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SITE SPECIFIC HYDROLOGIC MODELING AND FORECASTING AT NATIONAL WEATHER SERVICE WEATHER FORECAST OFFICES

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1. THE NWS AND SITE SPECIFIC MODELING

The National Weather Service (NWS) is investigating options for developing capabilities for Weather Forecast Offices (WFO) to perform hydrologic simulations for areas linked to hydrologic conditions maintained at River Forecast Centers (RFC). The NWS WFO's need a tool that will enable them to produce hydrologic forecasts for basins with short lead times. In this case, short means basins with response times less than the time that would be required for an RFC to produce a forecast. This tool has the following requirements:

- The tool should be robust.
- The tool should not require a lot of user interaction.
- It should not require the user to be a hydrologic forecaster.
- The tool should be simple, but flexible enough to handle a wide range of hydrologic conditions that occur in small basins with response times less than a day. For example, it should include the ability to model snowmelt, rainfall/runoff, and the effect of small impoundments.
- The tool should be consistent with the modeling approach used at the RFC, so that information from the RFC concerning hydrologic conditions of the area can be used to ensure proper operation of the WFO tool.
- The tool should allow for easy updating of rating curves.
- The tool should allow for changes to the data network.
- The tool should allow the input of Quantitative Precipitation Forecasts (QPF) and temperature forecasts.

The system under consideration is the FloodWatch system installed recently for Washoe County, Nevada.

2. FLOODWATCH AS A SITE SPECIFIC MODEL

FloodWatch is a flood forecasting tool that runs in conjunction with an existing data collection system on a personal computer. FloodWatch is integrated with a supporting database called HydroBase, which manages system configuration data, input, and results.

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FloodWatch simulates the hydrologic response of a watershed as a function of input precipitation, observed flow, reservoir elevations, and other data. Input data are read automatically but also can be entered, viewed, and edited manually. Streamflow forecasts are generated at locations in a watershed called forecast points. Observed and forecasted data can be exported in various formats. FloodWatch uses a variety of independent modeling components configured to generate continuous forecast information. Each component uses parametric data and operates on input and output time series. Components (which are referred to as *operations*) include:

- AdjustToObserved (adjust a simulated time series based on observations)
- Diversion (divert water from the stream)
- LagK Routing
- ReadDateValue (read time series file)
- ReadHydroBase (read time series)
- ReadStormWatch (read STORMWatch time series)
- Reservoir (simulates spill and fill, plus water supply withdrawals)
- Sacramento Soil Moisture Accounting Model
- SnowPack (snow model)
- TSExtend (extend the period of a time series)
- TSStats (statistical analysis of observed and simulated time series)
- TSSum (add/subtract/scale time series)
- UnitHydrograph (currently included in the Sacramento Soil Moisture Accounting Model)
- WriteDateValue (write time series file)
- WriteHydroBase (write time series)

For modeling purposes, the different operations are organized in an *operations table*. In addition to the operations listed above, a number of other operations are under development and will be included in future releases of the software. Implementation of the HydroBase database and its supporting features has reduced the need for a number of operations that were previously available (e.g., stage to flow conversion, mean areal precipitation computation).

The hydrologic simulation operations are continuous, physically based, conceptual models that are designed to produce streamflow forecasts in a variety of hydrologic conditions.

The FloodWatch Sacramento model is based on the U.S. National Weather Service Sacramento rainfall-runoff model and is written in state-space form (including the unit hydrograph model features) so that it

can use a Kalman filter. The Kalman filter is a mathematical tool that uses the observed streamflow to adjust soil moisture and streamflow conditions to produce a better streamflow forecast. In simple terms, the error between the simulation and observed data is used to adjust the internal states of the model, rather than just making an adjustment to the simulation. This allows FloodWatch to be run as a "hands-off" application. If observations are available, they are used to correct the simulations. If observations are not available for some period, the corrected model states from the previous run will help ensure a better forecast while observations are not available. Calibration of the Kalman filter and Sacramento model parameters are essential to ensure that adjusted soil moisture states are reasonable and that long-term hydrologic forecasts adequately match actual runoff volumes and timing.

