NATIONAL WEATHER SERVICE
OFFICE of HYDROLOGIC DEVELOPMENT

CONCEPT OF OPERATIONS

Sacramento Model Enhancement
To
Handle Implications of Frozen Ground on Watershed Runoff

Version 3.4

Revision History

Date	Version	Description	Author
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01/05/2005	1.1	Technical Edit	M. Smith
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1. INTRODUCTION

Frozen Ground Sacramento Soil Moisture Accounting (SAC) Model Enhancement Project, Project ID: OHD-05-002.

1.1 Document Overview

Section 1 of the Concept of Operations (CONOPS) identifies the project. Section 2 contains a brief explanation of the existing environment, capability and limitations that this project will address. Section 3 is a conceptual definition of the new feature to replace the existing capability

2. CURRENT STATE OF OPERATIONS

2.1 Description of the Current Environment

Seasonally frozen ground can have a very significant effect on the amount of runoff produced during the winter and spring. Lack of vegetation during the winter, shallow snow cover, and very cold temperatures produce optimal conditions for deep frost penetration. The Sacramento Soil Moisture Accounting model (SAC-SMA), widely used by the National Oceanic and Atmospheric Administration, National Weather Service NOAA/NWS, has a frozen ground component. It is based on an empirical frost index. There are two main parts to this frozen ground component. The first is the computation of a frost index and the second is the modification of the rainfall-runoff model based on the frost index. As stated by Anderson and Neuman [1984], further improvements should include more physically based approaches, e.g. a simple heat transfer procedure for computing the energy flux into or out of the ground, as well as the frost and thaw depths. This would also reduce a large number of recent model parameters.

The Hydrology Laboratory (HL) has begun the development of a new physically-based frozen ground parameterization capability. The first part is conceptualization of the heat transfer processes. Tests were performed using specially developed prototype algorithms and the code was determined to meet scientific needs. The code was then tested in a LINUX NWS River Forecast System (NWSRFS) Calibration System environment. Following that the algorithm was successfully ported into the Flood Early Warning (FEWS) Forecasting platform. The results were reviewed by NWS experts and have been proven to be supportable and scientifically sound.

The objective of this project is to leverage the work already completed to produce a new Sacramento Soil Moisture Accounting (SAC-SMA) capability and port it into the National Weather Service River Forecast System (NWSRFS) for AWIPS Release OB8.3.

2.2 User/Customer Identification & Organization

The NWS River Forecast Centers (RFCs) will be the primary users of the new SAC-SMA-HT (SAC-HT) feature.

2.3 Current Support Environment/Architecture

The existing Sacramento Soil Moisture Accounting model currently operates within the AWIPS-

supported LINUX NWSRFS environment for calibration, operational river forecasting, operational flash flood forecasting, and ensemble streamflow prediction. The existing SAC-SMA is also a component in NCEP operations.

3. PROPOSED SOLUTION CONCEPTS

3.1 New Capabilities and Functions

3.1.1 Background & Scientific Analysis

The physically-based frozen ground algorithm was developed by Victor Koren of the Hydrology Laboratory of the National Weather Service Office of Hydrologic Development. It was designed to replace the conceptual frozen ground component developed by Eric Anderson and Pat Neuman (Anderson and Neuman, 1984).

NWS modeling of frozen ground effects on the rainfall-runoff process began with the development of a conceptual modification to the SAC-SMA (Anderson and Neuman, 1984). This approach used the concept of a frost index which modified the runoff generated by the SAC-SMA. As a conceptual model, this approach required the calibration of 7 parameters. A successful collaboration between the Office of Hydrologic Development and National Center for Environmental Prediction (NCEP) resulted in the development of a heat-transfer component of the NCEP land surface model. As reported by Koren et al. (1999) and Mitchell et al. (2002), this parameterization proved to be a valid component that reduced biases in certain computed values.

Capitalizing on this successful collaboration, the Hydrology Laboratory developed an advanced approach to modify the SAC-SMA for the effects of frozen ground. This work led to a physically-based heat transfer component for the SAC-SMA that requires minimal calibration. Two basic requirements were identified for this component. The component must:

- Be simple enough to run with sparse and noisy data; and
- Match the complexity of the SAC-SMA.

A conceptual representation of soil moisture fluxes combined with a physically-based heat transfer model provides reasonable simulations of water and heat exchanges over a soil profile. Physically-based modification of the hydraulic soil properties due to the ice content leads to runoff simulation improvements for both snowmelt- and rainfall-induced floods. No additional parameters were introduced to account for frozen ground effects.

