NATIONAL WEATHER SERVICE
OFFICE of HYDROLOGIC DEVELOPMENT

CONCEPT OF OPERATIONS
And
REQUIREMENTS

ICP Redevelopment

Version 4.3

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Version 4.3
10/21/2006

REVISION HISTORY

Date	Version	Description	Author
10/10/2005	2.1	Initial CONOPS for ICP Redevelopment	S. Townsend
12/01/2005	2.2	HOSIP Review	M. Andre
12/07/2005	2.3	Updates to address review comments	S. Townsend
12/15/2005	2.4	HOSIP Admin formatting and editing changes	M. Andre
01/04/2006	2.5	HOSIP QA	M. Maxey
02/03/2006	2.6	Apply Gate 2 directed changes	S. Townsend, S. Malers (RTi)
04/04/2006	3.1	Update for Stage 3. Add Appendix B and list of supplemental documents with bug fixes and enhancement requests, to be transmitted with this document.	S. Malers (RTi)
06/05/2006	3.2	Update Appendix B to include additional software bugs as reported from the field, as per Gate 3 discussion.	S. Malers (RTi)
08/25/2006	4.1	Added decomposed technical requirements as Appendix C; reformatted original functional requirements in Appendix C; moved original use cases and functional requirements to Appendix D.	K. Casterton (RTi)
9/13/2006	4.2	Updated with feedback from OHD, added Graph Component Requirements 2.37 and 2.38	K.Casterton (RTi)
09/20/2006	4.3	HOSIP QA	J. Soler

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1. INTRODUCTION

The Interactive Calibration Program (ICP) is the main tool for hydrologic model calibration, which is a critical component of the Advanced Hydrologic Prediction Service (AHPS) implementation. The implementation of AHPS is time consuming and costly, largely due to inefficient and outdated procedures for hydrologic and hydraulic model implementation at National Weather Service (NWS) River Forecast Centers (RFCs). One of the largest components of the implementation process is calibration of hydrologic and hydraulic model parameters. ICP was designed to expedite the process of hydrologic model calibration. ICP needs to be re-coded to eliminate deeply embedded bugs that frequently cause ICP failure core dumps. More importantly, ICP should be re-coded to facilitate the addition of planned enhancements that will expedite model calibration and enhance the training of operational forecasters. To this end, ICP should be re-coded in an object-oriented framework that enables the development and integration of these enhancements. This framework should be implemented in such a way as to make it possible to merge ICP into CHPS/OMS as that system becomes available.

Taken From the Statement of Need document (SON)

2. CURRENT STATE OF OPERATIONS

2.1 Description of the Current Environment

Simply stated, calibration is the process of fine-tuning the model parameters so that simulated hydrologic variables agree with observed hydrologic variables (e.g., streamflow, soil moisture, snow water equivalent). The model parameters obtained during the calibration process are used in the forecast system that provides real-time streamflow forecasts. ICP is the main tool for hydrologic model calibration within the NWSRFS environment, which is a critical component of the AHPS implementation. The implementation of AHPS is time consuming and costly and one of the largest components of the implementation process is calibration of hydrologic and hydraulic model parameters.

ICP allows users to select a watershed and execute the manual calibration program (MCP3) to perform the hydrologic computations for the entire run period. MCP3 writes data values and other information to output files that are read by ICP in order to generate graphical displays. Graphical output is provided for the NWSRFS SNOW-17, SAC-SMA, WY-PLOT, and PLOT-TS operations. Model states for the SNOW-17 and SAC-SMA models can be displayed within the WY-PLOT and PLOT-TS displays. Output from other operations can be viewed as text through the ICP interface.

The current ICP needs to be re-coded to eliminate deeply embedded bugs that frequently cause ICP failure core dumps thereby adding additional interventions and frustration to a process that already has far too many manual interventions. These program bugs are best resolved by re-engineering ICP.

Taken From the SON

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2.2 User/Customer Identification & Organization

Classes of users or customers of the current system include:

- NWSRFS Model Calibrator
- Research Hydrologist
- Model Developer

2.3 Current Support Environment/Architecture

ICP currently is an AWIPS supported program and the source code is available. The environment of ICP is the same as the NWSRFS suite of applications based on the Linux Redhat Enterprise Linux (RHEL) 3.0 operation system (as of AWIPS OB6). The ICP was written in the C programming language and requires extensive use of the Linux operating system libraries. Moreover the ICP requires other NWSRFS components, namely the Manual Calibration Program (MCP3) component, in order to operate.

The ICP graphical user interface (GUI) uses X-windows Motif and is built with the X-Designer graphical window builder. The code is currently not adequately documented and is not contained within a sufficiently modular framework to allow for easy modifications for bug fixes and enhancements. Due to its reliance on the Linux system libraries and low level X-window programming, the ICP is difficult to maintain.

3. PROPOSED SOLUTION CONCEPTS

3.1 New Capabilities and Functions

This project proposes to re-implement the ICP application using a more modular design and taking advantage of more modern software development tools. The ultimate objective of the current project is to redesign and develop the ICP in an object-oriented framework without appreciably changing its functionality. Improvements to usability are expected, based on corrections of existing bugs and design flaws. This project does not include extensive enhancements to the current functionality of ICP. It is anticipated that through a redesign and development of ICP in a more modular and extensible framework, that in the future it will be easier to add new capabilities and new functionality. At OHD's direction, the replacement ICP will be developed in Java. The Swing GUI toolkit has been recommended in Stage 3.

Existing functionality is documented in the document "Task 3-0003 Interactive Calibration Program (ICP) Functional Requirements," RTi (2004), which is attached at the end of this document (Appendix D; see also Appendix C, in which Appendix D content has been reformatted as a table). Appendix B summarizes design actions that will be taken to address suggestions by Anderson (2003) and RTi (2004). Stage 3 input has also resulted in collection of the following documents, which list additional possible ICP enhancements:

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#	Document Title, Author, Date	Document File	Comments
1	"Interactive Calibration Program – Suggested Changed and Enhancements", Eric Anderson, January 2003	icp_report_main.doc	This is the report that RTi originally evaluated: Anderson (2003).
2	"Appendix A – Statistics for the Interactive Calibration Program,", January 2003	icp_report_appendix_A.doc	Suggested ICP statistics enhancements.
3	"Appendix D – ICP Status", Eric Anderson, February 2000	icp_report_appendix_B.doc	Older ICP review, appendix to the 2003 report listed above.
4	"Interactive Calibration Program (ICP) SNOW-17 Display," Eric Anderson, March 2005	eaa_ICP_SNOW-17_Display march 2005.doc	General recommendation is that the SNOW-17 display in ICP be updated to correct a number of issues and that the display subsequently be considered for use in IFP.
5	"Functional requirements for AB_OPT (WGRFC Perspective)", WCRFC, date unknown	Functional Requirements for AB_OPT-1.doc	"There has been some desire to link ICP and AB-OPT" – Mike Smith.

It is expected that functionality changes in the replacement ICP will be minor and will focus on usability issues. More extensive enhancements, as described in the above documents, can then be implemented as enhancements to the replacement ICP.

3.2 Operational Policies & Constraints

3.2.1 Scientific Constraints

Because the focus of the current project is to reproduce the current functionality of the existing ICP, no scientific constraints are anticipated.

3.2.2 Technical Constraints

The ICP is currently written in the C programming language utilizing low level X-windows based libraries as the main GUI, graphical, and tabular framework. This project will re-design the overall ICP framework using an object-oriented design, relying on the Java programming language. The application framework will be designed to enable

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adding enhancements and ease maintenance for OHD. Several graphing and tabular display packages will be explored to find satisfactory components that can be used to meet ICP requirements.

It is desirable that the performance of the new ICP is comparable or faster than the current ICP. Therefore, performance metrics will be applied to measure and evaluate performance of the new software developed in Stage 4 (see the Project Plan – Risk Assessment and Management for a list of performance metrics). Consideration of performance results may impact software design. Note that a large part of execution time is taken by the MCP3 FORTRAN program, which this project will not modify.

3.2.3 Policy Constraints

There are no known policy constraints to the redevelopment of the ICP.

3.2.4 Financial and/or Schedule Constraints

The ICP replacement project has the financial constraint that the existing task order budget will require the NWS to use a spiral budgeting model as AHPS money becomes available.

3.3 Operational Scenarios

User: **NWSRFS Model Calibrator**
This class of user will most likely be a hydrologist at an RFC, but can include other model calibrators (such as contractors) that use ICP to calibrate NWSRFS models. The model calibrator will use ICP to run one or more NWSRFS models (in a single MCP input deck) for a calibration period and to visualize model outputs and intermediate states (for some models). Based on the user's review of ICP displays, the model calibrator will edit model parameters and re-run the input deck to see the results of the parameter changes.

User: **Research Hydrologist**
The research hydrologist can use the display capabilities of ICP to visualize and compare multiple streamflow or other hydrological time series on a single plot. ICP is very useful for testing model enhancements and comparing the results of multiple models. An example of this occurred at the concluding workshop of the Distributed Model Inter-comparison Project at the NWS.

User: **Model Developer**
The model developer will use ICP as a platform for testing a new hydrologic or hydraulic model. Once the model is incorporated as an NWSRFS operation, ICP can be used to perform model calibration, sensitivity analyses, and to identify additional output variables from the model that may be useful.

3.4 Support Environment/Architecture

The proposed ICP will reside on Linux and will use the Java programming language with graphing, and tabular display packages decided in Stage 4. Java version 1.5.x, or later, consistent with AWIPS, will be used for development and at run time. The look and feel

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of the current ICP will be maintained even though the application infrastructure will change significantly.

3.5 Summary of Impacts

Operational Impacts:

Over time the replacement ICP application will have a positive impact on NWS operations by providing an easy to maintain framework, implementing a more usable and reliable user interface, and creating the ability for rapid development of additional features.

Organizational Impacts:

Only minor organizational impacts are expected. Because the replacement of the ICP will adhere to the functionality of the original ICP, little effort will be required for the development of training materials and for the assimilation of the new ICP into operational use. The Office of Climate, Water and Weather Services (OCWWS), Hydrology Services Division (HSD) and OHD will work towards developing the training materials and prioritize the tasks associated with training and provide the level of effort and a timetable for completing this task Development of updated ICP user and system documentation, and initial training materials should occur during replacement ICP software development.

Impacts During Development and Transition:

Because the new ICP will replace an existing program and its functionality, only minor impacts are expected during development of or transition to the new program. It is anticipated that the new ICP will be delivered to the RFCs as part of a scheduled AWIPS release complete with release notes describing steps for archiving and, if necessary, reverting operations back to the current program. The release notes will also describe any changes the user will need to be aware of to run the new program. Because the replacement ICP will be developed in Java, a Java Runtime Environment (JRE) compatible with the replacement ICP needs to be in place in the AWIPS operational environment. It should be possible to run the old and new ICP within the same system, to facilitate transition.

Changes to the existing functionality, as recommended by Anderson (2003), RTi (2004), and OHD, and resulting impacts are documented in Appendix D. It is expected that minor usability issues will be addressed in initial development and that larger enhancements will be implemented later.

3.6 Alternatives and Trade-offs Considered

The only alternative to the approach presented here is to leave the ICP as it is and not replace it. This alternative would have the advantage of initially costing far less than the proposed approach. This is not a viable alternative in that the current architecture is difficult to maintain and cannot be extended with new science relevant to the NWS mission.

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4. Requirements Development Methodology

The requirements were developed by deconstructing the functionality of the current ICP application. This deconstruction provided a list of functional operations, which were mapped to use cases. The use cases were then mapped to functional requirements. The use cases and functional requirements for this document were constructed from a report generated by a previous contract task (RTi, 2004), attached as Appendix D.

5. REQUIREMENTS

The requirements for this task were created in OHD task T3-0003 and described in a previous project report (RTi, 2004). Refer to the attached document (Appendix D) for reference to the requirements of this project. The requirements were determined from a functional decomposition analysis of the ICP. Subsequently, the function requirements from this report were summarized in tabular form (Appendix C). Decomposed technical requirements were also determined and are included in Appendix C.

6. REFERENCES

Anderson, E. (2003). "Interactive Calibration Program Suggested Changes and Enhancements." *NWS White Paper*, National Weather Service.

RTi (2004). "Interactive Calibration Program (ICP) Functional Requirements – Deliverable 3 Functional Requirements for the ICP Application." Riverside Technology, Inc.

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APPENDICES

Appendix A – Table of Acronyms

AHPS	Advanced Hydrologic Prediction Service
AWIPS	Advanced Weather Interactive Processor Service
CHPS	Community Hydrologic Prediction System
CONOPS	Concept of Operations
DMIP	Distributed Model Inter-comparison Project
ICP	Interactive Calibration Program
IDE	Integrated Development Environment
GUI	Graphical User Interface
HOSIP	Hydrologic Operations and Service Improvement Process
HSD	Hydrologic Services Division
HSEB	Hydrology Software Engineering Branch
HSMB	Hydrology Science Modeling Branch
MCP	Manual Calibration Program
NOAA	National Oceanic Atmospheric Administration
NWS	National Weather Service
NWSRFS	National Weather Service River Forecast System
OCWWS	Office of Climate, Weather and Water Service
OHD	Office of Hydrology Development
OMS	Object Modeling System
OO	Object Oriented
QA	Quality Assurance
RFC	River Forecast Center

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Appendix B – Functionality/Issues to be Considered in Replacement ICP Design, Beyond Existing Functionality

The following table lists additional features or enhancements considered for the ICP replacement, beyond the existing functionality (as documented in the following "Interactive Calibration Program [ICP] Functional Requirements" report). The table indicates how the feature/issue will be considered in design. The main goal of the replacement ICP is to provide the same functionality as the current version, while addressing maintenance and usability issues. The following list focuses on issues that have been identified by Eric Anderson (2003), RTi, and ICP users. In general, bugs and usability issues will be addressed in the initial replacement ICP, whereas functional changes will need to be addressed in later versions. It is expected that some functionality will change slightly in order to address some usability issues, requiring changes to documentation and training materials.

