Journal of the Nevada Water Resources Association

Spring 2006

Truckee River Edition

A publication of the Nevada Water Resources Association,
providing hydrologic information to the people of Nevada and adjacent States

In Memory of Michael P. Mann, a Dedicated Hydrologist, 1971 - 2005

Volume 3, Number 1

Simulating Operations in the Truckee-Carson RiverWare Modeling System

SHANE COORS**,** Hydraulic Engineer, U.S. Bureau of Reclamation, 705 N. Plaza St., Suite 320, Carson City, NV, 89701 (scoors@mp.usbr.gov)

ABSTRACT

A Truckee-Carson Basin RiverWare operations model has been developed by the Lahontan Basin Area Office (LBAO) of the United States Bureau of Reclamation. This model simulates operations within the Truckee and Carson basins according to all current basin policy including the 1935 Truckee River Agreement, the 1944 Orr Ditch Decree, the 1959 Tahoe Prosser Exchange Agreement, the 1994 Interim Storage Agreement, and 1997 Operational Criteria and Procedures (OCAP). An overview of the model is presented, and examples of specific operations within the system are explored.

The model runs on a daily timestep from the current time through the end of the calendar year. The model was developed in RiverWare© and includes a physical model of the basin comprised of objects and links, as well as a ruleset that prescribes the operational policy and physical constraints on the system. RiverWare's simulation process is described and its rule writing interface and language are demonstrated. Several representative objects from the physical model are highlighted, and sample rules reviewed.

Currently, the operations model is being substantially revamped to simulate the Truckee River Operating Agreement (TROA). TROA is an innovative, flexible operating agreement between the significant stakeholders in the Truckee-Carson Basin that allows for extensive exchanging and trading within the basin reservoirs. TROA presents many modeling challenges to the RiverWare modeling system as well as the LBAO modelers. A brief introduction to the fundamentals of TROA is given, followed by a survey of the many modeling intricacies that TROA requires.

INTRODUCTION

A Truckee-Carson Basin RiverWare operations model has been developed by the Lahontan Basin Area Office (LBAO) of the Bureau of Reclamation (BOR). The area of study is the combined Truckee and Carson River basins as described in Mann (2006a).

RIVERWARE OPERATIONS MODEL

RiverWare Modeling Within the Truckee-Carson Basin

As described by Zagona and others (2001), RiverWare© is a modeling system that models complex river and reservoir operations in a generalized modeling environment. The Truckee-Carson RiverWare Modeling System is made up of three separate RiverWare models: a water Accounting Model, a hydrologic Forecasting Model, and a river-reservoir Operations Model, as shown in figure 1.

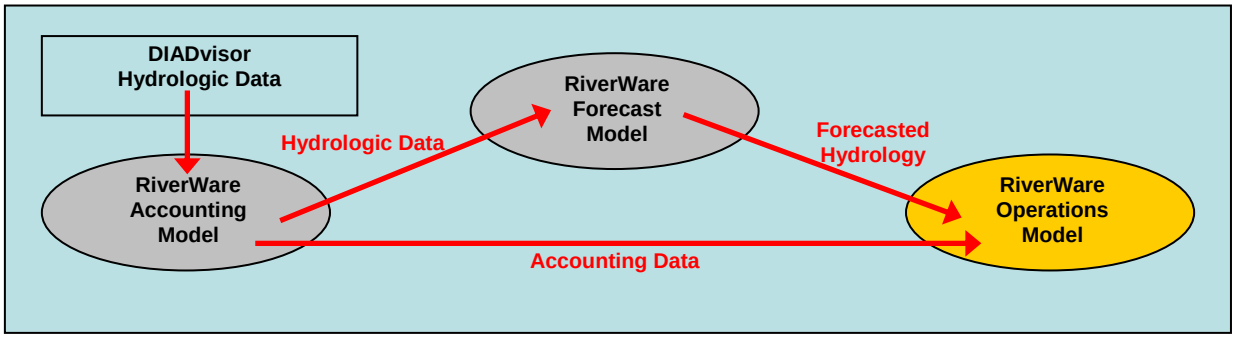

Figure 1. Schematic of Truckee-Carson RiverWare system.

The three models, while separate, are linked together as a system for the purpose of water accounting, forecasting, scheduling, and long-term planning for Truckee-Carson River Basin. The system is currently under development, and is intended to be used for implementation of the Truckee River Operating Agreement (TROA), the new basin operating policy. The current RiverWare system simulates current basin policy, and is being used for water-supply and operations forecasting. Development work is focusing on combining the accounting and operations models into a single accounting-operations model, as well as construction of a TROA ruleset. The forecasting and accounting models are described in greater detail by related papers submitted to the 2006 Federal Interagency Hydrologic Modeling Conference (Mann, 2006b; Boyer, 2006).

