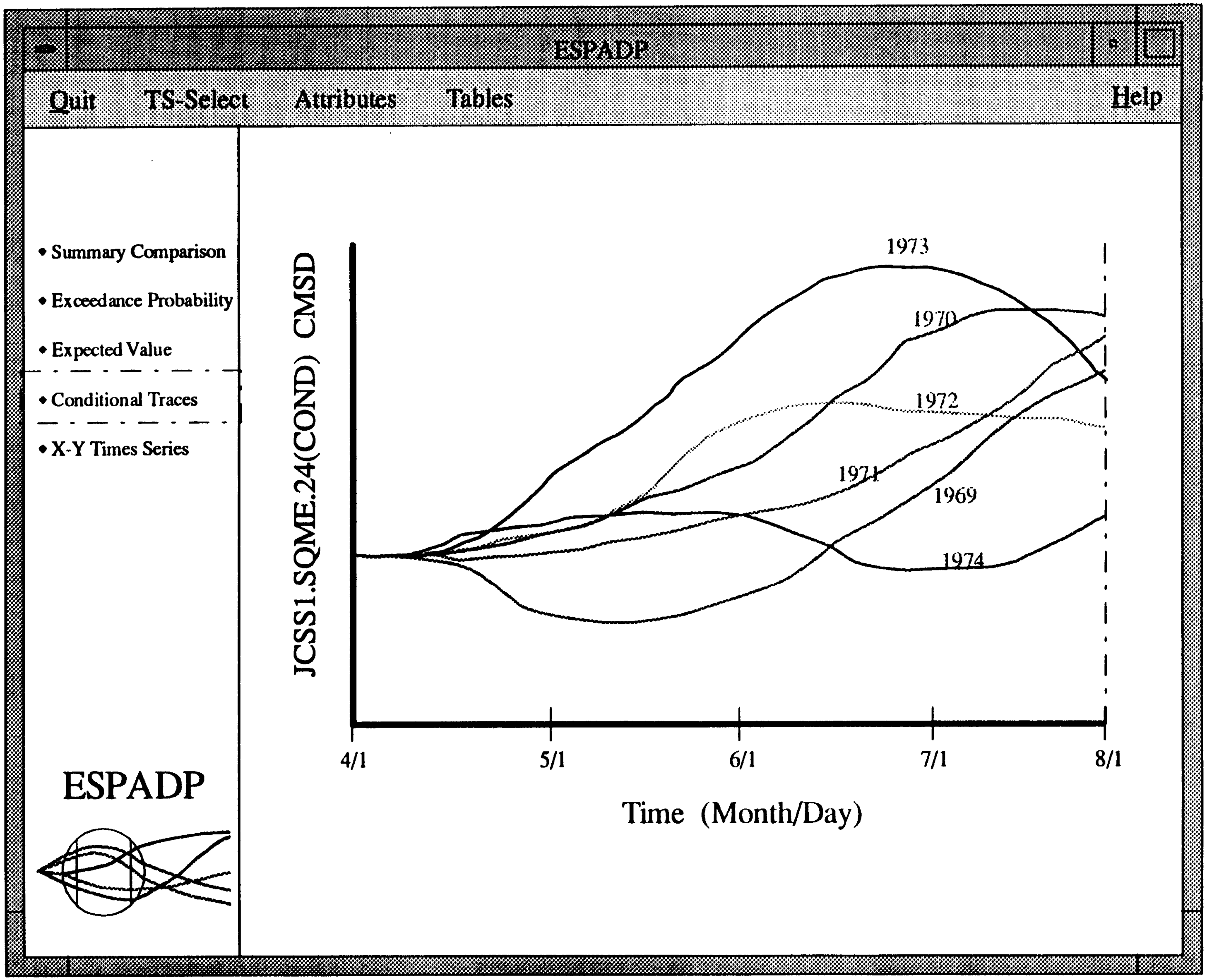

figure 10. - - Conditional Traces Plot