Functionality/Issues to be Considered in Replacement ICP Design, Beyond Existing Functionality

#	Functionality/Issue	Design Action	Proposed by
1	Excessive mouse clicks are needed for some activities (e.g., to select and run).	Evaluate how to streamline user actions.	Anderson, Page 4
2	ICP should retain knowledge about user selections (e.g., current control file).	Increase ICP's ability to re-use previous choices.	Anderson, Page 4
3	ICP should abandon use of some of the files and focus on using the .curr file.	Evaluate changes in replacement ICP, considering impact on users, documentation, and training. Additional changes may need to occur after the initial replacement.	Anderson, Pages 4, 12
3	Various menu changes (wording, order, add/delete items).	Evaluate changes in replacement, considering impact on users, documentation, and training. Additional changes may need to occur after the initial replacement.	Anderson, Page 5
4	The functionality to add or remove directories from within ICP should be	Evaluate the feature in design and revisit based on user feedback for	Anderson, Page 5

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#	Functionality/Issue	Design Action	Proposed by
	removed. However, other users appear to use this functionality.	the replacement ICP. This is a minor issue and does not need to be decided now.	
5	Remove ability to switch watersheds.	This recommendation seems to be based on bugs in ICP, limitations that should be avoidable in the new design (therefore consider allow switching watersheds).	Anderson, Page 5
6	Remove Relabel functionality to re-name or overwrite the input MCP3 deck from within ICP shall be removed.	Removing the feature will be considered if the design removes the need for this file management functionality.	Anderson, Page 6
7	Save time series other than SQME from the WY-PLOT operation.	This new functionality will NOT be implemented in the initial replacement but the design will not preclude its implementation in later updates.	Anderson, Page 7
8	Remove the Solve option under the Points item of the Select menu of the Percolation Analysis Curve PD vs. LZDEFR window (it does not work).	This feature will be removed as suggested but could be added to a later version if underlying functionality is corrected.	Anderson, Page 7
9	Add more intelligent defaults for selecting the PLOT-TS operation.	The new design will by default select the first items in lists in order to streamline user input. This will likely correct a number of usability issues.	Anderson, Page 8
10	The display for each PLOT-TS operation should include a title, similar to Water Year Plot displays.	This request will be implemented, assuming that the information for the title is available from the operation.	Anderson, Page 8
11	Remove Control menu from the PLOT-TS Display Adjustment window. Add	Evaluate the changes, considering impact on users, documentation,	Anderson, Page 8

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#	Functionality/Issue	Design Action	Proposed by
	an Okay button.	and training. This change would seem to increase usability with minor impact on design.	
12	The Help menu on the main Plot Time Series display should be moved to the right so that it is consistent with the Water Year Plot display.	The placement of Help menus is controlled by the look and feel. GUI look and feel issues should adhere to the standards for the operating system.	Anderson, Page 9
13	Capabilities need to be added to edit time series.	This functionality is NOT envisioned for the initial replacement ICP but can be added in a later release.	Anderson, Page 9-11
14	Models that are not in the input MCP3 deck shall not appear in the "Edit" menu for editing.	This is a basic usability issue that should be dealt with in the replacement ICP. For example, the models could be listed, but be disabled so that users cannot choose inappropriate values.	Anderson, Page 12
15	The API-CONT operation should be removed from the Selected Parameters list since the operation is not supported in ICP.	Remove from choices. Add in a later release if the operation is supported.	Anderson, Page 12
16	ICP shall set SAC-SMA parameter values to zero if negative parameters result from attempting to maintain the difference between models.	Fix this bug.	RTi
17	In the "Edit" – "Selected Parameters" menu, ICP shall allow the user to set the initial SAC-SMA state variables: UZTWC, UZFWC, LZTWC, LZFSC, LZFPC, and ADIMC.	These features will NOT be implemented in the initial replacement ICP but should be considered for a future enhancement.	Anderson, Page 13
18	Enhancements to UNIT-HG parameter	These features will NOT be	Anderson, Pages

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#	Functionality/Issue	Design Action	Proposed by
	edits.	implemented in the initial replacement ICP but should be considered for a future enhancement.	14-15
19	ICP shall set SNOW-17 parameter values to zero if negative parameters result from attempting to maintain the difference between models. One exception shall be the PXTEMP parameter that may be negative.	Fix this bug	RTi
20	Bugs identified by Anderson in Appendix A – February 2000.	Items identified as bugs or problems in existing functionality will be addressed in the design of the replacement ICP (existing bugs will not be perpetuated). New functionality (e.g., allowing time series to be edited) will not be added in the initial replacement ICP, but could be added in subsequent software updates.	Anderson, Appendix A ICP Status – February 2000.
21	"Major Enhancements" and "Other Possible Future Enhancements".	These features will NOT be implemented in the initial replacement ICP but should be considered for a future enhancement.	Anderson, Pages 15-19
22	r26-12 - When viewing a MCP3 deck the year in the display window is off by a year when crossing over into a new calendar year.	This bug will not be present in the initial replacement ICP.	ICP users
23	r27-23 - When time series of similar units but different time intervals are displayed together in a PLOT-TS	This bug will not be present in the initial replacement ICP.	ICP users

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#	Functionality/Issue	Design Action	Proposed by
	window, they shift relative to each other as the window is scrolled. As the total time covered in the display decreases, the problem becomes more and more apparent.		
24	r24-67 - ICP always displays in METRIC even though the label says they are in English. This fix was included in OB5.	This bug will not be present in the initial replacement ICP.	ICP users
25	r24-65 - The label for years 2000 or greater are displayed as three digits i.e. 100, 101, 102 etc. This fix was included in OB4.	This bug will not be present in the initial replacement ICP.	ICP users
26	Display time series in plot TS function - when zoomed in below a year view and when displaying time series of different time steps, the time series will incorrectly shift in relation to each other when scrolling through the data. This may be the same as item 23.	This bug will not be present in the initial replacement ICP.	ABRFC ICP users
27	Display in Water Year Plot - will not display in English units. This may be the same as item 24.	This bug will not be present in the initial replacement ICP.	ABRFC ICP users
28	Display in Water Year Plot - when scrolling through data, the years change incorrectly (i.e., it is confusing when moving through time and date changes from say 12/95 to 01/95 when moving from left to right). This may be the same as item 22.	This bug will not be present in the initial replacement ICP.	ABRFC ICP users

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Appendix C – ICP Functional Requirements and Decomposed Technical Requirements

This appendix contains a restatement of the ICP functional requirements (that were developed in a different format in a previous project and can now be found in their original format in Appendix D), as well as decomposed technical requirements for the areas of graphing, general technical requirements, performance, and hardware requirements. Consequently, the information herein provides information in a format suitable for developers. The use cases from Appendix D have not been reformatted here.

1. ICP Functional Requirements

The following table is a restatement of the functional requirements listed in Appendix D. *Note:* the shading in the table groups requirements according to functional areas.

ID	Title	Scope	Level	Use Case Satisfied	Description
ICP FR-1.0C	Application Environment	OS	Environment	ICP UC-1C	The ICP operating environment shall be set using the operating system environment or configuration files. This shall include directory locations and the path to the MCP3 executable program.
ICP FR-2.0C	Execution Path	OS	Environment	ICP UC-1C	The ICP execution path shall be set through the user's environment.
ICP FR-3.0C	GUI Start	GUI	Application	ICP UC-2C	The Graphical User Interface shall start when the user invokes a command from the OS.
ICP FR-4.0C	MCP3 Deck Selection	GUI	Application	ICP UC-3C	The ICP shall select an initial MCP3 deck through GUI menu and window components.
ICP FR-4.1C	Directory Creation and Deletion	OS/GUI	Environment	ICP UC-4C/ ICP UC-5C/ ICP UC-6C/ ICP UC-12C	ICP shall create or delete directories through GUI components during deck selection. The application environment shall indicate the base directory locations.

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ICP FR-4.2C	Copies Chosen Deck to Local Directory	OS	Application	ICP UC-13C	ICP shall work with a copy of the chosen MCP3 deck in the user's defined work directory. The work directory shall be defined in the application environment.
ICP FR-4.3C	Re-naming Chosen MCP3 Deck	OS/GUI	Application	ICP UC-7C	ICP shall be able to re-name the chosen MCP3 deck in the work directory. The user through GUI components shall choose the new name.
ICP FR-5.0C	Executes MCP3	OS/GUI	Application	ICP UC-8C	ICP shall execute MCP3 using the specified deck in the work directory. The user through GUI components shall invoke MCP3.
ICP FR-5.1C	MCP3 Output	OS	Application	ICP UC-13C	The ICP shall place MCP3 output in a user specified directory.
ICP FR-5.2C	MCP3 Notification	GUI	Application	ICP UC-9C	The ICP shall use GUI components to open a notification window of the completion and status of MCP3.
ICP FR-5.3C	Viewing MCP3 Output	GUI	Application	ICP UC-11C	The ICP shall use GUI components to open a window for viewing the text MCP3 output. These components shall have resizing and scrolling capabilities.
ICP FR-6.0C	Editing the Chosen MCP3 Input Deck	GUI	Application	ICP UC-10C	The user shall be able to edit the chosen MCP3 input deck by using standard GUI components.
ICP FR-6.1C	Making and Saving SAC-SMA Parameter Changes	GUI	Application	ICP UC-14C	The ICP shall use GUI components to edit SAC-SMA parameters in the chosen MCP3 deck. These parameters include UZK, PCTIM, ADIMP, RIVA, ZPERC, REXP, LZFPM, LZFSM, LZSK, LZPK, PFREE, and SIDE. The user can preserve the ratio/difference for specified parameters in any SAC model in a basin listed in the input deck.
ICP FR-6.1.1C	Editing ET-Demand Curves or PE Adjustment Factors	GUI	Application	ICP UC-15C	The ICP shall use GUI or plotting components to add or edit the monthly ET-Demand curve or the monthly PE adjustment factors.
ICP FR-6.2C	Making and Saving SNOW-17 Parameter Changes	GUI	Application	ICP UC-16C	The ICP shall use GUI components to edit SNOW-17 parameters in the chosen MCP3 deck. These parameters include SCF, MFMAX, MFMIN, NMF, UADJ, SI, DAYGM, MBASE, PXTEMP, PLWHC, and TIPM. The user can preserve the ratio/difference for selected parameters across multiple models in an input file for a basin.
ICP FR-6.2.1C	Editing AESC Curve	GUI	Application	ICP UC-17C	The ICP shall use GUI or plotting components to edit the nine monthly AESC curve values.

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ICP FR-6.3C	Editing the Unit Hydrograph Ordinates	GUI	Application	ICP UC-18C	The ICP shall use GUI or plotting components to add or edit Unit Hydrograph Ordinate values. The area under the curve represented by the UHG ordinates will be preserved as any editing is performed.
ICP FR-7.0C	WY-PLOT Operation Display	GUI	Application	ICP UC-19C/ICP UC-20C	The ICP shall use standard GUI and plotting components for creating the graphical plot of the WY-PLOT operation display.
ICP FR-7.1C	WY-PLOT Operation Display Data	GUI	Application	ICP UC-24C/ICP UC-25C/ICP UC-26C	The user shall be able to graphically display an instance of each of the SNOW-17, SAC-SMA, and WY-PLOT operations and have the ability to toggle through these multiple instances to display any model or operation result.
ICP FR-7.1.1C	WY-PLOT Operation Display Vertical Resize	GUI	Application	ICP UC-19C/ICP UC-20C	The ICP shall use plotting components to allow the user to resize in the vertical direction each of the sections of the WY-PLOT operation display.
ICP FR-7.1.2C	WY-PLOT Operation Display Date-Time Axis	GUI	Application	ICP UC-19C/ICP UC-20C	The ICP shall define the X-axis of the WY-PLOT operation display to be the date-time axis.
ICP FR-7.1.3C	WY-PLOT Operation Display Legend	GUI	Application	ICP UC-19C/ICP UC-20C	The ICP shall use GUI and plotting components to display a color-coded legend of the WY-PLOT operation display.
ICP FR-7.1.4C	WY-PLOT Operation Display Time Series View	GUI	Application	ICP UC-19C/ICP UC-20C	The user shall be able to toggle between arithmetic and log scale on the Y-axis.
ICP FR-7.1.5C	WY-PLOT Operation Display Data Value	GUI	Application	ICP UC-19C/ICP UC-20C	The ICP shall use GUI and plotting components to display a view of chosen date-time and time series value in the WY-PLOT operation display. The user shall be able to 'click' in the WY-PLOT near the time series to determine the date/hour and value of the time series.
ICP FR-7.1.6C	WY-PLOT Operation Display Hydrograph Scrolling	GUI	Application	ICP UC-19C/ICP UC-20C	The ICP shall use plotting components to allow the user to scroll through the hydrograph. The user shall be able to do this either continuously with a scrollbar or by selected date-time intervals.
ICP FR-7.1.7C	WY-PLOT Operation Display SAC-SMA Data Axis	GUI	Application	ICP UC-19C	The ICP shall define the Y-axis of the WY-PLOT operation display to be the data axis in units determined by the units of the time series.
ICP FR-7.1.8C	WY-PLOT Operation Display SAC-SMA Zone Contents	GUI	Application	ICP UC-19C	The ICP shall plot UZTW and LZTW as deficits and UZFW, LZFSW, and LZFPW as contents in the WY-PLOT SAC-SMA operation display.

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ICP FR-7.1.9C	WY-PLOT Operation Display SAC-SMA Runoff	GUI	Application	ICP UC-19C	The ICP shall plot the percent of total runoff from each of the six runoff components: surface, direct, impervious, interflow, supplemental base flow, and primary base flow. The ICP shall also show rain plus melt and total runoff.
ICP FR-7.1.10C	WY-PLOT Operation Display SNOW-17 Plots	GUI	Application	ICP UC-20C	The ICP shall plot the following values in the WY-PLOT SNOW-17 operation display: rain/snow elevation, type of precipitation, energy exchange, air temperature, TINDEX, snow temperature, liquid water fraction, rain plus melt and negative heat storage, rain on bare ground, rain plus melt on snow covered area, area extent of snow cover, water equivalent of snow pack, and observed and simulated snow depth.
ICP FR-7.2C	WY-PLOT Time Series Locator	GUI	Application	ICP UC-21C	The ICP shall use plotting components to display a small time series plot of the entire WY-PLOT time series. This plot shall be used to locate and scroll to specific events in the time series.
ICP FR-7.3C	WY-PLOT Time Series Date Range	GUI	Application	ICP UC-21C	The ICP shall use GUI and plotting components to allow the user to change the range of allowed date values in the X-direction. The default values shall be obtained from the chosen MCP3 deck.
ICP FR-7.4C	WY-PLOT Time Series Data Range	GUI	Application.	ICP UC-22C	The ICP shall use GUI and plotting components to allow the user to change the range of allowed data values in the Y-direction. The default values shall be obtained from the chosen MCP3 deck
ICP FR-7.5C	Saving WY-PLOT Time Series	OS/GUI	Application	ICP UC-23C	The ICP shall be able to save current SQME time series for use on subsequent WY-PLOT displays. The ICP shall use GUI components to select a location to save the time series.
ICP FR-7.6C	Using saved WY-PLOT Time Series	GUI	Application	ICP UC-27C	The ICP shall use GUI and plotting components to display saved SQME time series on the current WY-PLOT.
ICP FR-7.7C	Modifying the SAC-SMA Percolation Demand Curve	GUI	Application	ICP UC-28C	The ICP shall use GUI and plotting components to allow the user to modify the percolation demand curve by changing the following parameters: ZPERC, REXP, LZFSM, and LZFPM.
ICP FR-8.0C	PLOT-TS Operation Display	GUI	Application	ICP UC-29C/ ICP UC-33C	The ICP shall use standard GUI and plotting components for creating the graphical plot of the PLOT-TS operation that is defined by the chosen MCP3 deck.
ICP FR-8.1C	PLOT-TS Operation Display Data	GUI	Application	ICP UC-29C	The user shall be able to graphically display any instance of PLOT-TS information.

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ICP FR-8.1.1C	PLOT-TS Operation Display Vertical Resize	GUI	Application	ICP UC-33C	The ICP shall use plotting components to allow the user to resize in the vertical direction each of the sections of the PLOT-TS operation display.
ICP FR-8.1.2C	PLOT-TS Operation Display Date-Time Axis	GUI	Application	ICP UC-33C	The ICP shall define the X-axis of the PLOT-TS operation display to be the date-time axis.
ICP FR-8.1.3C	PLOT-TS Operation Display Data Axis	GUI	Application	ICP UC-33C	The ICP shall define the units of the Y-axis of the PLOT-TS operation display based upon the units of the time series type.
ICP FR-8.1.4C.	PLOT-TS Operation Display Time Series View	GUI	Application	ICP UC-33C	The ICP shall use GUI and plotting components to display a view of chosen date-time and time series value in the PLOT-TS operation display. The user can toggle between Log and arithmetic scales in any display pane
ICP FR-8.1.5C	PLOT-TS Operation Display Hydrograph Scrolling	GUI	Application	ICP UC-33C	The ICP shall use plotting components to allow the user to scroll through the display. The user shall be able to do this either continuously with a scrollbar or by selected date-time intervals.
ICP FR-8.2C	PLOT-TS Operation Display Legend	GUI	Application	ICP UC-32C	The ICP shall use GUI and plotting components to display a color-coded legend of the PLOT-TS operation display.
ICP FR-8.3C	PLOT-TS Time Series Locator	GUI	Application	ICP UC-30C.	The ICP shall use plotting components to display a small time series plot of the entire PLOT-TS time series. This plot shall be used to locate and scroll to specific events in the time series
ICP FR-8.4C	PLOT-TS Time Series Date Range	GUI	Application	ICP UC-31C	The ICP shall use GUI and plotting components to allow the user to change the range of allowed date values in the X-direction. The default values shall be obtained from the chosen MCP3 deck.
ICP FR-8.5C	PLOT-TS Time Series Data Range	GUI	Application	ICP UC-31C	The ICP shall use GUI and plotting components to allow the user to change the range of allowed data values in the Y-direction. The default values shall be obtained from the chosen MCP3 deck.
ICP FR-8.6C	Saving PLOT-TS Time Series	OS/GUI	Application	ICP UC-34C	The ICP shall be able to save current PLOT-TS time series for use on subsequent PLOT-TS displays. The ICP shall use GUI components to select a location to save the time series.
ICP FR-8.7C	PLOT-TS Time Series Display Data Value	GUI	Application	ICP UC-33C	The user can ‘click’ in any display pane near a plotted time series to get the day/time/value of the point in the time series.