Model Workspace

Within the RiverWare modeling environment, the basin is physically represented and flows are simulated within the model workspace. Figure 2 shows a section of the Operations Model workspace.

Objects on the workspace represent reservoirs, reaches, confluences, diversions, power generating facilities, water users, and store all physical and accounting data. The objects are linked and the simulation process involves simulating the flow of the Truckee and Carson Rivers from upstream to downstream. Each object has engineering methods that govern how the water is simulated to flow across the object. Conveyance loss methods, lateral inflows, seepage methods, and accounting methods are specified for each of the objects. The objects can be arranged on the workspace to visually mimic the actual layout of the basin. This provides for a very intuitive and flexible representation of the modeled Truckee-Carson Basin.

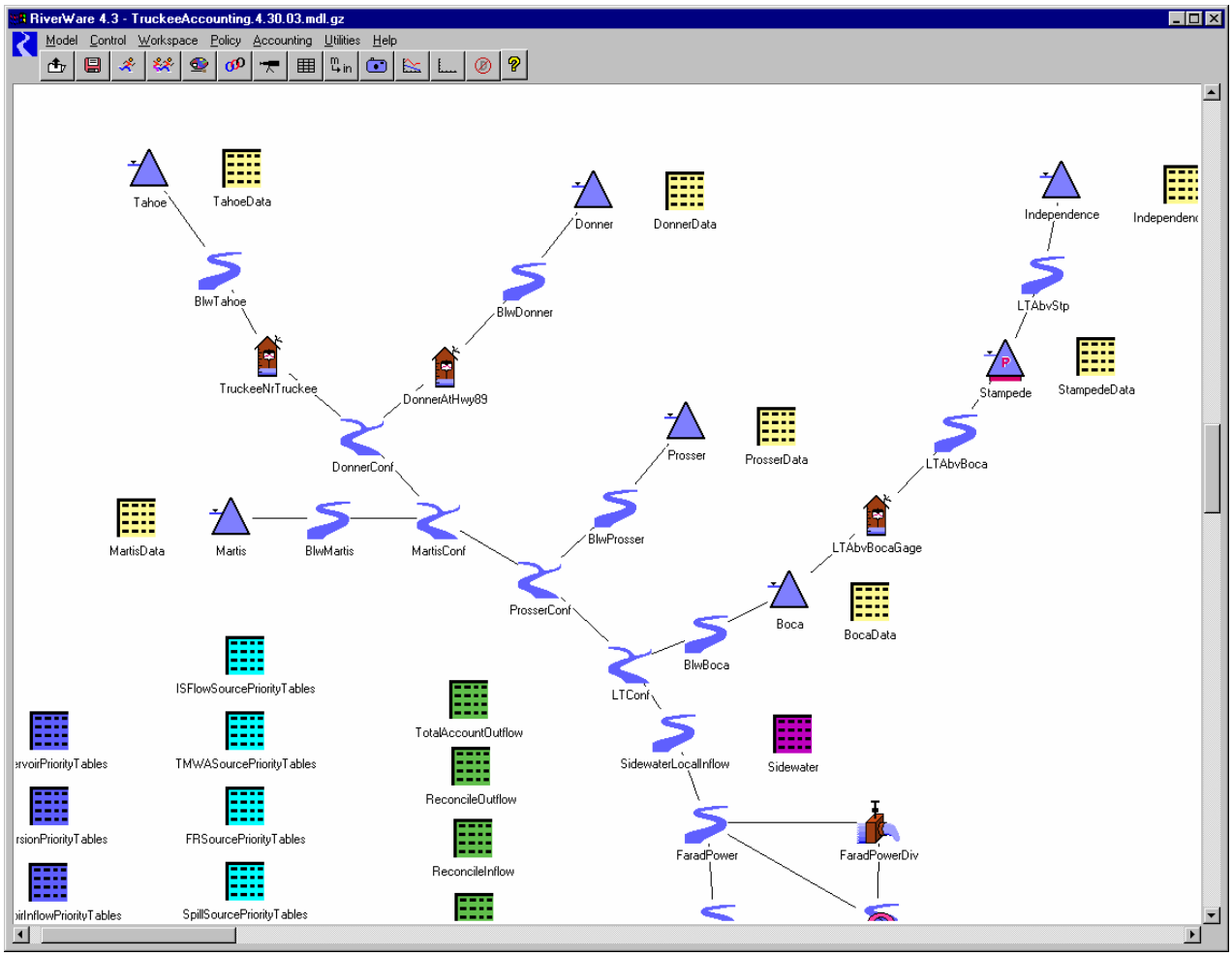

Figure 2. Portion of RiverWare Operations Model workspace.