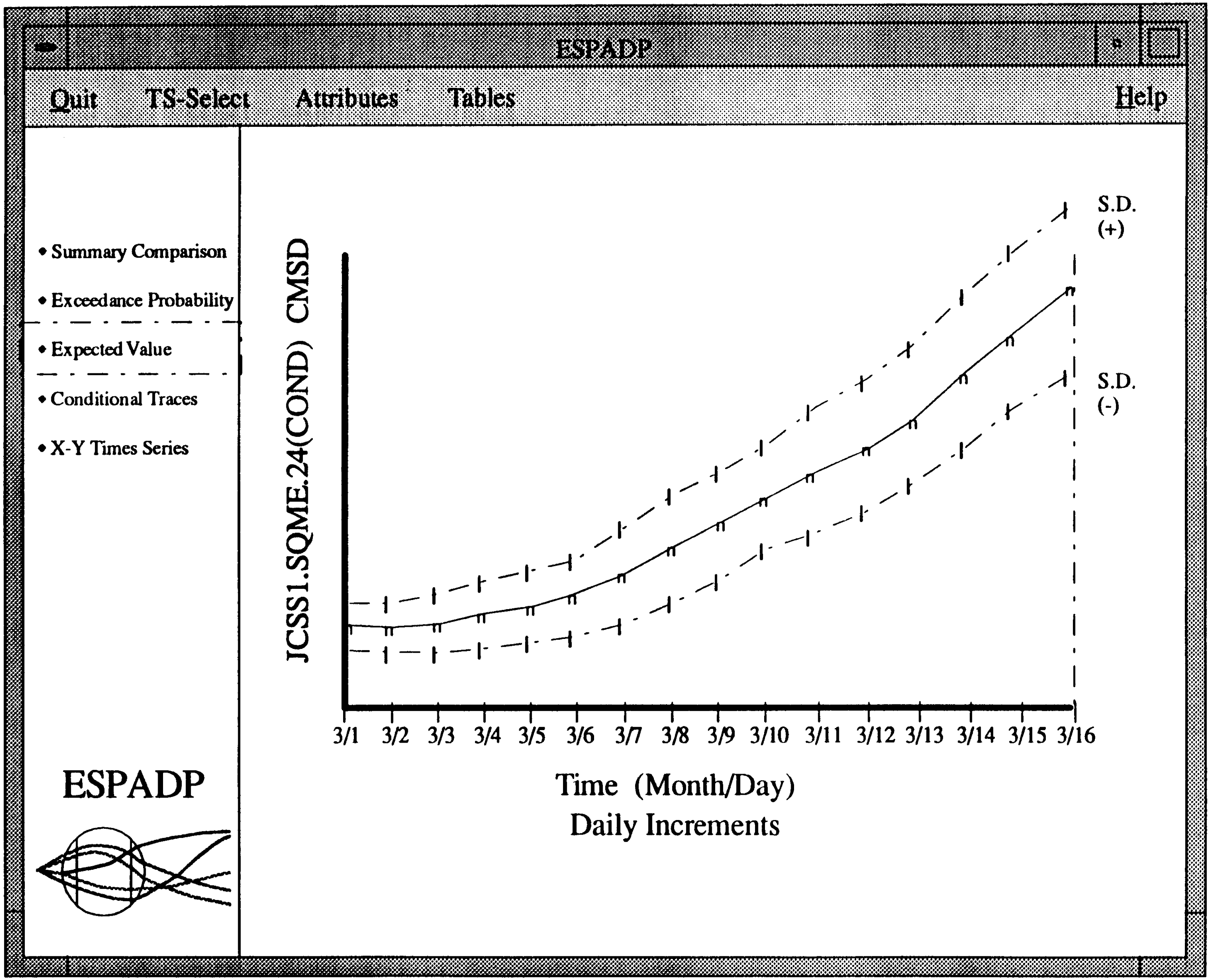

figure 11. - - Expected Value Plot