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ICP FR-8.8C	Using saved PLOT-TS Time Series	GUI	Application	ICP UC-35C	The ICP shall use GUI and plotting components to display saved time series on the current PLOT-TS.

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2. Properties and Requirements Specific to ICP Graphs

This section describes the properties of all graphs shown in ICP in order to define technical requirements for graphing components. An attempt has been made to use terminology consistent with the ICP manual.

2.1 Graph Properties

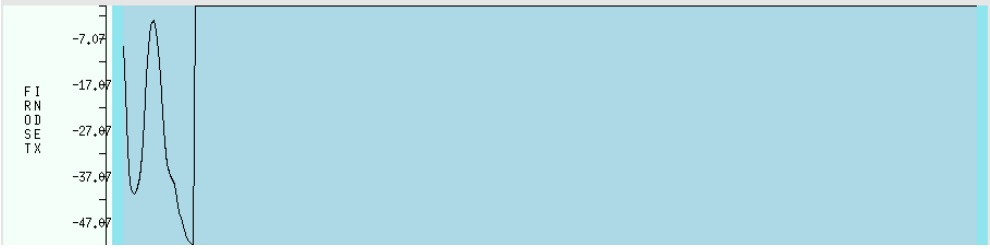

Figure 1: Frost Index Pane

2.1.1 WY Plot SAC-SMA Operation Display – Frost Index Pane

Data	Frost Index (if present in the input deck) from zero degrees.
Graph Type	Line graph
Default Color	Line is black, background is colored blue
Label	FROST INDEX, Y-axis labeled in degrees
Vertical Resize?	Yes

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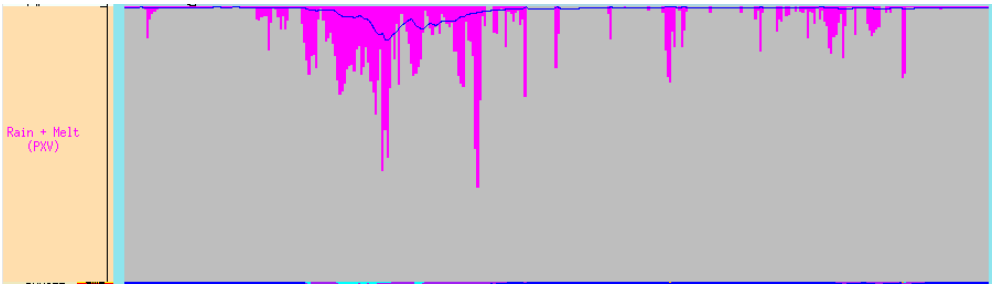

Figure 2: Rain + Melt Pane

2.1.2 WY Plot SAC-SMA Operation Display – Rain + Melt Pane

Data	Rain + Melt (bar chart) and Runoff data (line chart)
Graph Type	Bar chart from top down overlaid with a line graph
Default Color	Line is blue; rain + melt is indicated as descending magenta bars with a beige background
Label	Left Y-axis label is “Rain + Melt (PXV)” with no scale.
Vertical Resize?	Yes

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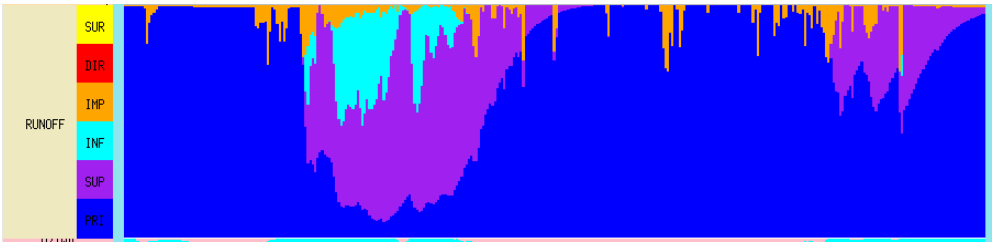

Figure 3: Runoff Pane

2.1.3 WY Plot SAC-SMA Operation Display – Runoff Pane

Data	Runoff data, which is comprised of 6 different components: SUR, DIR, IMP, INF, SUP, and PRI.
Graph Type	Bar chart plotted from top down. Bars are shown in the graph and color coded to match the runoff component they represent. Bars are centered on x-axis.
Default Color	The runoff components are represented by the following colors: SUR = yellow DIR = red IMP = orange INF = light blue SUP = purple PRI = royal blue
Label	Left Y-axis labeled “Runoff” and also includes a legend indicating the color that each runoff component represents
Vertical Resize?	Yes

Figure 4: UZTWD Pane

2.1.4 WY Plot SAC-SMA Operation Display – UZTWD Pane

Data	UZTWD
Graph Type	Bar chart from top down
Default Color	UZTWD is colored in pink, the background is colored in blue
Label	Left Y-axis labeled “UZTWD” and indicates the maximum value by “max:” There is no scale present.
Vertical Resize?	Not individually. The UZTWD, LZTWD, UZFWC, LZFSC, and LZFPC graphs are all sized together with proportional stretching.

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Figure 5: LZTWD Pane

2.1.5 WY Plot SAC-SMA Operation Display – LZTWD Pane

Data	LZTWD
Graph Type	Bar chart from top down
Default Color	LZTWD is colored in pink, the background is colored in blue
Label	Left Y-axis labeled “LZTWD” and indicates the maximum value by “max:” There is no scale present.
Vertical Resize?	Not individually. The UZTWD, LZTWD, UZFWC, LZFSC, and LZFPC graphs are all sized together with proportional stretching.

Figure 6: UZFWC Pane

2.1.6 WY Plot SAC-SMA Operation Display – UZFWC Pane

Data	UZFWC
Graph Type	Bar chart from top down
Default Color	UZFWC is colored in pink, the background is colored in blue
Label	Left Y-axis labeled “UZFWC” and indicates the maximum value by “max:” There is no scale present.
Vertical Resize?	Not individually. The UZTWD, LZTWD, UZFWC, LZFSC, and LZFPC graphs are all sized together with proportional stretching.

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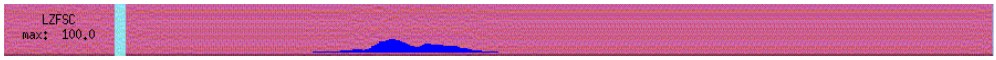

Figure 7: LZFSC Pane

2.1.7 WY Plot SAC-SMA Operation Display – LZFSC Pane

Data	LZFSC
Graph Type	Bar chart from top down
Default Color	LZFSC is colored in pink, the background is colored in blue
Label	Left Y-axis labeled “LZFSC” and indicates the maximum value by “max:” There is no scale present.
Vertical Resize?	Not individually. The UZTWD, LZTWD, UZFWC, LZFSC, and LZFPC graphs are all sized together with proportional stretching.

Figure 8: LZFPC Pane

2.1.8 WY Plot SAC-SMA Operation Display – LZFPC Pane

Data	LZFPC
Graph Type	Bar chart from top down
Default Color	LZFPC is colored in pink, the background is colored in blue
Label	Left Y-axis labeled “LZFPC” and indicates the maximum value by “max:” There is no scale present.
Vertical Resize?	Not individually. The UZTWD, LZTWD, UZFWC, LZFSC, and LZFPC graphs are all sized together with proportional stretching.

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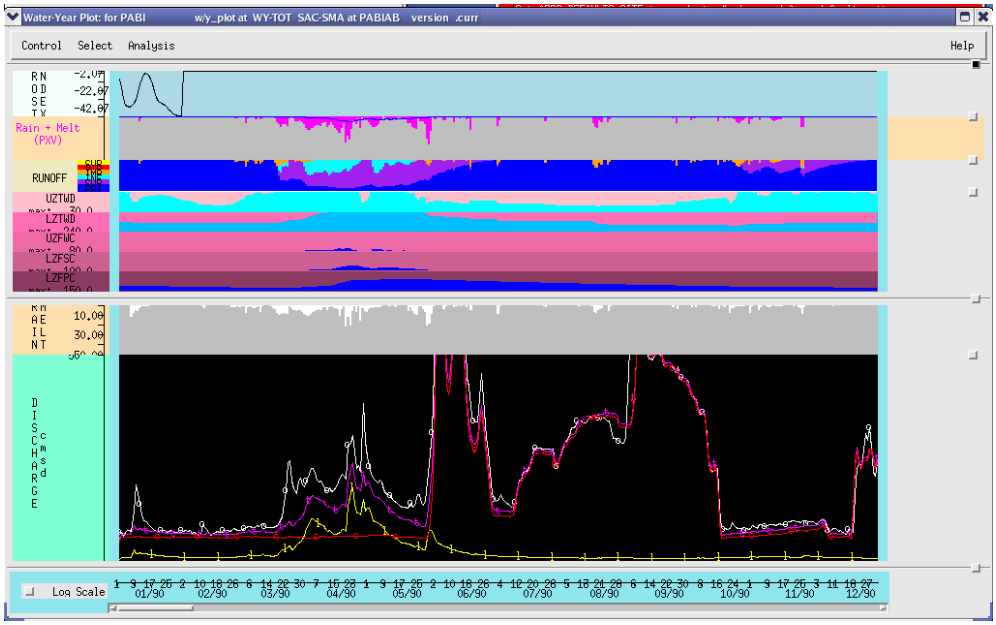

Figure 9: SAC-SMA Operation Display

2.1.9 WY Plot SAC-SMA Operation Display

Other	The user shall be able to view a “thumbnail”/overview of the entire WY plot time series, including an indicator for the portion of the time series that is shown in the display. The user shall be able to interact with the "thumbnail" view of the WY plot to view points in the main WY plot. When the user right-clicks on a point in the discharge graph a vertical and horizontal crosshair appears to show the date/time and time series value for the point on the line.

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Figure 10: PRECIP/Rain Snow Elevation Pane

2.1.10 WY Plot Snow-17 Operation Display – PRECIP/Rain Snow Elevation Pane

Data	Rain and Snow precipitation and elevation levels
Graph Type	Continuous bar chart overlaid with bar chart plotted from top down
Default Color	The rain precipitation is plotted as white bars. The snow precipitation is plotted as blue bars. The rain/snow elevation is plotted as a continuous blue bar. The background is colored beige.
Label	The left Y-axis is labeled “PRECIP (mm)” and has a scale starting at the top and increasing as the line goes down. The right Y-axis is labeled “R/S Elev” in units of meters. The right Y-axis scale starts at the bottom and increases as the line goes up.
Vertical Resize?	Yes

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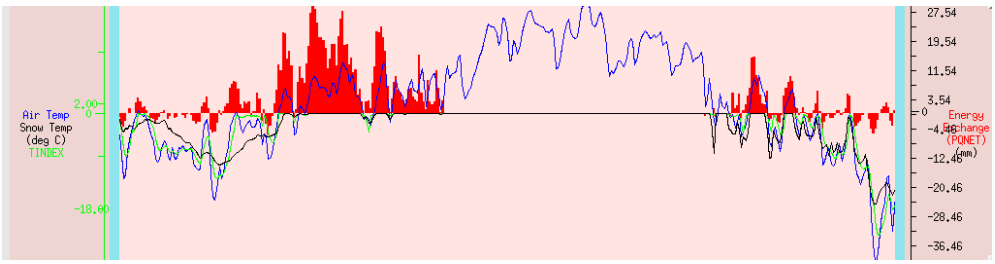

Figure 11: Air Temp/Snow Temp/TINDEX/Energy Exchange Pane

2.1.11 WY Plot Snow-17 Operation Display – Air Temp/Snow Temp/TINDEX/Energy Exchange Pane

Data	Air temp, snow temp, TINDEX, and energy exchange
Graph Type	Bar chart overlaid with a line chart
Default Color	Air temp is plotted as a light blue line. Snow temp is plotted as a black line. TINDEX is plotted as a green line. Energy exchange is plotted as red bars.
Label	The left Y-axis is labeled “Air Temp”, “Snow Temp (deg C)”, and “TINDEX”. The right Y-axis scale is labeled “Energy Exchange (PQNET) (mm)”.
Vertical Resize?	Yes
Legend	The color of the axis label indicates how that data is represented. The Air Temp label on the axis is colored blue to indicate that the blue line represents air temp. The Snow Temp label on the axis is colored black to indicate that the black line represent snow temp line. The TINDEX label on the axis is colored green to indicate that the green line represents TINDEX. The Energy Exchange label is colored red to indicate that the red bars represent Energy Exchange.

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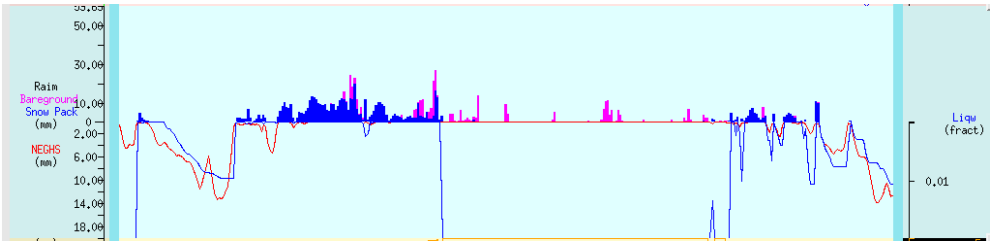

Figure 12: Raim, Bareground, Snow Pack, NEGHS, Liwq Pane

2.1.12 WY Plot Snow-17 Operation Display – Raim, Bareground, Snow Pack, NEGHS, Liqw Pane

Data	Raim (rain plus melt), Bareground, Snow pack, NEGHS, and Liqw levels
Graph Type	Bar chart overlaid with a line chart
Default Color	The stacked blue and magenta bars represent total raim. Bareground raim is plotted by magenta and snow pack raim is plotted by blue. NEGHS is plotted as a red line. LiqW is plotted as a blue line.
Label	The left Y-axis is labeled “Raim”, “Bareground’, “Snow Pack (mm)”, and ‘NEGHS (mm)”. The right Y-axis is labeled “Liqw” (fract”) and only shows the negative scale. The background is light blue.
Vertical Resize?	Yes
Legend	The color of the axis label indicates how that data is represented. The Bareground label on the axis is colored magenta to indicate that the magenta bars represent raim bareground. The Snow Pack label on the axis is colored blue to indicate that the blue bars represent raim snow pack. The NEGHS label is colored red to indicate that the red line represents NEGHS. The Liqw label is colored blue to indicate that the blue line represents Liqw.