The resulting basic algorithm consists of two main parts and is detailed in the Algorithm Description for this project. In the first, a physically-based heat transfer component is used to determine the distribution of heat and liquid/frozen water in a soil column. Next, the SAC-SMA model is modified to include the effects of frozen soil on the generation of runoff.

3.1.2 Feature Description

In the above described scientific research and experimentation stage, a prototype was developed by the HSMB and used to prove the scientific theory. The code was tested in a LINUX

NWSRFS Calibration System environment and met scientific needs. Testing has proven the algorithm and physics to be scientifically correct. The new feature developed in this project will expand and leverage this capability producing the same scientific results. The new SAC-HT model will function as a new NWSRFS operation in calibration mode, operational river forecasting, the generation of flash flood guidance, and ensemble forecasting mode. The new SAC-HT operation will not replace the current SAC-SMA NWSRFS operation. Instead, the new SAC-HT operation will be added to NWSRFS as an additional operation.

SAC-HT includes a physically-based frozen ground parameterization including the initial conceptualization of the heat transfer processes. Preliminary testing, using specially developed prototype algorithms, was conducted. The results proved to be supportable and scientifically sound. A by-product of the new SAC-HT will be physically-based estimates of soil moisture content.

Specifically, this project is intended to enhance the prototype model to make it operational. SAC-HT will provide:

- An alternative to the empirical frost-index.
- The ability to compute the effect of temperature on soil moisture.
- The ability to compute the effect of frost depth on soil moisture.
- An alternative modification of rainfall runoff transformation based on a physically-based frost index.
- The ability to produce physically-based soil moisture content and soil temperature estimates.
- The ability to turn options on to produce a simulated snow depth time series.

3.2 Operational Policies & Constraints

3.2.1 Scientific Constraints

HSMB has developed prototype code within the HSEB-defined development environment that computes the effect of frozen ground. It has been tested in the context of the NWSRFS Calibration System using the Manual Calibration Program (MCP). The developed capability needs to produce the same scientific results as the prototype.

3.2.2 Technical Constraints

Validation in the NWSRFS modes other than calibration through MCP3 was not explicitly tested. Testing scenarios used in calibration mode will need to be updated/ modified in order to verify the model in the other NWSRFS modes (i.e. deterministic Operational Forecast System/ Interactive Forecast Preparation OFS/IFP and probabilistic Ensemble Streamflow Prediction ESP).

3.2.3 Policy Constraints

There are no known policy-related concerns about disseminating new soil-moisture products to the public.

3.2.4 Financial and/or Schedule Constraints

Funding for this project was provided under the AHPS FY06 budget. It is scheduled for inclusion within AWIPS Release OB8.3.

3.3 Operational Scenarios

The new SAC-HT will run as an NWSRFS operation in the following NWSRFS modes:

- Calibration;
- Operational river forecasting (note that the SAC-HT will support FFG just like the existing SAC-SMA operation)
- Generating flash flood guidance; and Ensemble forecasting.

3.4 Summary of Impacts

3.4.1 Operational Impacts

Note that the SAC-HT model will be a new NWSRFS operation and will not replace the existing SAC-SMA. Users of the new SAC-HT operation will potentially have to create one additional time series, snow depth. Fortunately, a recent version of NWSRFS SNOW-17 operation can generate this time series on the user's request. They also may have to perform quality assurance on that data and have to decide how to interpret and disseminate physically-based soil moisture and temperature estimates. Instructions will be developed with the capability in HOSIP Stage 4.

3.4.2 Organizational Impacts

The NWS Office of Climate, Weather, and Water Services (OCWWS) will have to be trained on the new SAC-HT operation in order to support field use. Field sites may want to use the SAC-HT data within their own field developed systems. An example would be displaying the data on a specific RFC web page. OCWWS will have to provide training for field users who want to use the new SAC-HT operation.

3.4.3 Impacts During Development

There are no identified impacts during the development of the new SAC-HT operation at this time.

3.4.4 Impacts During Transition

Minor transition impacts would occur from the distribution of the new model. Switching from the existing SAC-SMA/Frozen Ground model to the new version should not require any new parameter calibration, assuming the original SAC-SMA/Frozen Ground model was properly calibrated. If the original SAC-SMA model was improperly calibrated to account for frozen ground effects, then the implementation of the new model may require that the SAC-SMA parameters be properly adjusted by the user.