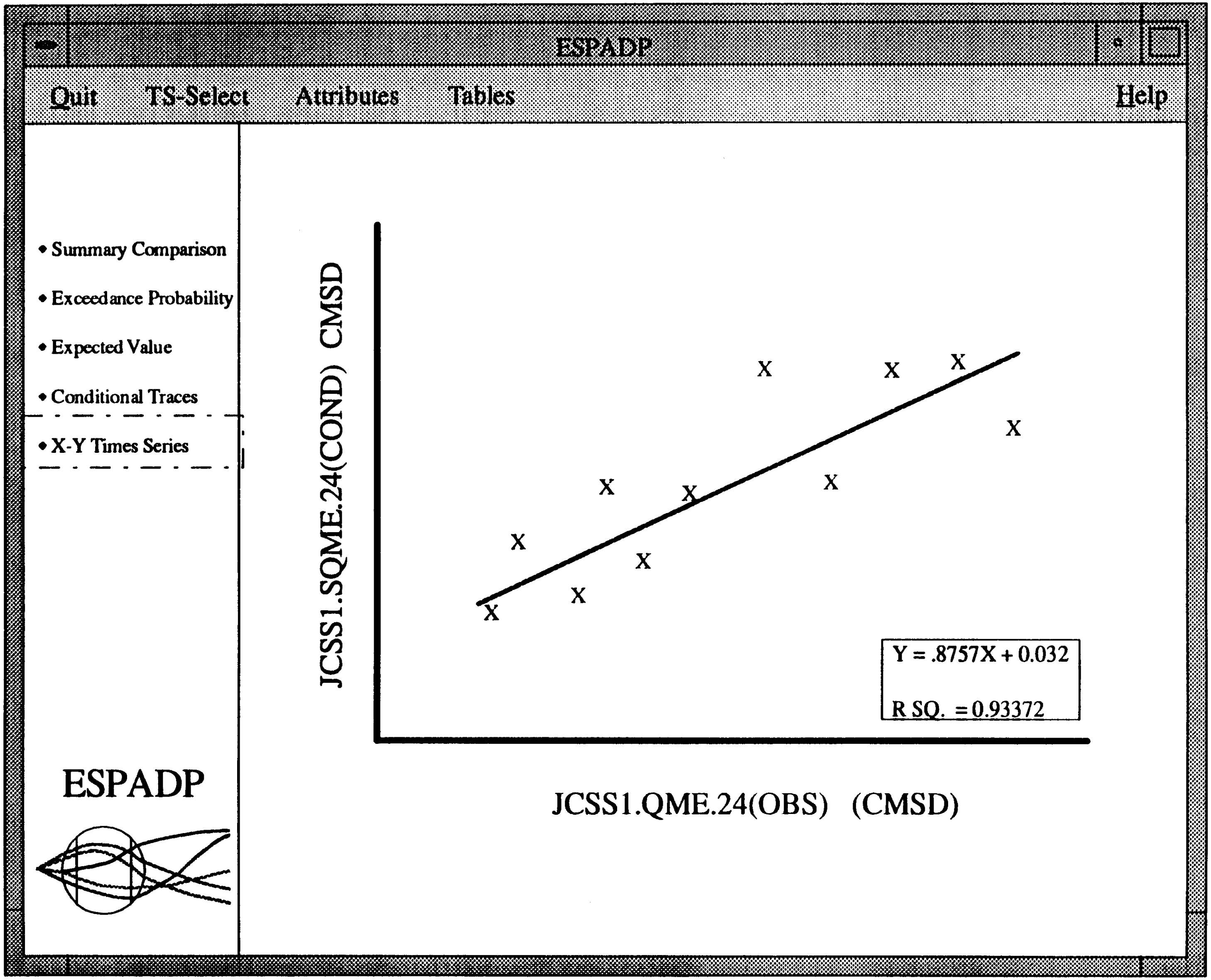

figure 12. - - X-Y Time Series Plot