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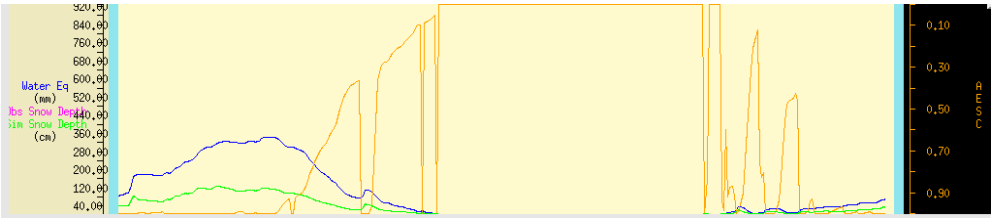

Figure 13: Water Eq, Obs Snow Depth, Sim Snow Depth, AESC Pane

2.1.13 WY Plot Snow-17 Operation Display – Water Eq, Obs Snow Depth, Sim Snow Depth, AESC Pane

Data	Water Eq, Obs Snow Depth, Sim Snow Depth, AESC
Graph Type	Line chart
Default Color	Water Eq is plotted as a blue line. Obs Snow Depth is plotted as a magenta line. Sim Snow Depth is plotted as a green line. AESC is plotted as an orange line. The background is light yellow.
Label	The left Y-axis is labeled “Water Eq (mm)”, “Obs Snow Depth”, “Sim Snow Depth” (cm)”. The left Y-axis has a scale. The right Y-axis is labeled “AESC”. The right Y-axis has a scale. Right Y-axis scale is plotted from the top-down.
Vertical Resize?	Yes
Legend	The color of the axis label indicates how that data is represented. The Water Eq label on the axis is colored blue to indicate that the blue line represents Water Eq. The Obs Snow Depth label on the axis is colored magenta to indicate that the magenta bars represent observed snow depth. The Sim Snow Depth label is colored green to indicate that the green line represents simulated snow depth. The AESC label is colored orange to indicate that the orange line represents AESC.

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Figure 14: Rain + Melt Pane

2.1.14 WY Plot– Rain + Melt Pane

Data	Rain + Melt
Graph Type	Bar chart from top down
Default Color	Rain melt is indicated by white bars; the background is colored beige
Label	Left Y-axis labeled “Rain Melt” and a scale is present, starting at the top and increasing as the line descends.
Vertical Resize?	Yes
Other	The Rain Melt graph is the same for either a SAC or Snow model.

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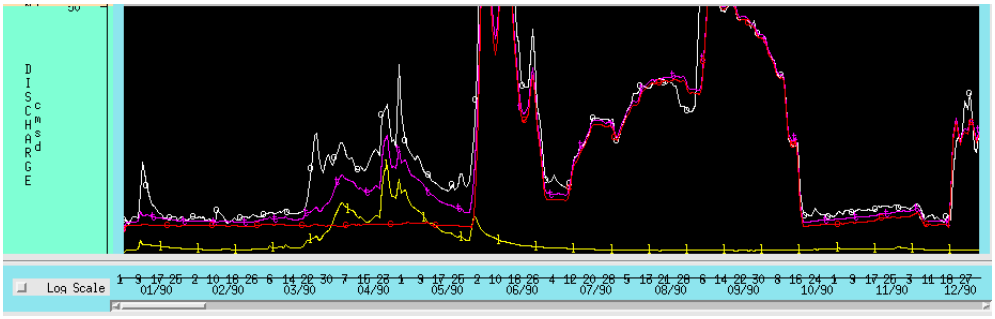

Figure 15: WY Plot Operation Display - Discharge Pane

2.1.15 WY Plot Operation Display – Discharge Pane

Data	Observed and simulated discharge
Graph Type	Line graph
Default Color	Observed data is plotted in white; simulated data is plotted in pink. Previous simulation is plotted in pink dashed lines.
Label	Left Y-axis labeled “DISCHARGE” and the units cmsd (for arithmetic scale) are also labeled. For log scale the Y-axis units are units of runoff (mm). The X-axis displays the date.
Vertical Resize?	Yes
Other	The WY Plot is the same for either a SAC or Snow model. User can easily change between log or arithmetic scale from the UI (today this is done by toggling a checkbox). The user shall be able to click on the graph and view the numerical value of the date/time and the time series value. When the screen is maximized, the user shall be able to view one year’s worth of data in a single window. The user shall be able to scroll horizontally to see other years. The user shall be able to scroll horizontally by manually moving the scrollbar, by left-clicking and holding in the WY Plot scrollbar, or by left-clicking in the WY Plot and dragging the mouse left or right (cursor changes to a hand icon). Note: when scrolling on the Discharge graph, all other graphs will also scroll horizontally. The user may adjust the X-axis and the WY-PLOT Y-axis scales by selecting the Change Analysis Window.

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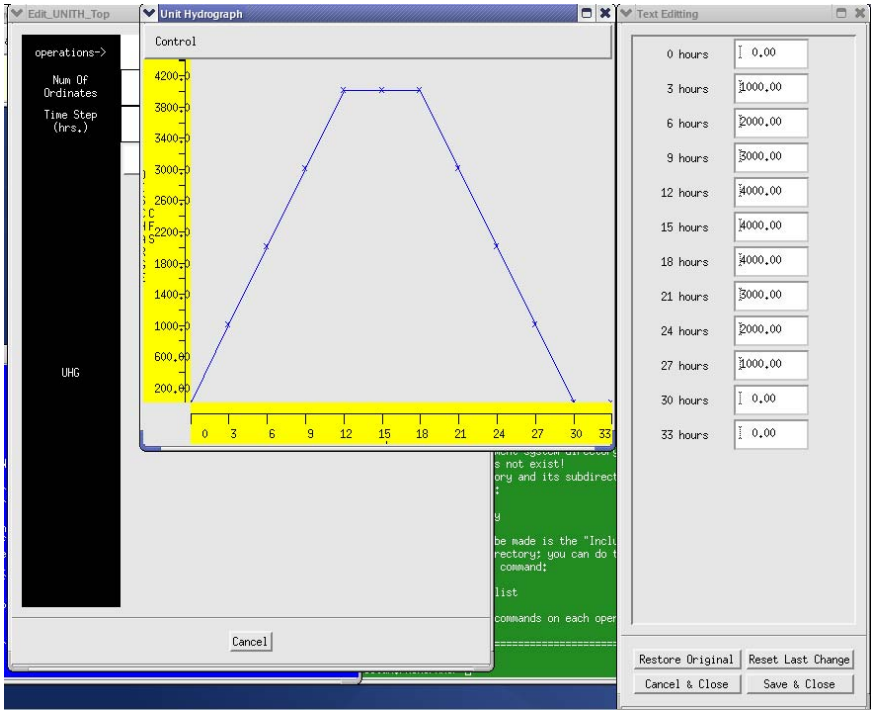

Figure 16: Unit Hydrograph

2.1.16 Unit Hydrograph

Data	Time series of discharge
Graph Type	Line
Default Color	Line is plotted in blue. Background is gray. X and Y-axes are highlighted in yellow.
Label	The left Y-axis is labeled “Discharge CFS” and the X-axis is labeled in units of time as defined by the graph.
Other	The user shall be able to edit the Unit Hydrograph ordinates by changing the values in the table or directly on the plot. The changes to the plot take effect in the table, and vice versa. The user is able to restore original values to the table/plot. The user is able to reset the last edit made to the table/plot. The user is able to cancel all edits made to the table and close the table/plot. The user is able to save all edits made to the table/plot and close the table/plot. The line has tick marks for the intersecting X points. The user is able to click a tick mark on the plot and drag it to a new value/position along the y-axis. This new value is reflected in the table.

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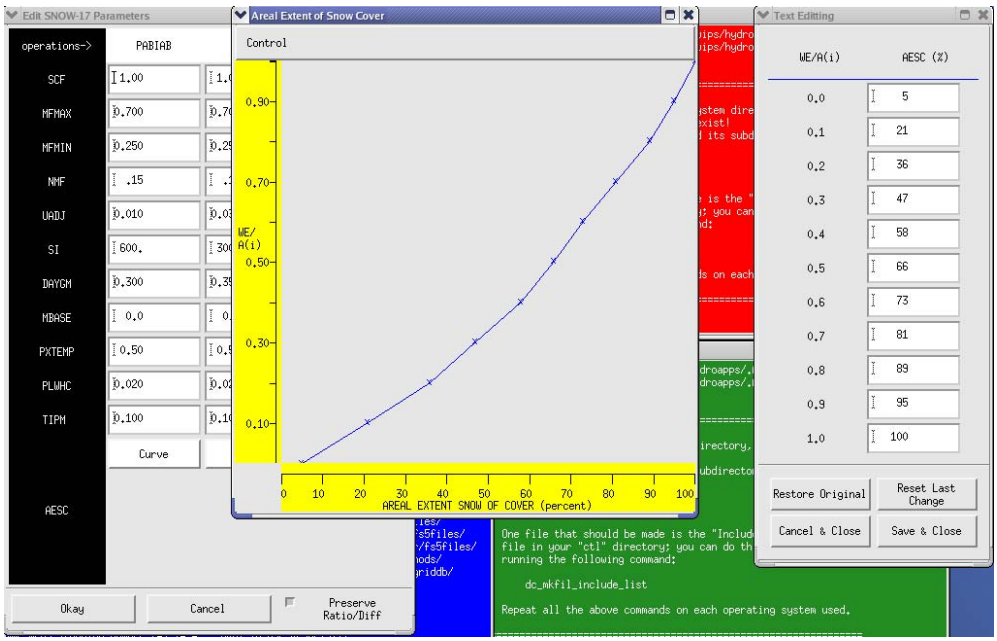

Figure 17: AESC Curve Graph

2.1.17 AESC Curve Graph

Data	Time series of discharge
Graph Type	Line
Default Color	Line is plotted in blue. Background is gray. X and Y-axes are highlighted in yellow.
Label	The left Y-axis is labeled “WE/A(i)” and the X-axis is labeled “AREAL EXTENT SNOW OF COVER (percent)”. The X-axis scale ranges from 0 to 100 percent.
Other	The user shall be able to edit the AESC curve ordinates by changing the values in the table or directly on the plot. The changes to the plot take effect in the table, and vice versa. The user is able to restore original values to the table/plot. The user is able to reset the last edit made to the table/plot. The user is able to cancel all edits made to the table and close the table/plot. The user is able to save all edits made to the table/plot and close the table/plot. The line has tick marks for the intersecting X points. The user is able to click a tick mark on the plot and drag it to a new value/position along the y-axis. This new value is reflected in the table.

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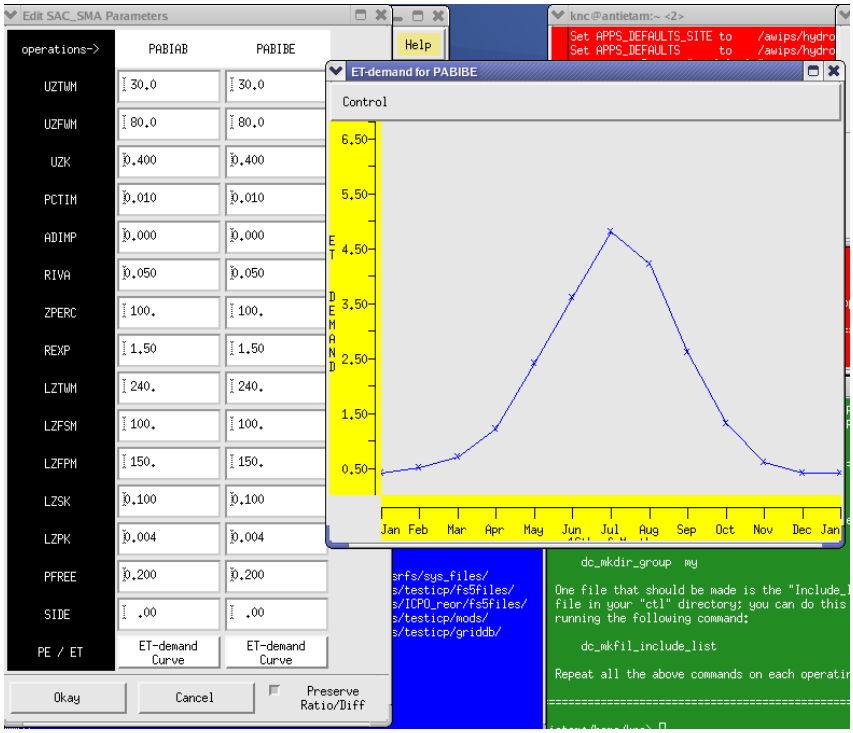

Figure 18: ET-demand Curve

2.1.18 ET-demand Curve

Data	Et-demand vs. time in months
Graph Type	Line
Default Color	Line is plotted in blue. Background is gray. X and Y-axes are highlighted in yellow.
Label	The left Y-axis is labeled “ET DEMAND” and the X-axis is labeled in months. The X-axis scale shows dates by month. Data points are indicated on the line by “X” symbols.
Other	The user shall be able to edit the Et-demand curve ordinates by changing the values in the table or directly on the plot. The changes to the plot take effect in the table, and vice versa. The user is able to restore original values to the table/plot. The user is able to reset the last edit made to the table/plot. The user is able to cancel all edits made to the table and close the table/plot. The user is able to save all edits made to the table/plot and close the table/plot. The user is able to click a tick mark on the plot and drag it to a new value/position along the y-axis. This new value is reflected in the table.

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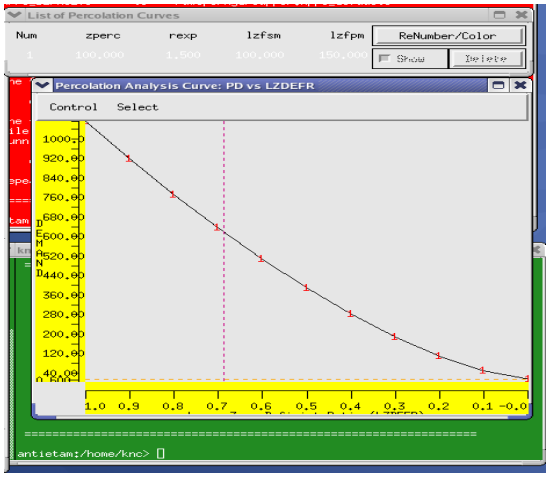

Figure 19: Percolation Analysis Curve

2.1.19 Percolation Analysis Curve

Data	Percolation demand vs. lower zone deficit ratio (LZDEFR)
Graph Type	Line
Default Color	Line is plotted in black. Background is gray. X and Y-axes are highlighted in yellow. A vertical crosshair appears in red.
Label	The left Y-axis is labeled “Percolation Demand” and the X-axis is labeled “Lower Zone Deficit Ratio (LZDEFR)”. Data points on the line are indicated by number symbols for the dataset that the line represents.
Other	If the user switches to the WY Plot view while the Percolation Analysis Curve is open, the cursor appears as a cross hair. If the user clicks in the WY Plot, the Percolation Analysis Curve shows a vertical line drawn through the point on the percolation curve corresponding to the point that was clicked on the WY plot. A default curve is always displayed and colored in black. The default curve cannot be hidden or deleted. The user shall be able to create multiple new curves by manually entering new values for the variables zperc, rexp, lzfsm, and lzfpm. The system assigns a unique color and a new number to the new curve. For each percolation curve the user is able to see the associated values of the variables zperc, rexp, lzfsm, and lzfpm. The user is able to select to assign new numbers and colors to the curves. The system determines the new numbers and colors for the curves. The user is able to show or hide the curves. The default curve can never be hidden. The user is able to delete curves. The default curve can never be deleted. When the user closes the Percolation Analysis Curve the WY Plot cursor resumes its normal arrow shape.