In addition, the SAC-HT requires:

- Observed or simulated snowsimulated snow depth information. Simulated snow depth can be derived using the existing Snow-17 model. In this case, the user simply 'turns on' this option by specifying the time series attributes in the Snow-17 operation definition. Observed snow depth can be used if available. (Note that snow depth data are not required if the user only wants to generate soil moisture data).
- Observed or simulated aeral snow cover information. Aereal snow cover can be derived using the existing Snow-17 model. In this case, the user simply 'turns on' this option by specifying the time series attributes in the Snow-17 operation definition. Observed aereal snow cover can be used if available. (Note that aerial snow cover data are not required if the user only wants to generate soil moisture data).
- Observed or simulated snow water equivalent. Simulated snow water equivalent can be derived using the existing Snow-17 model. In this case, the user simply 'turns on' this option by specifying the time series attributes in the Snow-17 operation definition. Observed snow water equivalent can be used if available. (Note that snow water equivalent data are not required if the user only wants to generate soil moisture data).
- Mean areal temperature time series for the basin. These data are readily defined using the OFS Mean Areal Temperature (MAT) preprocessor. (Note that temperature data are not required if the user only wants to generate soil moisture data).
- Observed Precipitation (MAPX or MAP), these data are readily defined using the corresponding OFS preprocessor or Rain plus melt (RAIM), RAIM can be derived using the existing Snow-17 model. (Note that RAIM data is not required if the user only wants to generate soil moisture data).
- Parameters defined from soil texture data. These texture data have been defined for the entire country and exist as grids. They are contained in the most recent version of the Calibration Assistance Program (CAP) for easy use. The parameters defined from the texture data are defined in the Algorithm Description Document for this project.
- The annual average long term air temperature at the soil surface. These data have been defined for the entire country and exist as grids. They are contained in the most recent version of CAP. . The details of how these temperature data are used appear in the Algorithm Description Document for this project.

3.5 Alternatives and Trade-offs Considered

No other alternatives were considered.

4. REQUIREMENTS DEVELOPMENT METHODOLOGY

All requirements are to be delivered for AWIPS OB 8.3 except for those noted as "future enhancements" (which are still under research and development and not yet operational for AWIPS).

5. USE CASES

Use cases are derived from the User Classes and are defined in the HOSIP Stage 2 (Concept Exploration & Validation) and Stage 3 (Applied Research & Analysis). The use cases are detailed steps that a user or class of users will undertake in order to accomplish a specific task or function using the new system. *Use Cases are not necessary*. However, they are a very effective way of defining the detailed functional and data requirements for a system or capability. If used, the use cases need to be detailed and specific. Use cases shall be stored in the OHD DOORS Requirements database. All use cases shall be presented for each user class.

5.1 Run SAC-HT in Calibration Mode Use Case

Use Case:	*Run SAC-HT in Calibration mode*
Date created:	*6/11/2007*
Actor:	*Hydrologist*
Description:	The new SAC-HT operation is used to model the effects of frozen ground on the rainfall/runoff conversion. As a by product, soil temperature and soil moisture can be computed for various depths over an area. In order to determine the proper parameter values, the model is executed through NWSRFS-MCP3 (Historical Mode) for time periods of 1 month to many years
Preconditions:	• All input data is available in datacard format (MAP, if modeling Frozen Ground Effects also need MAT, SWE, AESC, and SNDP). • A datatype to hold frozen level depths has been defined
Post conditions:	A runoff time series is produced in datacard format. If modeling with frozen ground effects, a frozen ground index time series and frozen level depth time series are created (upper and lower boundaries)
Priority:	
Frequency of use:	
Normal course:	1. Define model parameters and input data (disk location, time series file names) in a segment definition / deck 2. Execute mcp3 via 'calb' script or via ICP. The calb script is shown below: calb –p mcp3 –I **inputFileName** –o **outputFileName** 3. Check for errors in output file 4. View generated time series files in ICP
Alternative course:	
Exceptions:	*Errors*

Assumptions:	*Parameter values and time series names/locations are known*
Notes and Issues:	•