In March 2001 Riverside Technology, inc. (RTi) installed FloodWatch at the WFO in Reno, Nevada. In this implementation FloodWatch uses real-time precipitation, temperature, and streamflow observations gathered by the WFO from various sources to automatically produce real-time streamflow forecasts in 10 minute intervals. Four forecast points are defined in the Reno area: the Truckee River near Truckee, Galena Creek at Galena Creek State Park, Steamboat Creek at Steamboat, and the North Truckee Drainage at Spanish Springs Road. Models employed include the NWS Snowpack and Sacramento Soil Moisture Accounting (SAC-SMA) models, as well as diversion and reservoir operations. Figure 1 shows the region and the basins of interest.

The simulated basins vary greatly in their climate conditions – from arid desert in the North Truckee Drainage to steep, wet mountains in the Galena Creek and Truckee basins. To reflect these differences and to produce accurate forecasts, FloodWatch was site-specifically calibrated using available historic data records. To further increase accuracy, a Kalman filter was incorporated to adjust the SAC-SMA model should the simulations differ from the observations. FloodWatch also supports the updating of computed snow water equivalent in the Snowpack model to observed conditions – this will simulate the complex snow conditions in the spring season.

Observed precipitation, snow, and streamflow data play an important role in operational forecasting. FloodWatch can import these data independently via the Standard Hydrologic Exchange Format (SHEF), however, in the Reno implementation a StormWatch database (from the DIAD corporation) is used to assimilate observations from multiple sources (GOES, ALERT, radio).

The data are automatically processed into applicable formats; e.g., stage observations are converted to flow using rating tables. Since rating tables frequently change, FloodWatch supports editing and adding of this information. Raw and/or processed data should subsequently be quality controlled by the operator and data summaries, graphs, and tables are available to support this task.

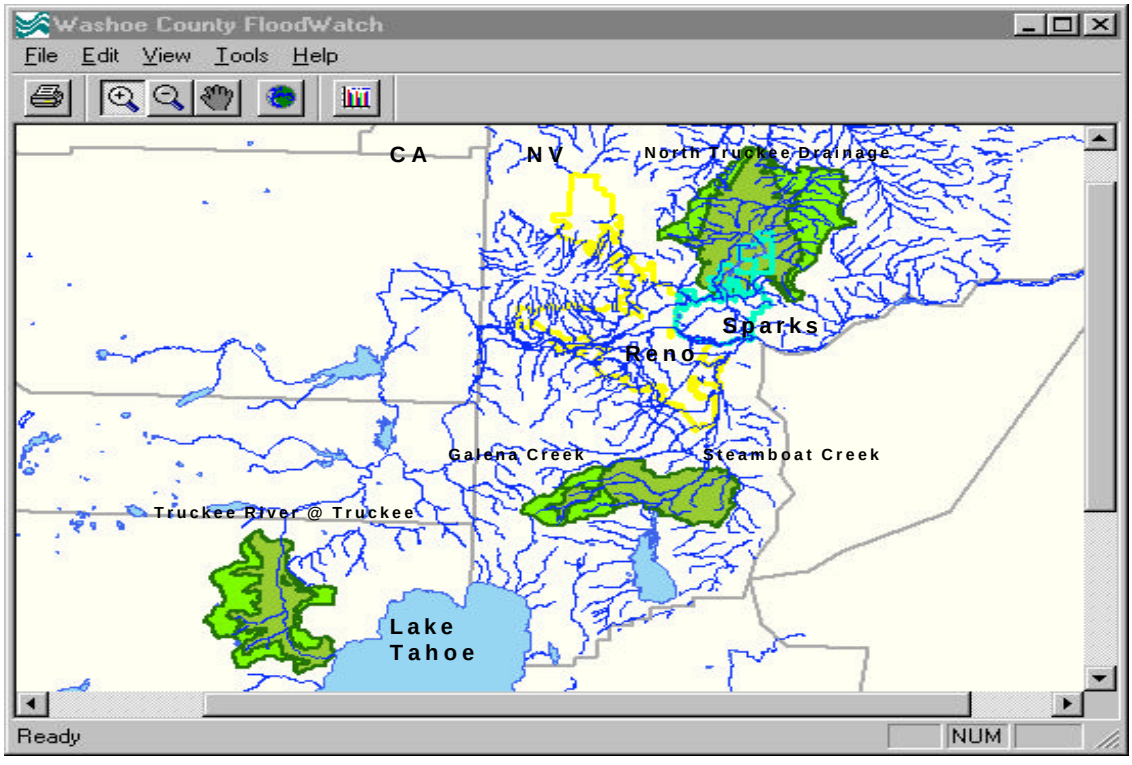

Figure 1. Overview of the Modeled Area in the FloodWatch Main Window

An important aspect of operational forecasting is the ability to use precipitation forecasts to produce streamflow outlooks. The NWS supplies the Reno WFO with QPF several times per day and the operator can enter the data into FloodWatch to calculate different forecast scenarios. Figure 2 shows a FloodWatch forecast plot with two scenarios: One assumes no precipitation in the future while the other employs an impending rain event. Visual warnings will alert the forecaster should a forecast exceed user defined monitoring and flood levels.