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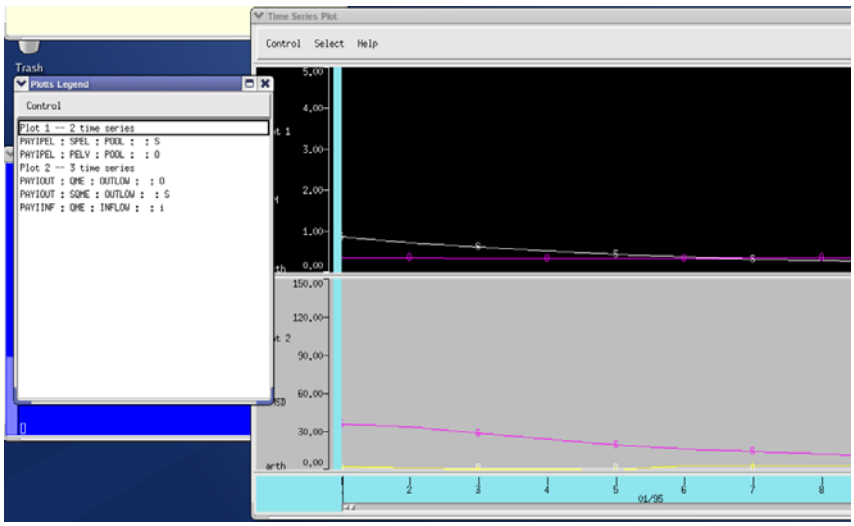

Figure 20: Plot-TS

2.1.20 Plot-TS

Data	Time series plot of a user time series.
Graph Type	Line
Default Color	Color determined in input deck.
Label	The left Y-axis is labeled with the plot name “Plot X” where X is the plot number and with the Y-axis variable name. The left Y-axis shows a scale, determined by the user in the input deck. The X-axis (the same X axis for both plots) is labeled with time. The plotted lines are also labeled, using symbols as specified by the user in the input deck.
Vertical resize?	Yes
Other	The user shall be able to choose to show multiple time series charts, stacked on top of each other. The user shall be able to view a legend that displays the plot name, the symbols used in the line plot, and the meaning of the symbols. The user shall be able to change the Y-axis and X-axis scales for each plot. The user shall be able to modify the visible extent for the plot. The user shall be able to modify the maximum for the plot. The user shall be able to modify the minimum for the plot. The user shall be able to scroll horizontally using a scrollbar or by left-clicking in the plot and dragging. The user shall be able to right-click in a plot to see the date and Y-axis value for the point closest on the line to where the user clicked. A vertical crosshair will appear for the point.

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2.2 Summary of Graph Component Requirements

This section describes the technical requirements for the component that will be used to create ICP graphs. This table will be used to document the evaluation of candidate graphing packages.

ID Number	Requirement	Priority	Applies to Graph Type
2.1	The graphing component must support line, bar, and area graphs of time series data.	Must	WY Plot
2.2	The graphing component provides API support for retrieving points plotted on a graph.	Must	WY Plot
2.3	The graphing component must support the ability to plot multiple types of graphs (I.e. time series plot and a bar chart, etc.)	Must	WY Plot
2.4	The graphing component must provide support for plotting bar charts from the top down. The Y-axis scale also starts from the top down for these types of graphs.	Must	WY Plot
2.5	The graphing component must support the ability to customize line and background color for the graph.	Must	WY Plot, Plot-TS
2.6	The graphing component must support the ability to display an overview of the WY plot, a ”thumbnail” version of the main WY plot. The user should be able to scroll on parts of the WY plot thumbnail and the main WY plot will display that portion of the WY plot.	Must	WY Plot, Plot-TS
2.7	The graphing component must support the ability to create multiple Y-axis labels for either sides of the graph.	Must	WY Plot
2.8	The graphing component must support the ability to create a color-coded legend.	Must	WY Plot, Plot-TS
2.9	The graphing component must provide for vertical resize.	Must	WY Plot, Plot-TS
2.10	The graphing component ideally provides support for stacking multiple charts vertically but using the same X-axis (of the discharge graph) and allowing for horizontal scrolling among all of the graphs.	Must	WY Plot
2.11	The graphing component provides for "windowing" data, i.e. showing only one year of data at a time.	Must	WY Plot, Plot-TS
2.12	The graphing component provides support for toggling between arithmetic and log scales for the data axis.	Must	WY Plot, Plot-TS

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ID Number	Requirement	Priority	Applies to Graph Type
2.13	The graphing component provides support for a legend to be displayed on the graph.	Must	WY Plot
2.14	The graphing component provides support for clicking on a point on a line and determining the actual date/time and time series value for that point.	Must	WY Plot, Plot-TS
2.15	The graphing component provides support for displaying a vertical line/crosshair on the WY plot.	Must	WY Plot, Plot-TS
2.16	The graphing component provides support for configuration of graph properties, including background and foreground color, symbols on the lines.	Must	All
2.17	The graphing component provides support for allowing the user to select a saved set of points to plot on the graph.	Must	WY Plot, Plot-TS
2.18	The graphing component provides support for allowing the user to select points on the graph to save.	Must	WY Plot, Plot-TS
2.19	The graphing component provides support for horizontal scrolling via a scrollbar.	Must	WY Plot, Plot-TS
2.20	The graphing component provides support for horizontal scrolling via clicking and dragging in the WY plot.	Must	WY Plot
2.21	The graphing component provides support for drag and drop movement of plotted points on a line, either along the X-axis or for the Y-axis.	Must	Unit Hydrograph, ET-demand curve hydrograph, AESC curve hydrograph
2.22	The graphing component provides support for editing ordinate values in a table and seeing the ordinate updated in the plot, as well as vice versa.	Must	Unit Hydrograph
2.23	The graphing component provides support for canceling all edits made to the graph (since it was last saved) and restoring original values.	Must	Unit Hydrograph
2.24	The graphing component provides support for canceling the last edit made to the graph.	Must	Unit Hydrograph
2.25	The graphing component provides support for labeling the X and Y axis	Must	All
2.26	The graphing component must provide support for time series graphs.	Must	Unit Hydrograph, ET-demand curve hydrograph, AESC curve hydrograph
2.27	The graphing component provides zoom capabilities.	Want	WY Plot

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ID Number	Requirement	Priority	Applies to Graph Type
2.28	The graphing component provides support for printing	Want	All
2.29	The graphing component provides support for saving graphs to an image file, .png or .jpg	Want	All
2.30	The graphing component provides support for importing data from a standard format (i.e. CSV)	Want	All
2.31	The graphing component provides support for exporting data to a standard format (i.e. CSV)	Want	All
2.32	The graphing component provides support for changing the background color for printing.	Want	All
2.33	The graphing component provides support for popup menus on the graph.	Want	All
2.34	The graphing component provides support for context sensitive popup menus.	Want	All
2.35	The vertical line extends to all graphs stacked on top of the WY plot.	Want	WY Plot
2.36	The graphing component provides support for extracting a data value for a point on a graph and displaying the mouse position in data coordinates.	Want	WY Plot, Plot-TS
2.37	For points where there are missing data, the graphing component shall plot no points in the graph (i.e. there will be a gap)	Must	All
2.38	The graphing component shall not connect the lines when no time series data are available.	Must	All

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3. General Technical and UI Requirements

This section describes general technical requirements.

ID Number	Requirement	Priority
3.1	The ICP replacement will be developed using Java version 1.5.0.	Must
3.2	ICP will be implemented and tested on Linux version rhel4u2 (2.6.x).	Must
3.3	ICP code will be compiled with Ant version 1.6.2.	Must
3.4	Automated Java regression tests for ICP will be implemented using Junit version 3.8.1.	Must
3.5	The ICP code will contain comments, including header comments and general comments for algorithms to enable better maintainability, and will adhere to OHD coding standards.	Must
3.6	ICP will support the use of external editors for viewing the wide output listing.	Must
3.7	ICP will be implemented in the default Java look and feel for Linux.	Must
3.8	ICP will provide support for logging of messages to a file, for either error handling or debug purposes.	Must
3.9	ICP will not support password protection for creating new files (OS constraints will apply).	Must
3.10	ICP will observe App defaults and environment variables currently available today.	Must
3.11	ICP documentation will be provided in Word.	Must
3.12	ICP version information will be available to the user in the UI.	Must
3.13	The MCP3 Fortran executable will generate an output listing and interact with ICP as it does today.	Must
3.14	ICP will validate values that are entered for model properties and notify the user if the values are out of range.	High Want

4. Performance Requirements

This section contains information about the ICP performance requirements.

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ID Number	Requirement	Priority
4.1	Startup time shall be comparable or faster than current ICP startup time.	Must
4.2	Time to plot data on WY-PLOT shall be comparable to or faster than current ICP WY-PLOT time.	Must
4.3	Time to execute MCP3 shall be comparable to or faster than current MCP3 execution time.	Must
4.4	Time to save deck parameters shall be comparable to or faster than current saving time.	Must
4.5	Time to scroll WY-PLOT shall be comparable to or faster than current time to scroll WY-PLOT.	Must
4.6	Time to move points on Unit HG/AESC curve/ET-demand curve shall be comparable to or faster than current time to move points on these graphs.	Must
4.7	Time to rename input deck shall be comparable to or faster than the current time to rename an input deck.	Must
4.8	Time to plot saved SQME points shall be comparable to or faster than the current time to plot saved SQME points.	Must

5. Hardware Requirements

The following section describes hardware requirements for ICP.

ID Number	Requirement	Priority
5.1	ICP shall target users running software on computers with 1 to 3 monitors.	Must
5.2	ICP software shall be developed for and accepted on computers compatible with the AWIPS OB8.2 release.	Must

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Appendix D – Task Completion Report Including Original Use Cases and Requirements

Task Completion Report

Task 3-0003
Interactive Calibration Program (ICP) Functional Requirements
Deliverable 3
Functional Requirements for the ICP Application

submitted to

National Weather Service/NOAA
Office of Hydrologic Development
1325 East-West Highway
Silver Spring, Maryland, 20910
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by

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October 2004

A report of Riverside Technology, inc. to the National Oceanic and Atmospheric Administration pursuant to NOAA Contract No. DG133W-03-CQ-0021, Task 3-0003

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Introduction

The National Weather Service (NWS) is responsible for issuing warnings during life threatening weather situations, including flooding events. The mission of the Office of Hydrologic Development (OHD) is to develop and use science, software, and information for river and stream forecasts that will provide lead-time for warnings of flooding events. Well-calibrated hydrologic and hydraulic models are critical components of accurate and timely flood warnings.

The Interactive Calibration Program (ICP) has been used since 1998 to calibrate models in the NWS River Forecast System (NWSRFS). ICP is a great improvement over the batch mode of running model calibrations that had been used previously. ICP allows users to make many runs and analyze the results within a relatively short period of time. The ICP displays give the forecasters necessary insights into how the models operate in order to effectively make real-time adjustments to model parameters with the forecast system.

In addition, ICP serves as a major tool in hydrologic research and development. For example, ICP was used in the development of the new frozen ground component of the Sacramento model. In addition, ICP was used to display participants' simulations at the recent concluding workshop of the Distributed Model Intercomparison Project (DMIP)(Reed et al., 2004). In this case, the use of ICP allowed 12 participating groups to see their simulations plotted simultaneously, allowing for efficient and objective evaluation.

ICP allows users to select a watershed and execute the manual calibration program (MCP3) to perform the hydrologic computations for the entire run period. MCP3 writes data values and other information to output files that are read by ICP in order to generate graphical displays. Graphical output is provided for the NWSRFS SNOW-17, SAC-SMA, WY-PLOT, and PLOT-TS operations. Model states for the SNOW-17 and SAC-SMA models can be displayed within the WY-PLOT display. Output from other operations can be viewed as text through the ICP interface.

Although the NWS has performed maintenance and enhancement activities, the existing ICP application is difficult to maintain and has functional limitations. As the functionality of ICP will continue to be required, the ability to enhance and extend the software is necessary to allow the NWS to continue to calibrate models for additional forecast points throughout the country. The NWS needs a functional analysis to define the requirements of the existing ICP. Reviewing the existing ICP and documentation in order to record functional operations and mapping these operations to requirements have accomplished this task.

Task Objectives

The objective of this task order is to perform requirements analysis of the existing ICP functionality. To accomplish this objective, RTi performed the following:

- Analyzed the existing ICP application and reviewed documentation to develop a clearly written list of functions included in the current program. Documented functions that did not perform as intended were included with the correct function described. The analysis was performed through demonstration; this included a detailed review of each Graphical User Interface (GUI) component, including menus and windows to determine functionality (see ***Figure 1***.) The result of this analysis was the document: *List of Functional Operations for the ICP Application* (RTi, 2004) submitted to the NWS.

- The task did not include system design or analysis of the current implementation's software development strategies. It focused on the functions included in the ICP, which could be used to create requirements that are implementation independent.

- RTi also included additional recommended requirements for the enhancement of the ICP application. These requirement additions and modifications were the result of recommendations from the document: *Interactive Calibration Program Suggested Changes and Enhancements* (Anderson, 2003).

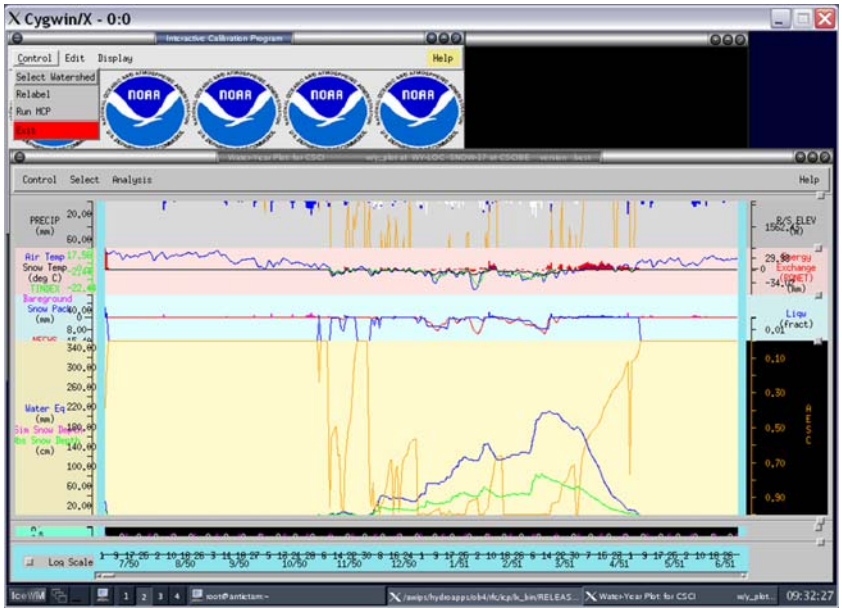

Figure 1. A Sample Screen of ICP that was reviewed.

Document Structure

This requirements document contains the functional requirements determined from the analysis of the ICP. It contains **Use Case** and **Functional Requirements** sections for existing ICP functionality and **Functional Requirements** for recommended additional functionality.

The **Use Case** section was derived from the result set of the functional analysis done on the existing ICP that was documented in *List of Functional Operations for the ICP Application* (RTi, 2004). The use cases are the lowest set of functions that define the usage of the ICP during a session. These use cases were then mapped to functional requirements of the ICP.

The **Functional Requirement** sections contain the actual requirements necessary to define the ICP at the lowest functional level. These requirements were written to be implementation independent and may be inserted into requirements tracking software.

Use Case and Functional Requirement Notation

The notation of the use cases is consistent with the format derived from Alistair Cockburn's *Writing Effective Use Cases* (Cockburn, 2001) (See ***Figure 2*** for an example.) The notation of the functional requirements was derived from Ivy F. Hooks and Kristin A. Farry's *Customer-Centered Products* (Hooks, and Farry, 2001) while maintaining consistency with the use case notation (***Figure 3***.)