5.2 Define Normal SAC-SMA parameters for new SAC-HT Use Case

Use Case:	*Define Normal SAC-SMA parameters for new SAC-HT operation (non SAC-HT parameters)*
Date created:	*6/11/2007*
Actor:	*Hydrologist*
Description:	The new SAC-HT operation uses most/all of the existing SAC-SMA parameters. In some cases the values can be directly transferred from the existing SAC-SMA model used in a given area. In other cases the parameter values need to be adjusted. The difference depends on how the existing SAC-SMA model was calibrated to account for the effects of frozen ground.
Preconditions:	
Postconditions:	
Priority:	
Frequency of use:	
Normal course:	1. Examine existing SAC-SMA calibration for frozen ground effects and follow one of two paths: a. If properly calibrated using the existing conceptual frozen ground option, then the SAC-SMA parameters can be used directly. b. If the SAC-SMA was improperly calibrated to account for the effects of frozen ground (i.e. warping the parameters out of range to account for something they weren't designed for), then the SAC-SMA model parameters may need to be recalibrated so that the SAC-HT component models the frozen ground effects and the regular Sacramento model handles the rest of the rainfall/runoff conversion. The idea here is to have each component of the SAC-HT correctly modeling the right components of the hydrograph.
Alternative course:	
Exceptions:	
Assumptions:	Documentation on the calibration of the existing SAC-SMA model, especially for the effects of frozen ground.
Notes and Issues:	

5.3 Define parameters needed specifically for SAC-HT Use Case

Use Case:	*Define Parameters needed specifically for the heat-transfer option.*
Date created:	*6/11/2007*
Actor:	*Hydrologist*
Description:	The new SAC-HT operation requires the users to define two additional physically-based parameters and specify them in the input to the SAC-HT model in the NWSRFS segment definition. They are: 1. Long term mean air temperature over the basin. This is a proxy for the mean soil temperature at a 2-1/2 meter depth over a basin 2. Soil texture classification over a basin: number from 1 to 12. The values are currently available as grids in CAP
Preconditions:	RFC has working knowledge of the Calibration Assistance Program (CAP) and ArcView to define mean areal values from grids.
Postconditions:	
Priority:	
Frequency of use:	
Normal course:	1. Define or acquire basin boundary 2. Input boundary into CAP 3. Define average 2 ½ meter depth basin average temperature 4. Define basin average soil texture 5. Specify average temperature and soil texture in SAC-HT input in segment definition.
Alternative course:	
Exceptions:	
Assumptions:	
Notes and Issues:	

6. Appendices

Appendix A – Table of Acronyms

Acronym	Acrostic / Definition
AHPS	Advanced Hydrologic Prediction Service
AWIPS	Advanced Weather Interactive Processor Service
CAT	CHPS Acceleration Team
CHPS	Community Hydrologic Prediction System
CONOPS	Concept of Operations
FEWS	Flood Early Warning System, from Delft Hydraulics
HOSIP	Hydrologic Operations and Service Improvement Process
HL	Hydrology Laboratory
HSEB	Hydrologic Software Engineering Branch
HSMB	Hydrologic Science and Modeling Branch
LINUX	UNIX based Operating System (OS)
MAT	Mean Areal Temperature
MCP	Manual Calibration Program
NCEP	National Centers for Environmental Prediction
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
NWSRFS	National Weather Service River Forecast System
OCWWS	Office of Climate, Weather, and Water Services
OHD	Office of Hydrologic Development
RFCs	River Forecast Centers
SAC	Sacramento referring to the Sacramento Model Soil Moisture Accounting Model
SAC-SMA	Sacramento Model Soil Moisture Accounting Model
SAC-SMA-HT	Sacramento Model Soil Moisture Accounting Module with Heat Transfer (Frozen Ground enhancements)
SAC-HT	Sacramento Model Soil Moisture Accounting Module with Heat Transfer (Short version of acronym)
SNOW-17	Snow Accumulation and Ablation Model
SON	Statement of Need
UNIX	Trademark of Operating System developed at Bell labs in the 1960's
WFOs	Weather Forecast Offices