RTi also is working as part of an NWS team to develop flood warning systems in Honduras and Guatemala in support of the NWS Hurricane Mitch Reconstruction Activities. FloodWatch is being implemented in both countries to provide flood forecasts and also will be used in Honduras in conjunction with FLDVIEW to produce flood inundation maps for the Rio Choluteca.

3. OUTLOOK

The NWS is committed to providing the capability for short lead time hydrologic forecasts at WFO's. FloodWatch is one of several alternatives being assessed. This powerful forecasting tool will continue to be tested internationally and domestically and is being considered to support WFO hydrologic forecasting needs nationwide.

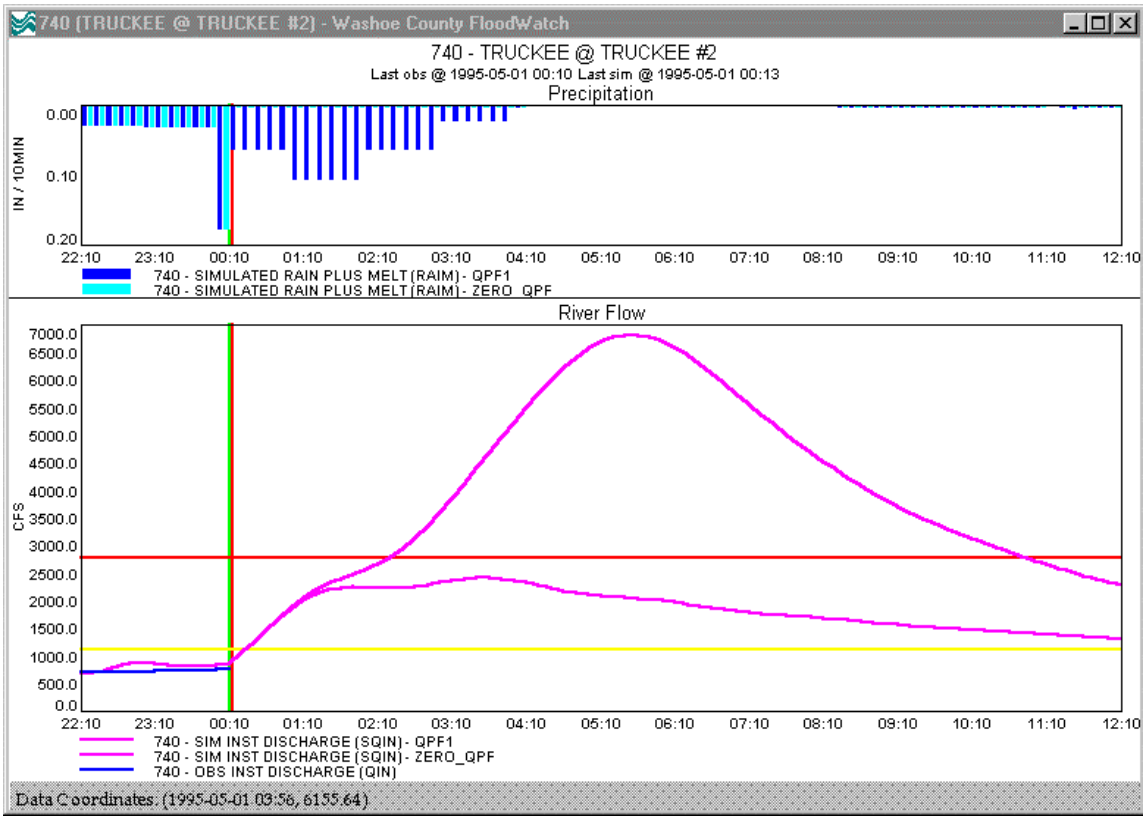

Figure 2. Forecast Scenarios in the Truckee River Basin