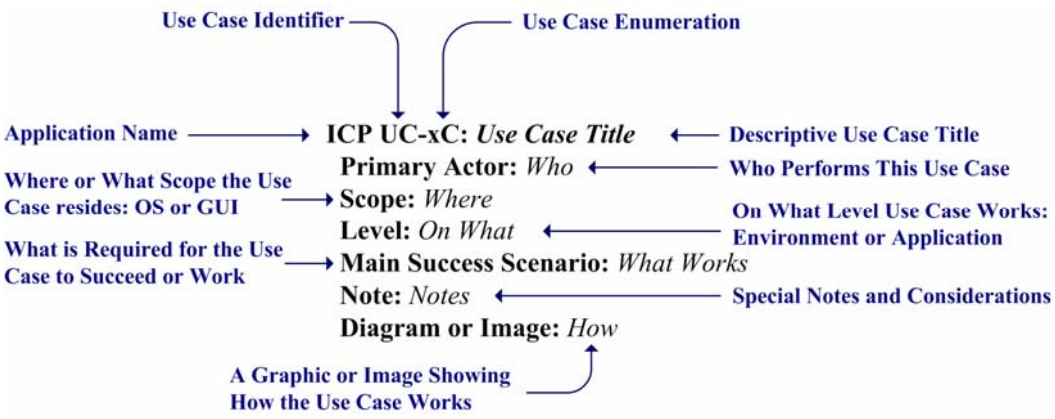

Figure 2. Use Case Notation

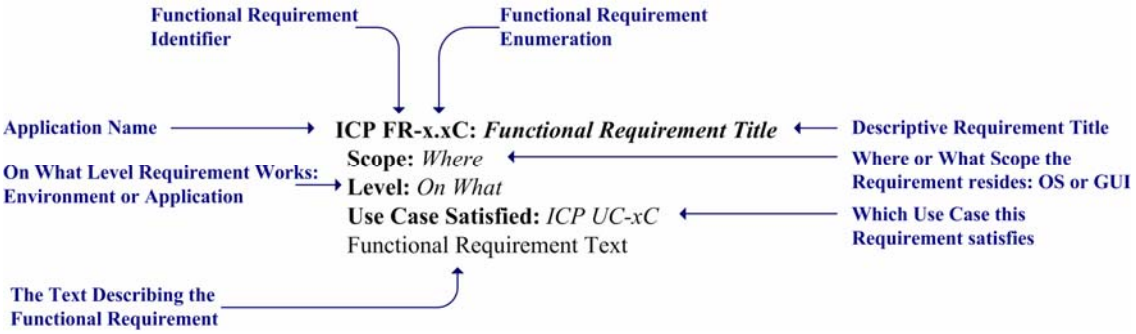

Figure 3. Functional Requirement Notation

Functional Requirements for the current ICP

The functionality of the current ICP was captured through documentation review and operation. This functionality was documented in the document: *List of Functional Operations for the ICP Application* (RTi, 2004). The functional operations from that document were mapped first to use cases that comprise ***Section 3.1*** then the use cases were mapped to the functional requirements of ***Section 3.2***.

Use Cases

This section lists use cases needed to create the list of functional requirements detailed in ***Section 3.2***. To illustrate the use case scenarios, many screen shots from the current ICP implementation are referenced. These screen shots are located in the ***Appendix***.

ICP UC-1C: Application Environment
Primary Actor: ICP Users
Scope: OS
Level: Environment
Main Success Scenario: Users can create an ICP operational environment through the use of NWSRFS Apps_defaults tokens, and environment variables.

ICP UC-2C: Application start
Primary Actor: ICP Users
Scope: OS
Level: Application
Main Success Scenario: ICP will start by issuing the command *icp*.

ICP UC-3C: Choosing a MCP3 Deck
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can select an MCP3 input deck to run. The input deck for *Watershed* shall be located in the directory identified by $(mcp_decks)/*Region*/*Basin*/*Watershed*/<Watershed.curr>. The options under *Region*, *Basin*, and *Watershed* display any available directory path under the $(mcp_decks) directory. The *Watershed* directory typically refers to a segment name.
Diagram or Image: Figure A1

ICP UC-4C: Create or Delete Directory
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can create a new directory or delete an existing directory at the *Region* level.
Note: Anderson (Anderson, 2003) recommends removing this functionality as most users use UNIX system commands external to ICP.

ICP UC-5C: Create or Delete Directory
Primary Actor: ICP Users
Scope: GUI
Level: Application

Main Success Scenario: The user can create a new directory or delete an existing directory at the *Basin* level.
Note: Anderson (Anderson, 2003) recommends removing this functionality as most users use UNIX system commands external to ICP.

ICP UC-6C: Create or Delete Directory
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can create a new directory or delete an existing directory at the *Watershed* level.
Note: Anderson (Anderson, 2003) recommends removing this functionality as most users use UNIX system commands external to ICP.

ICP UC-7C: Re-naming a MCP3 Input Deck
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can re-name the input file selected for the watershed.
Note: Anderson (Anderson, 2003) recommends that the "Overwrite" and "Re-label" options be removed, as the user should only be dealing with a single input deck. The "Overwrite" and "Re-label" options appear as the user works through many of the use cases below.

ICP UC-8C: Executing MCP3 on Chosen MCP3 Deck
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can execute the MCP3 on the selected input deck. The user can also choose whether or not the Wide Listing output contains the line printer output for the WY-PLOT and PLOT-TS operations.
Diagram or Image: Figure A2

ICP UC-9C: Notification
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user is notified when the MCP3 program is completed and is notified of the status code of the finished process.
Diagram or Image: Figure A3

ICP UC-10C: Editing the Chosen MCP3 Input Deck
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can select and manually edit the input deck. The edit window has very basic editing functionality including placement of the cursor with the mouse and arrow keys, horizontal and vertical scroll bars, and standard operation of the Insert, Delete, Home, End, Page Up, and Page Down keys.

ICP UC-11C: Viewing the MCP3 Output
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can view the text MCP3 output in a non-editable window with resizing and scrolling capabilities.
Diagram or Image: Figure A4

ICP UC-12C: Application Permissions
Primary Actor: System Administrator
Scope: OS
Level: Environment
Main Success Scenario: ICP executing as the user will have permission to create directories and files in the user specified locations for MCP3 deck selection.

ICP UC-13C: Application Work Area
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: ICP will create/copy selected decks and output files to a user specified work area.

ICP UC-14C: Making and Saving Parameter Changes to the SAC Models
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can make and save parameter changes to all SAC models listed in the MCP3 input deck that is run by ICP. The edits can be made in text boxes and will be properly formatted in the MCP3 input deck. The ratio or differences among parameters for multiple SAC-SMA models can be maintained or not. The user can view a list of the following SAC-SMA model parameters for all models included in the current segment: UZK, PCTIM, ADIMP, RIVA, ZPERC, REXP, LZFPM, LZFSM, LZSK, LZPK, PFREE, and SIDE, including a table and plot of the ET-Demand curve. The user can edit the parameters and when finished with all edits can decide whether to accept or cancel the changes**.**
Note: Recommendation – Current functionality allows a parameter value to be set to a value less than zero when attempting to maintain the difference between models. In these cases, the parameter should be set to zero. Anderson (Anderson, 2003) suggests additional functionality in allowing the user to view and edit the initial model states – LZTWC, LZFSC, LZFPC, and ADIMC.
Diagram or Image: Figure A5

ICP UC-15C: Editing ET-Demand Curves or PE Adjustment Factors
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can edit the monthly ET-Demand curve or the monthly PE Adjustment Factors by changing the twelve monthly values in a table or directly on the plot. Changing the plot automatically changes the tabular values. After edits are made for

this curve, the user can choose to save the edits and close, reset the last change, cancel all edits and close, or restore the original values.

ICP UC-16C: Making and Saving Parameter Changes to the SNOW-17 Models
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can make and save parameter changes to all SNOW-17 models listed in the MCP3 input deck that is run by ICP. The edits can be made in text boxes and will be properly formatted in the MCP3 input deck. The ratio or differences among parameters for multiple SNOW-17 models can be maintained or not. The user can view a list of the following SNOW-17 model parameters for all models included in the current segment: SCF, MFMAX, MFMIN, NMF, UADJ, SI, DAYGM, MBASE, PXTEMP, PLWHC, and TIPM, including a table and plot of the AESC curve. The user can edit the parameters and when finished with all edits can decide whether to accept or cancel the changes.
Note: Recommendation – Current functionality allows a parameter value to be set to a value less than zero when attempting to maintain the difference between models. In many of these cases, the parameter should be set to zero.

ICP UC-17C: Editing the AESC Curve
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can edit the AESC curve by changing the nine monthly values in a table or directly on the plot. For plot editing, the user can 'grab' each point defined by the divisions of the WE/Ai scale and adjust the corresponding AESC value. After edits are made for this curve, the user can choose to save the edits and close, reset the last change, cancel all edits and close, or restore the original values. Changing the plot automatically changes the tabular values.
Diagram or Image: Figure A5

ICP UC-18C: Editing the Unit Hydrograph Ordinates
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can edit the Unit Hydrograph ordinates by changing the values in a table or directly on the plot. The user can choose to cancel the most recent edit or all edits in the session, or to accept all changes, after which the changes are saved to the MCP3 input deck. The sum of the unit hydrograph ordinates is maintained as those ordinates are changed.

ICP UC-19C: Functionality of the WY-PLOT Operation Display (SAC-SMA)
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The display of the WY-PLOT operation for SAC-SMA has the following functionality:

- The vertical sizes of each of the five sections in the display can be changed by selecting and dragging the button at the right of the pane separator between each

section.

- A radio button can be used to toggle the Y-axis from log scale to arithmetic scale.
- The X-axis of the WY-PLOT is the date.
- The Y-axis of the WY-PLOT is in units of discharge (cmsd) in arithmetic scale, and units of runoff (mm) in log scale. Metric units are always shown regardless of the ENG/METRIC option on MCP3 input card A2.
- A legend for the discharge can be displayed by placing the cursor on the left vertical scale and clicking either the right or the left button. The legend is color coded to match the colors on the plot.
- The following information is shown about the SAC-SMA operation that the user has selected:
    - Frost Index (if present in the input deck) as a black line from zero degrees
    - Rain plus melt (descending magenta bars) and total runoff (blue line)
    - Percent of total runoff from each of the six runoff components (surface, direct, impervious, interflow, supplemental base flow, and primary base flow)
    - SAC-SMA model states shown as UZTW and LZTW deficits, and UZFW, LZFSW, and LZFPW contents.
- The user can right-click the mouse in the panes near the time series plots to get the numerical value of the date/time and the time series value. A window appears to display the date/time and time series in CMS.
- The user can scroll horizontally through the hydrograph at different rates – by one day or one window at a time, or by "dragging the hydrograph" to continuously scroll in either direction.
- The user can click on the streamflow portion of the hydrograph near a time series to determine the date/hour and time series value.

Diagram or Image: Figure A7

ICP UC-20C: Functionality of the WY-PLOT Operation Display (SNOW-17)

Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The display of the WY-PLOT operation for SNOW-17 has the following functionality:

- Rain/Snow elevation is shown on the right hand axis (in meters) as a continuous line from the bottom of the plot. Precipitation is shown on the left hand axis (in millimeters) as a bar graph from the top of the plot. The type of precipitation is also identified. Snow is shown as a white bar and rain is shown as a blue bar.
- Energy exchange is shown on the right hand axis (in mm) as a red bar. Air temperature (blue line) and TINDEX (green line) are shown on the left hand axis (in deg C). Snow temperature is plotted as a black line in units of DEGC.
- Liquid water fraction is shown on the right hand axis and is shown as a blue line. Rain plus melt and negative heat storage (NEGHS) are both shown in millimeters on the left hand axis. Rain on bare ground is shown as magenta bars and rain plus melt on snow covered area is shown as blue bars. NEGHS is shown as an orange line.
- Areal extent of snow cover (fraction of 1.0) is shown on the right hand axis as an orange line. Water equivalent of the snow pack (millimeters) is shown on the left hand axis as a blue line. Simulated and observed snow depth time series are also plotted.

ICP UC-21C: View of Entire WY-PLOT Time Series
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can view a "thumbnail" of the entire WY-PLOT time series plotted, including a locator window identifying the portion of the time series shown in the display. The locator window can be scrolled, which will also scroll the plot.

ICP UC-22C: Changing Date and Data Range in WY-PLOT Time Series Display
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can change the range of the date shown in the X-direction of the WY-PLOT Time Series display. The user can also set the minimum and maximum data range to be displayed on the Y-axis. Changes in the data range can be made through manual editing or the use of a scroll bar. Defaults for all values can be obtained from the MCP3 input deck.

ICP UC-23C: Saving Time Series for Subsequent Display
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can save a current SQME time series to display on a subsequent WY-PLOT.

ICP UC-24C: Displaying Model Information for SAC-SMA
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can display the model information for any SAC-SMA operation as defined in the MCP3 input deck. The user can select which instance of the SAC-SMA operation to display.

ICP UC-25C: Displaying Model Information for SNOW-17
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can display the model information for any SNOW-17 operation as listed in the MCP3 input deck. The user can select which instance of the SNOW-17 operation to display.

ICP UC-26C: Operations Display
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can display one instance each of all SNOW-17, SAC-SMA, and WY-PLOT information in a single window. The user is able to toggle through all instances of these models and plot the results.

ICP UC-27C: Saved SQME

Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user will be able to display previously saved SQME time series on the current WY-PLOT. Only the previously saved SQME time series can be displayed.

ICP UC-28C: Modifying the Percolation Demand Curve
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can modify the percolation demand curve by either manually changing the four most sensitive parameters that define the curve (ZPERC, REXP, LZFSM, and LZFPM), fitting a 'cloud' of points derived through evaluation of the input percolation curve (over the whole range of the lower zone deficiency ratio) or letting the program compute the four parameters of a best fit line through the points. The user can add or delete points when constructing the cloud. The user can develop, and compare multiple curves (and delete intermediate curves) identified by numbers and colors on the same plot. The plot of the percolation curve displays the value of PBASE as a horizontal line. The numerical value of PBASE is identified on the y axis.
Note: Anderson (Anderson, 2003) suggests that the "Solve" option in this item be removed as in most cases it "can lead to improper suggested parameter adjustments." Currently, the user must exit the percolation analysis to manually edit the four percolation parameters (if necessary). The functionality to save the modified parameters within the framework of percolation analysis windows could be added.
Diagram or Image: Figure A8

ICP UC-29C: Display of PLOT-TS
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can display the results of the PLOT-TS operation as defined in the MCP3 input deck.
Diagram or Image: Figure A9

ICP UC-30C: View of Entire PLOT-TS Time Series
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can view a "thumbnail" graph of the entire PLOT-TS time series plotted, including a locator window identifying the portion of the time series shown in the window. The locator window can be scrolled which will also scroll the plot in the window.

ICP UC-31C: Changing Date and Data Range in PLOT-TS Time Series Display
Primary Actor: ICP Users
Scope: GUI

Level: Application
Main Success Scenario: The user can change the range of the date shown in the X-direction of the PLOT-TS Time Series display. The user can also set the minimum and maximum data range to be displayed on the Y-axis. Changes in the data range can be made through manual editing or the use of a scroll bar. Defaults for all values can be obtained from the MCP3 input deck.

ICP UC-32C: Viewing a PLOT-TS Legend
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can view a legend identifying all plots, time series names, and plotting symbols within the plot. The legend will be color-coded for easier reference among plots.

ICP UC-33C: Functionality of the PLOT-TS Operation Display
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The display of the PLOT-TS operation has the following functionality:

- The vertical sizes of each of the three sections in the display can be changed by selecting and dragging the button at the right of the pane separator between each section.
- The X-axis of the PLOT-TS is the date.
- The Y-axis of the PLOT-TS is in arithmetic scale. The units of the axis are defined by the units of the time series.
- The user can right-click the mouse in the panes near the time series plots to get the numerical value of the date/time and the time series value. A window appears to display the date/time and time series value.
- The user can scroll horizontally through the hydrograph at different rates – by one day or one window at a time, or by "dragging the hydrograph" to continuously scroll in either direction.
- The user can switch between log scale and arithmetic scale in any display pane.