APPENDIX B – REQUIREMENTS TABLE

IDENTIFICATION NUMBER	REQUIREMENT	PRIORITY LEVEL	QUALIFICATION TYPE
1.0	**FUNCTIONAL (OPERATIONAL & SCIENTIFIC) REQUIREMENTS**		
1.1	A new SAC-SMA operation, SAC-HT, shall provide an alternative to the empirical frost-index to improve the accuracy of the SAC-SMA during frozen ground situations	High	Test
1.1.1	The SAC-HT operation shall have a thermodynamic and a water balance component	High	Test
1.1.1.1	The SAC-HT operation shall compute a frost index time series	High	Test
1.1.1.1.1	The thermodynamic component shall compute the effect of soil temperature on soil moisture	High	Test
1.1.1.1.2	The thermodynamic component shall compute the effect of frost depth on soil moisture	High	Test
1.1.2	The water balance component shall produce an alternative modification of the rainfall-runoff transformation based on the physically-based frost index	High	Test
1.1.3	Existing SAC-SMA operation shall remain operationally intact	High	Test
1.1.4	A by-product of the new SAC-SMA operation shall be the ability to produce physically-based estimates of soil moisture content and soil temperature.	High	Test
1.1.4.1	The SAC-HT operation shall have the option to compute estimates of soil moisture content without requiring a temperature time-series	Med	Test
1.2	The new SAC-HT operation shall support multiple operational modes		
1.2.1	The new SAC-HT operation shall support normal NWSRFS in calibration mode	High	Test
1.2.2	The new SAC-HT operation shall support operational river forecasting	High	Test
1.2.3	The new SAC-HT operation shall support generation of operational flash flood guidance (FFG)	Med	Test
1.2.4	The new SAC-HT operation shall support ensemble forecasting	High	Test
1.3	The new SAC-HT operation shall include an ability to utilize Snow-17 data	High	Test
1.3.1	The Snow-17 model shall be changed to allow the user to "turn on" the option to produce the Simulated Snow Depth time series	High	Test
3.0	**TECHNICAL REQUIREMENTS**		
3.1	**Technical Requirements**		
3.1.1	The enhancement shall implement the calculations defined in the Algorithm Description Document	High	Test
3.1.2	The Parameter Input Routine (PIN) for the SAC-HT operation shall accept parameter data defined in the operation definition	High	Test

Priority (How Necessary is Requirement) – High, Medium, Low
Qualification Type – Test, Inspect, Demonstrate, None
(Definition of how the requirement will be verified)

IDENTIFICATION NUMBER	REQUIREMENT	PRIORITY LEVEL	QUALIFICATION TYPE
3.1.3	The Print Parameter Routine (PRP) for the SAC-HT operation shall print parametric data defined in the operation definition	High	Test
3.1.4	The Print Carryover Routine (PRC) for the SAC-HT operation shall print carryover data	High	Test
3.1.5	The Card Punch Routine (PUC) for the SAC-HT operation shall write out the existing operation definition	High	Test
3.1.5	The Carryover Transfer Routine (COX) for the SAC-HT operation shall do any needed carryover transfer when redefining parametric data	High	Test
3.1.7	The TAB routine for the new SAC-HT operation shall define and allocate space for all input and output time series	High	Test
3.1.8	The SAC-HT operation shall produce 1, 6, 12, or 24 hour soil temperature and soil moisture time series versus depth. The timestep must equal that of the Precipitation time series	High	Future Enhancement
3.1.9	The SAC-HT operation shall produce a 1, 6, 12, or 24 hour frozen depth level time series. The timestep must equal that of the Precipitation time series	High	Test
3.1.10	The SAC-HT operation shall incorporate the features of the existing SAC-SMA operation	High	Test
3.1.10.1	The SAC-HT operation shall be able to use the existing SAC-SMA parameters	High	Test
3.1.10.2	The SAC-HT operation shall produce a 1 ,6, 12, or 24 hour runoff time-series. The timestep must equal that of the Precipitation time series.	High	Test
3.1.10.3	The SAC-HT operation shall produce a runoff component time-series (ROCL – 7 components). The timestep must equal that of the Precipitation time series	High	Test
3.1.10.4	The SAC-HT operation shall produce a time-series of the original SAC-SMA states (SASC – 6 states). The timestep must equal that of the Precipitation time series	High	Test
3.1.10.5	The SAC-HT operation shall produce a 1, 6, 12, or 24 hour frost-index time series. The timestep must equal that of the Precipitation time series	High	Test
3.1.10.6	The SAC-HT operation shall accept monthly PET demand values as input	High	Test
3.1.10.7	The SAC-HT operation shall accept monthly PET correction factors as input	Med	Test
3.1.10.8	The SAC-HT operation shall accept a 24 hour PET time series as input	Med	Test
3.1.10.9	The SAC-HT operation shall accept a 1, 6, 12, or 24 hour Precipitation (RAIN + MELT) time series as input	High	Test
3.1.10.10	The SAC-HT operation shall accept a 1, 6, 12, or 24 hour Areal Extent of Snow time series as input. The timestep must equal that of the Precipitation time series	High	Test
3.1.10.11	The SAC-HT operation shall accept 1, 6, 12, or 24 hour Mean Areal Temperature time series as input. The timestep can be any multiple of the Precipitation time series	High	Test