ICP UC-34C: Saving PLOT-TS Time Series for Subsequent Display
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can select any of the PLOT-TS time series in the plot to be stored for plotting at a later time on a subsequent appearance of the plot.

ICP UC-35C: Saved PLOT-TS Time Series
Primary Actor: ICP Users
Scope: GUI
Level: Application
Main Success Scenario: The user can display previously saved time series on the current PLOT-TS. Only the previously saved time series can be displayed.

Hierarchical List of Functional Requirements

This section contains the hierarchical list of functional requirements that represent the functional operations of the current ICP. These requirements may be utilized in the development of a new ICP.

ICP FR-1.0C: Application Environment
Scope: OS
Level: Environment
Use Case Satisfied: ICP UC-1C
The ICP operating environment shall be set using the operating system environment or configuration files. This shall include directory locations and the path to the MCP3 executable program.

ICP FR-2.0C: Execution Path
Scope: OS
Level: Environment
Use Case Satisfied: ICP UC-1C
The ICP execution path shall be set through the user's environment.

ICP FR-3.0C: GUI Start
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-2C
The Graphical User Interface shall start when the user invokes a command from the OS.

ICP FR-4.0C: MCP3 Deck Selection
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-3C
The ICP shall select an initial MCP3 deck through GUI menu and window components.

ICP FR-4.1C: Directory Creation and Deletion
Scope: OS/GUI
Level: Environment
Use Case Satisfied: ICP UC-4C/ ICP UC-5C/ ICP UC-6C/ ICP UC-12C
ICP shall create or delete directories through GUI components during deck selection. The application environment shall indicate the base directory locations.

ICP FR-4.2C: Copies Chosen Deck to Local Directory
Scope: OS
Level: Application
Use Case Satisfied: ICP UC-13C
ICP shall work with a copy of the chosen MCP3 deck in the user's defined work directory. The work directory shall be defined in the application environment.

ICP FR-4.3C: Re-naming Chosen MCP3 Deck
Scope: OS/GUI
Level: Application
Use Case Satisfied: ICP UC-7C
ICP shall be able to re-name the chosen MCP3 deck in the work directory. The user through GUI components shall choose the new name.

ICP FR-5.0C: Executes MCP3
Scope: OS/GUI
Level: Application
Use Case Satisfied: ICP UC-8C
ICP shall execute MCP3 using the specified deck in the work directory. The user through GUI components shall invoke MCP3.

ICP FR-5.1C: MCP3 Output
Scope: OS
Level: Application
Use Case Satisfied: ICP UC-13C
The ICP shall place MCP3 output in a user specified directory.

ICP FR-5.2C: MCP3 Notification
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-9C
The ICP shall use GUI components to open a notification window of the completion and status of MCP3.

ICP FR-5.3C: Viewing MCP3 Output
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-11C
The ICP shall use GUI components to open a window for viewing the text MCP3 output. These components shall have resizing and scrolling capabilities.

ICP FR-6.0C: Editing the Chosen MCP3 Input Deck
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-10C
The user shall be able to edit the chosen MCP3 input deck by using standard GUI components.

ICP FR-6.1C: Making and Saving SAC-SMA Parameter Changes
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-14C
The ICP shall use GUI components to edit SAC-SMA parameters in the chosen MCP3 deck. These parameters include UZK, PCTIM, ADIMP, RIVA, ZPERC, REXP, LZFPM, LZFSM, LZSK, LZPK, PFREE, and SIDE. The user can preserve the ratio/difference for specified parameters in any SAC model in a basin listed in the input deck.

ICP FR-6.1.1C: Editing ET-Demand Curves or PE Adjustment Factors
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-15C
The ICP shall use GUI or plotting components to add or edit the monthly ET-Demand curve or the monthly PE adjustment factors.

ICP FR-6.2C: Making and Saving SNOW-17 Parameter Changes
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-16C
The ICP shall use GUI components to edit SNOW-17 parameters in the chosen MCP3 deck. These parameters include SCF, MFMAX, MFMIN, NMF, UADJ, SI, DAYGM, MBASE, PXTEMP, PLWHC, and TIPM. The user can preserve the ratio/difference for selected parameters across multiple models in an input file for a basin.

ICP FR-6.2.1C: Editing AESC Curve
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-17C
The ICP shall use GUI or plotting components to edit the nine monthly AESC curve values.

ICP FR-6.3C: Editing the Unit Hydrograph Ordinates
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-18C
The ICP shall use GUI or plotting components to add or edit Unit Hydrograph Ordinate values. The area under the curve represented by the UHG ordinates will be preserved as any editing is performed.

ICP FR-7.0C: WY-PLOT Operation Display
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-19C/ICP UC-20C
The ICP shall use standard GUI and plotting components for creating the graphical plot of the WY-PLOT operation display.

ICP FR-7.1C: WY-PLOT Operation Display Data
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-24C/ICP UC-25C/ICP UC-26C
The user shall be able to graphically display an instance of each of the SNOW-17, SAC-SMA, and WY-PLOT operations and have the ability to toggle through these multiple instances to display any model or operation result.

ICP FR-7.1.1C: WY-PLOT Operation Display Vertical Resize
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-19C/ICP UC-20C
The ICP shall use plotting components to allow the user to resize in the vertical direction each of the sections of the WY-PLOT operation display.

ICP FR-7.1.2C: WY-PLOT Operation Display Date-Time Axis
Scope: GUI
Level: Application

Use Case Satisfied: ICP UC-19C/ICP UC-20C
The ICP shall define the X-axis of the WY-PLOT operation display to be the date-time axis.

ICP FR-7.1.3C: WY-PLOT Operation Display Legend
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-19C/ICP UC-20C
The ICP shall use GUI and plotting components to display a color-coded legend of the WY-PLOT operation display.

ICP FR-7.1.4C: WY-PLOT Operation Display Time Series View
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-19C/ICP UC-20C
The user shall be able to toggle between arithmetic and log scale on the Y-axis.

ICP FR-7.1.5C: WY-PLOT Operation Display Data Value
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-19C/ICP UC-20C
The ICP shall use GUI and plotting components to display a view of chosen date-time and time series value in the WY-PLOT operation display. The user shall be able to 'click' in the WY-PLOT near the time series to determine the date/hour and value of the time series.

ICP FR-7.1.6C: WY-PLOT Operation Display Hydrograph Scrolling
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-19C/ICP UC-20C
The ICP shall use plotting components to allow the user to scroll through the hydrograph. The user shall be able to do this either continuously with a scrollbar or by selected date-time intervals.

ICP FR-7.1.7C: WY-PLOT Operation Display SAC-SMA Data Axis
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-19C
The ICP shall define the Y-axis of the WY-PLOT operation display to be the data axis in units determined by the units of the time series.

ICP FR-7.1.8C: WY-PLOT Operation Display SAC-SMA Zone Contents
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-19C
The ICP shall plot UZTW and LZTW as deficits and UZFW, LZFSW, and LZFPW as contents in the WY-PLOT SAC-SMA operation display.

ICP FR-7.1.9C: WY-PLOT Operation Display SAC-SMA Runoff
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-19C
The ICP shall plot the percent of total runoff from each of the six runoff components:

surface, direct, impervious, interflow, supplemental base flow, and primary base flow. The ICP shall also show rain plus melt and total runoff.

ICP FR-7.1.10C: WY-PLOT Operation Display SNOW-17 Plots
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-20C
The ICP shall plot the following values in the WY-PLOT SNOW-17 operation display: rain/snow elevation, type of precipitation, energy exchange, air temperature, TINDEX, snow temperature, liquid water fraction, rain plus melt and negative heat storage, rain on bare ground, rain plus melt on snow covered area, areal extent of snow cover, water equivalent of snow pack, and observed and simulated snow depth.

ICP FR-7.2C: WY-PLOT Time Series Locator
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-21C
The ICP shall use plotting components to display a small time series plot of the entire WY-PLOT time series. This plot shall be used to locate and scroll to specific events in the time series.

ICP FR-7.3C: WY-PLOT Time Series Date Range
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-21C
The ICP shall use GUI and plotting components to allow the user to change the range of allowed date values in the X-direction. The default values shall be obtained from the chosen MCP3 deck.

ICP FR-7.4C: WY-PLOT Time Series Data Range
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-22C
The ICP shall use GUI and plotting components to allow the user to change the range of allowed data values in the Y-direction. The default values shall be obtained from the chosen MCP3 deck.

ICP FR-7.5C: Saving WY-PLOT Time Series
Scope: OS/GUI
Level: Application
Use Case Satisfied: ICP UC-23C
The ICP shall be able to save current SQME time series for use on subsequent WY-PLOT displays. The ICP shall use GUI components to select a location to save the time series.

ICP FR-7.6C: Using saved WY-PLOT Time Series
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-27C
The ICP shall use GUI and plotting components to display saved SQME time series on the current WY-PLOT.

ICP FR-7.7C: Modifying the SAC-SMA Percolation Demand Curve
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-28C
The ICP shall use GUI and plotting components to allow the user to modify the percolation demand curve by changing the following parameters: ZPERC, REXP, LZFSM, and LZFPM.

ICP FR-8.0C: PLOT-TS Operation Display
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-29C/ ICP UC-33C
The ICP shall use standard GUI and plotting components for creating the graphical plot of the PLOT-TS operation that is defined by the chosen MCP3 deck.

ICP FR-8.1C: PLOT-TS Operation Display Data
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-29C
The user shall be able to graphically display any instance of PLOT-TS information.

ICP FR-8.1.1C: PLOT-TS Operation Display Vertical Resize
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-33C
The ICP shall use plotting components to allow the user to resize in the vertical direction each of the sections of the PLOT-TS operation display.

ICP FR-8.1.2C: PLOT-TS Operation Display Date-Time Axis
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-33C
The ICP shall define the X-axis of the PLOT-TS operation display to be the date-time axis.

ICP FR-8.1.3C: PLOT-TS Operation Display Data Axis
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-33C
The ICP shall define the units of the Y-axis of the PLOT-TS operation display based upon the units of the time series type.

ICP FR-8.1.4C: PLOT-TS Operation Display Time Series View
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-33C
The ICP shall use GUI and plotting components to display a view of chosen date-time and time series value in the PLOT-TS operation display. The user can toggle between Log and arithmetic scales in any display pane.

ICP FR-8.1.5C: PLOT-TS Operation Display Hydrograph Scrolling
Scope: GUI

Level: Application
Use Case Satisfied: ICP UC-33C
The ICP shall use plotting components to allow the user to scroll through the display. The user shall be able to do this either continuously with a scrollbar or by selected date-time intervals.

ICP FR-8.2C: PLOT-TS Operation Display Legend
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-32C
The ICP shall use GUI and plotting components to display a color-coded legend of the PLOT-TS operation display.

ICP FR-8.3C: PLOT-TS Time Series Locator
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-30C
The ICP shall use plotting components to display a small time series plot of the entire PLOT-TS time series. This plot shall be used to locate and scroll to specific events in the time series.

ICP FR-8.4C: PLOT-TS Time Series Date Range
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-31C
The ICP shall use GUI and plotting components to allow the user to change the range of allowed date values in the X-direction. The default values shall be obtained from the chosen MCP3 deck.

ICP FR-8.5C: PLOT-TS Time Series Data Range
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-31C
The ICP shall use GUI and plotting components to allow the user to change the range of allowed data values in the Y-direction. The default values shall be obtained from the chosen MCP3 deck.

ICP FR-8.6C: Saving PLOT-TS Time Series
Scope: OS/GUI
Level: Application
Use Case Satisfied: ICP UC-34C
The ICP shall be able to save current PLOT-TS time series for use on subsequent PLOT-TS displays. The ICP shall use GUI components to select a location to save the time series.

ICP FR-8.7C: PLOT-TS Time Series Display Data Value
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-33C

The user can ‘click’ in any display pane near a plotted time series to get the day/time/value of the point in the time series.

ICP FR-8.8C: Using saved PLOT-TS Time Series
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-35C
The ICP shall use GUI and plotting components to display saved time series on the current PLOT-TS.

Recommended ADDITIONAL requirements for the UPDATED ICP

This section contains the hierarchical list of recommended requirements for the enhancement or replacement of ICP functionality. These requirements are recommended based on performance, bug fixes, and general user feedback from the document: *Interactive Calibration Program Suggested Changes and Enhancements* (Anderson, 2003).

ICP FR-1.0R: Directory Creation or Deletion
Scope: OS
Level: Environment
Use Case Satisfied: ICP UC-4C/ ICP UC-5C/ ICP UC-6C/ ICP UC-12C
The ICP shall not have functionality to add or remove directories. This requirement shall replace **ICP FR-4.1C**.

ICP FR-2.0R: Re-Naming the Chosen MCP3 Deck
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-7C
The ICP shall not allow users to re-name or overwrite the chosen MCP3 deck. This requirement shall replace **ICP FR-4.3C**.

ICP FR-3.0R: Editing the Chosen MCP3 Input Deck
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-10C
The ICP shall not allow users to choose models that are not in the chosen MCP3 deck. This requirement shall enhance **ICP FR-6.0C**.

ICP FR-4.0R: Making and Saving SAC-SMA Parameter Changes
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-14C
The ICP shall set parameter values to zero if negative parameters result from attempting to maintain the difference between models. This requirement shall enhance **ICP FR-6.1C**.

ICP FR-4.1R: Additional SAC-SMA Parameters
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-14C
The ICP shall set additional parameter values: LZTWC, LZFSC, LZFPC, and ADIMC. This requirement shall enhance **ICP FR-6.1C**.

ICP FR-5.0R: Making and Saving SNOW-17 Parameter Changes
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-16C
The ICP shall set parameter values to zero if negative parameters result from attempting to maintain the difference between models. One exception shall be the PXTEMP parameter that may be negative. This requirement shall enhance **ICP FR-6.2C**.

ICP FR-6.0R: Modifying the SAC-SMA Percolation Demand Curve
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-27C
The ICP shall not include a "Solve" option. This requirement shall enhance **ICP FR-7.7C**.

ICP FR-6.1R: Saving the SAC-SMA Percolation Demand Curve
Scope: GUI
Level: Application
Use Case Satisfied: ICP UC-27C
The ICP shall be able to save the percolation parameters within the Percolation Demand Curve window. This requirement shall enhance **ICP FR-7.7C**.

Summary

This task involved reviewing current documentation and performing functional analysis of the existing ICP software to produce a list of operations. This review and functional analysis is documented in *List of Functional Operations for the ICP Application* (RTi, 2004). The above documented list of function operations was used to create the **Use Cases** documented in ***Section 3.1***. Once the use cases were determined, the **Functional Requirements** of ***Section 3.2*** were created to address the use cases. Finally **Recommended Additional Requirements** have been included in ***Section 4.0*** to allow for enhancement of any future ICP product and represent the recommended additional functionality of the ICP documented by *Interactive Calibration Program Suggested Changes and Enhancements* (Anderson, 2003). These functional requirements, both existing and recommended, will be utilized in a future project to implement a replacement application to the current ICP that has all of the existing functionality and some recommended enhancements.

References

Anderson, E. (2003). "Interactive Calibration Program Suggested Changes and Enhancements." *NWS White Paper*, National Weather Service.

Cockburn, A. (2001). "Writing Effective Use Cases." Addison-Wesley.

Hooks, I.F. and Kristin, F.A. (2001). "Customer-Centered Products." AMACON.

Reed, S., Koren, V., Smith, M., Zhang, Z., Moreda, F., Seo, D.-J., and DMIP Participants, 2004. Overall distributed model Intercomparison project results. Journal of Hydrology, Vol. 298, 27-60.

RTi (2004). "Interactive Calibration Program (ICP) Functional Requirements – Deliverable 1 List of Functional Operations for the ICP Application." Riverside Technology, Inc.

APPENDIX - SCREEN SHOTS OF THE CURRENT ICP FOR USE CASE REFERENCE

This appendix contains screenshots of the ICP that are referred to in ***Section 3.1***.

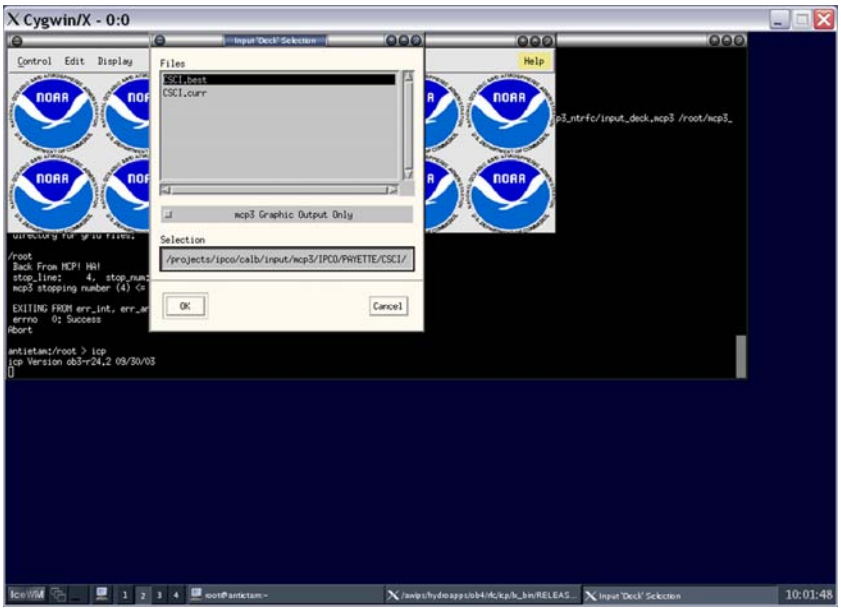

Figure A1. Choosing a MCP3 Deck

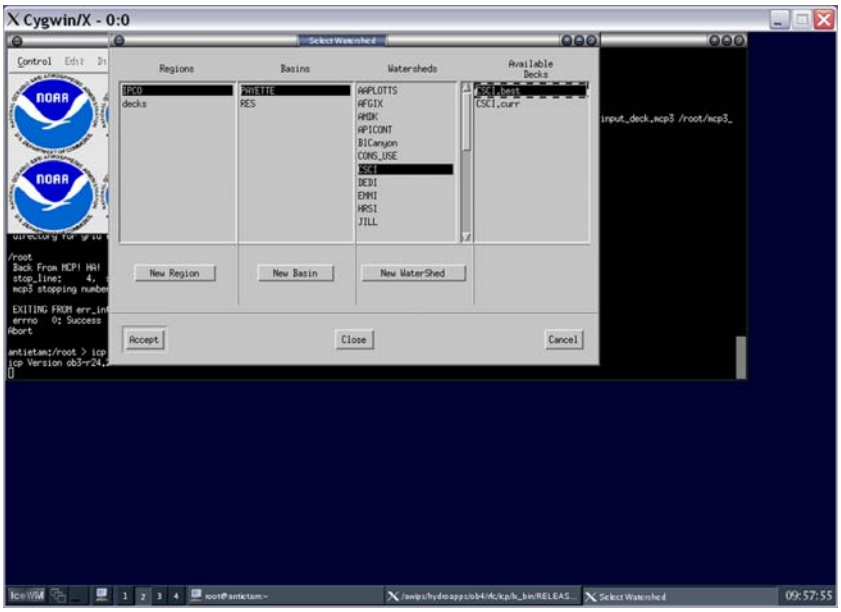

Figure A2. Executing MCP3 on Chosen MCP3 Deck

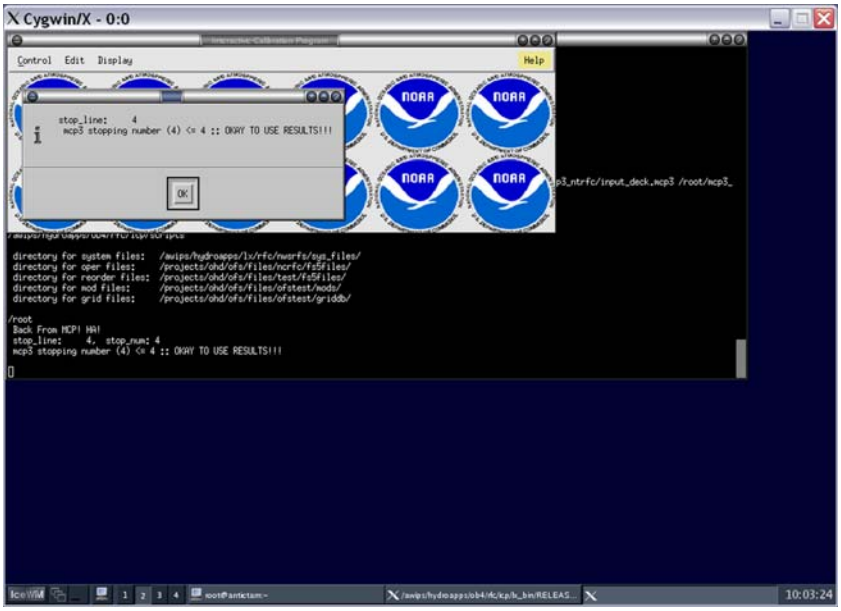

Figure A3. Notification

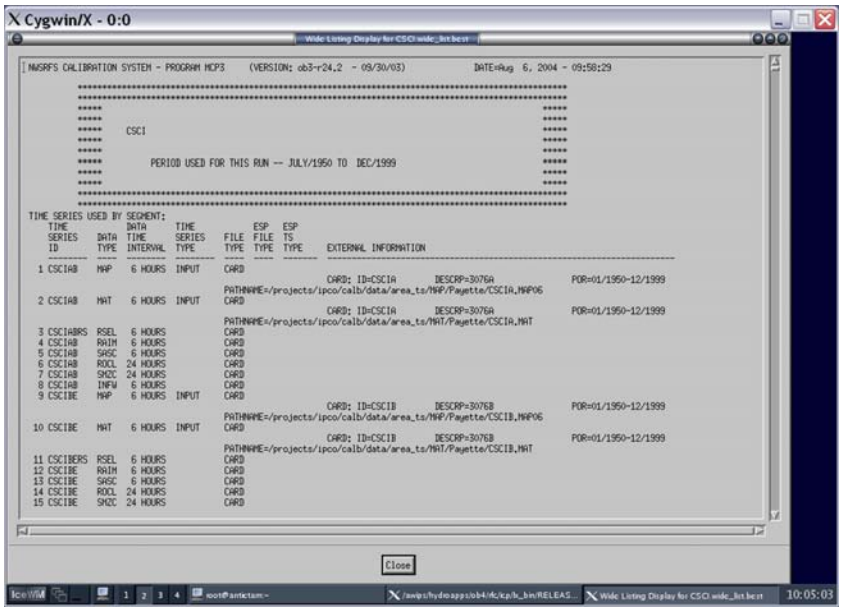

Figure A4. Viewing the MCP3 Output

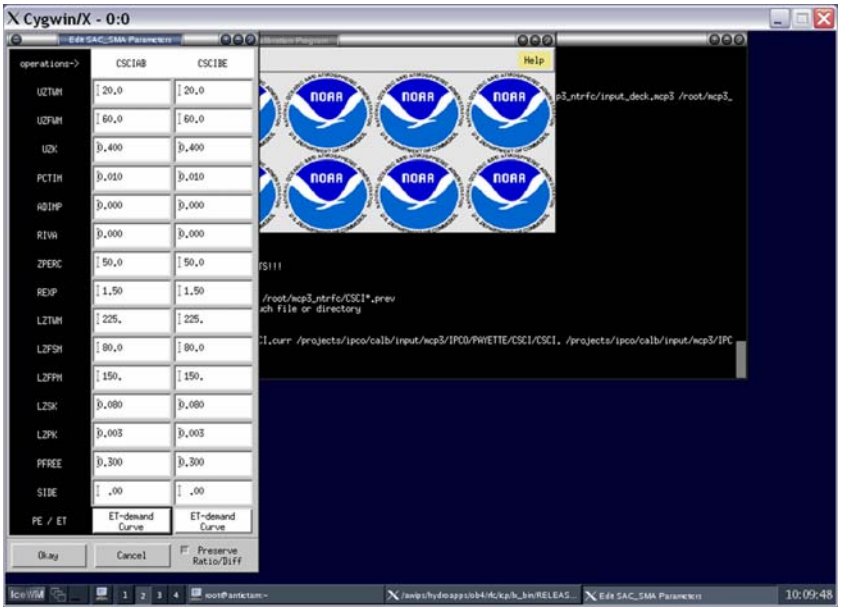

Figure A5. Making and Saving Parameters

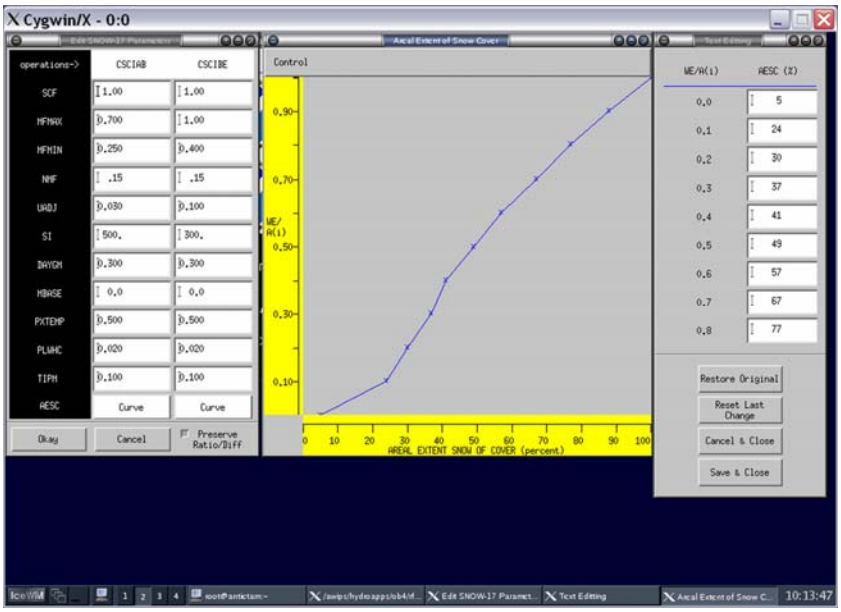

Figure A6. Editing the AESC Curve

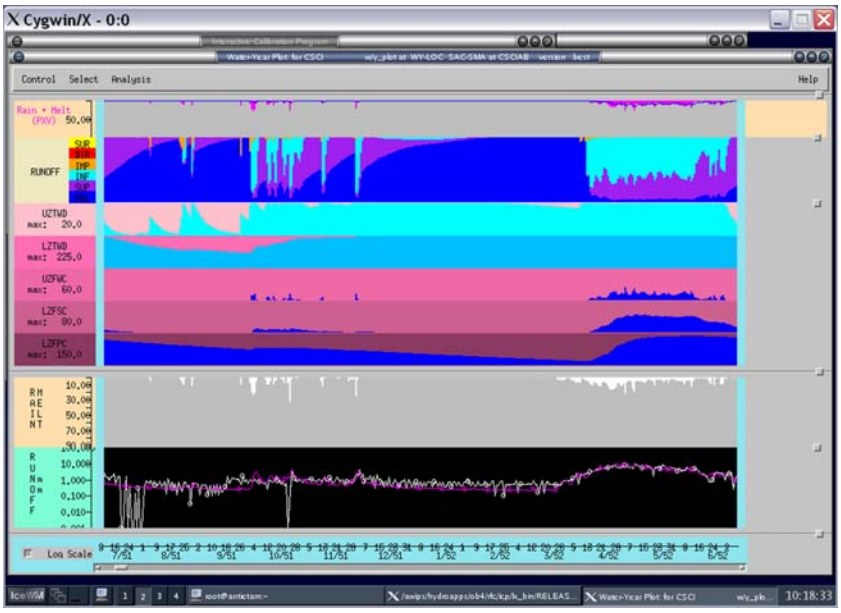

Figure A7. Functionality of the WY-PLOT Operational Display

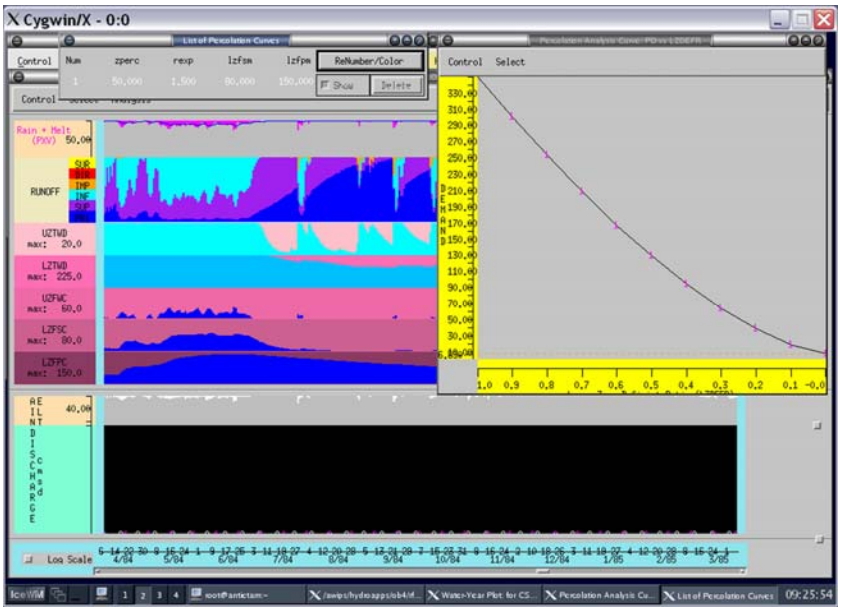

Figure A8. Modifying the Percolation Demand Curve

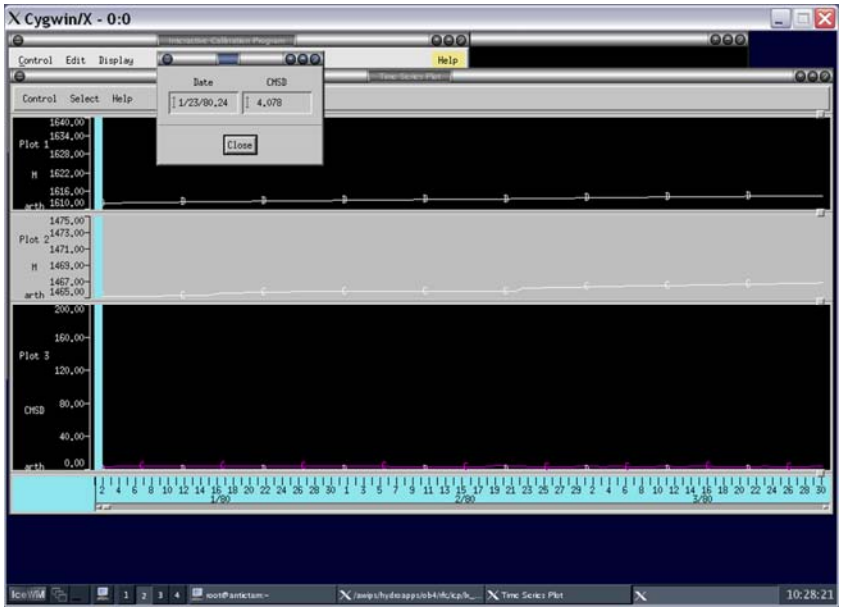

Figure A9. Display of PLOT-TS