IDENTIFICATION NUMBER	REQUIREMENT	PRIORITY LEVEL	QUALIFICATION TYPE
3.1.10.12	The SAC-HT operation shall be able to start using carryover (i.e. state values from a previous run)	High	Test
3.1.10.13	The SAC-HT operation shall print detailed soil-moisture output (see Card 2 of existing SAC-SMA definition)	Med	Test
3.1.10.14	When using the SAC-HT operation in calibration mode, the user shall have the option to specify which months to print detailed soil-moisture output	Med	Test
3.1.10.15	The SAC-HT operation shall have the option to produce a FINDX from the new physically based frozen ground algorithm, but not alter runoff with frozen ground effects (i.e. like setting SATR=0 in original SAC-SMA)		
3.2	**Security & Privacy Requirements**		
3.2.1	The SAC-HT operation shall comply with existing AWIPS security & privacy requirements.	High	Test
3.3	**Input Requirements**		
3.3.1	The SAC-HT operation shall accept physically-based soil temperature value at a 2 ½ meter depth.	High	Test
3.3.2	The SAC-HT operation shall accept physically-based soil temperature data at multiple depths (soil temperature profile) and derive frost depth .	Med	Future Enhancement
3.3.3	The SAC-HT operation shall work with current Basin Definitions and be substitutable for existing SAC-SMA models without requiring recalibration other than to account for Frozen Ground Effects	High	Test
3.3.4	The SAC-HT operation shall utilize Simulated Snow Depth time series from Snow-17	High	Test
3.3.5	The SAC-HT operation shall utilize soil texture data that have been defined for the entire country and exist as grids. These data shall be input to the CAP for easy use	High	Test
3.4	**Processing & Performance Requirements**[1]		
3.4.1	The SAC-HT enhancement will run with the same accuracy as the existing feature when frozen ground related inputs are not necessary and with greater accuracy when the Frozen Ground Feature is necessary.	High	Test
3.4.2	The SAC-HT enhancement will run in a normal processing environment The runtimes shall be approximately three times as long as the current SAC-SMA operation	High	Test
3.5	**Internal Data Requirements**		

[1] Processing and performance requirements for the SAC-HT operations will be verified during the operational development Stage 4 by working with NCRFC to refine and prioritize requirements for the SAC-HT model into testable features. At that time these parameters will be refined further.

IDENTIFICATION NUMBER	REQUIREMENT	PRIORITY LEVEL	QUALIFICATION TYPE
3.5.1	The SAC-HT operation shall allow the user to store physically-based soil moisture and temperature time series for various depths. (Reference 3.9.2)	High	Test
3.6	**System Environment Requirements**		
3.6.1	The SAC-HT operation shall operate in the existing AWIPS system environment	High	Test
3.7	**Architecture Requirements**		
3.7.1	The SAC-HT operation shall operate in the existing AWIPS system architecture	High	Test
3.8	**Communications Requirements**		
3.8.1	The SAC-HT operation shall operate within the existing AWIPS communication infrastructure	High	Test
3.9	**Interface Requirements**		
3.9.1	The SAC-HT operation shall be compatible with existing NWSRFS interfaces	High	Test
3.9.2	Time series generated by the SAC-HT operation shall be in standard OH datacard in calibration mode, PRD FS5files format in forecast mode, and ESP time series format in ensemble mode for use in other NWSRFS programs	High	Test
3.10	**Training Requirements**		
3.10.1	Documentation and User Manual material for the new SAC-HT operation shall be written and provided to OCWWS for the development of Training material	High	Inspect
3.10.2	OCWWS shall train the RFCs on the use of the new SAC-HT operation	High	Inspect
3.11	**Derived Requirements**		
3.11.1	A new set of operational instructions shall be developed for the normal calibration operational mode	High	Inspect
3.11.2	A new set of operational instructions shall be developed for the river forecasting operational mode	High	Inspect
3.11.3	A new set of operational instructions shall be developed for flash flood forecasting operational mode	High	Inspect
3.11.4	A new set of operational instructions shall be developed for the ensemble forecasting	High	Test
3.12	**Constraints**		
3.12.1	The SAC-HT operation shall implement the Scientific Algorithm correctly	High	Test

IDENTIFICATION NUMBER	REQUIREMENT	PRIORITY LEVEL	QUALIFICATION TYPE
3.12.2	The SAC-HT shall be operational with the release of OB8.3	High	Demo