Rule set

The Truckee-Carson Basin RiverWare Operations model also consists of a ruleset. This ruleset characterizes the basin policy that governs the operations within the basin. Decrees, agreements, physical constraints, and other operational criteria are represented in the model's ruleset. Figure 3 shows a portion of the Operations Model ruleset.

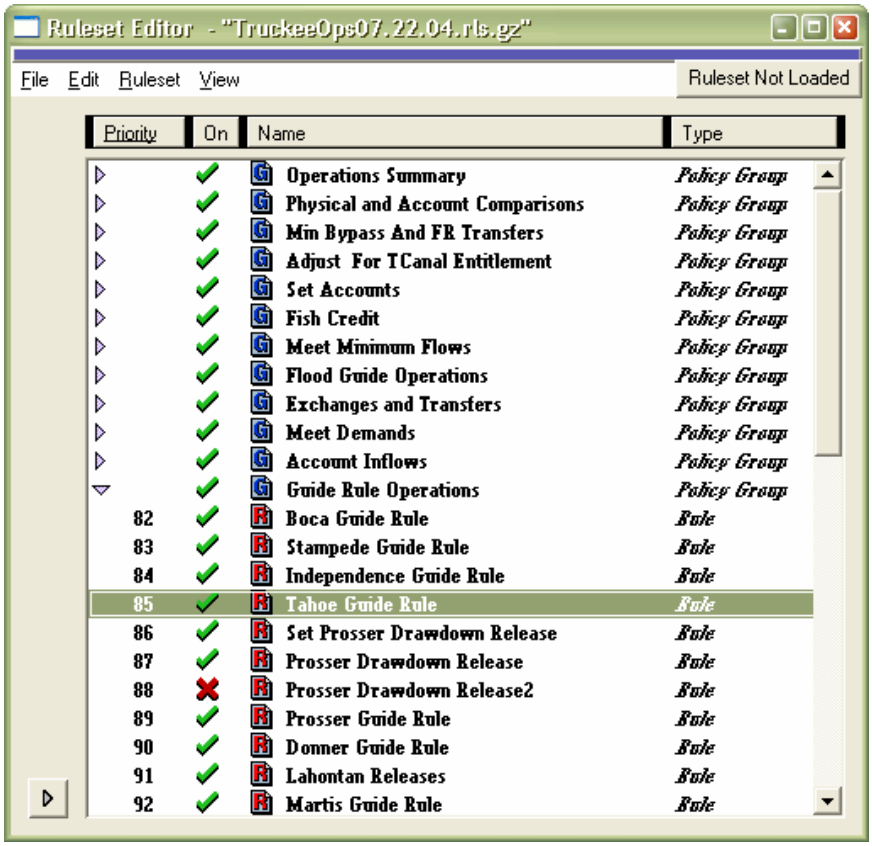

Figure 3. Portion of RiverWare Operations Model ruleset.

Rules are written in the RiverWare scripting language. The rules are arranged in priority order such that the highest priority rules are at the top of the rule set and the lowest priority rules are at the bottom. During each timestep of the simulation, the model starts at the bottom of the ruleset and "fires" the rules, one at a time from bottom to top. Because each successive rule the model processes as it works its way up the ruleset is of higher priority than those previously processed, it will overwrite any values previously set for that day. For instance, the release from a reservoir may initially be set according to a guide rule that prescribes a desired elevation value for a given date. Another higher priority rule may be encountered later (higher up in the ruleset) that prescribes a higher release in order to meet a downstream demand. Finally, a still higher priority rule may require a reduction in the release value in order to accomplish an exchange or "in-lieu-of release" with another reservoir. In this way, the higher priority rules have the last opportunities to change releases and other operations in the system. It should be noted that generally the rules become more restrictive as their priority values increase such that the satisfaction of a higher priority rule will also satisfy the lower priority rules. One timestep consists of firing each rule in the ruleset and then simulating the resulting flows within the linked physical model. Rules not only control the physical operations in the model; the accounting that is done in each timestep after the physical flows are set is accomplished with rules as well. Figure 4 shows an example of a rule written in the RiverWare Policy Language (RPL).

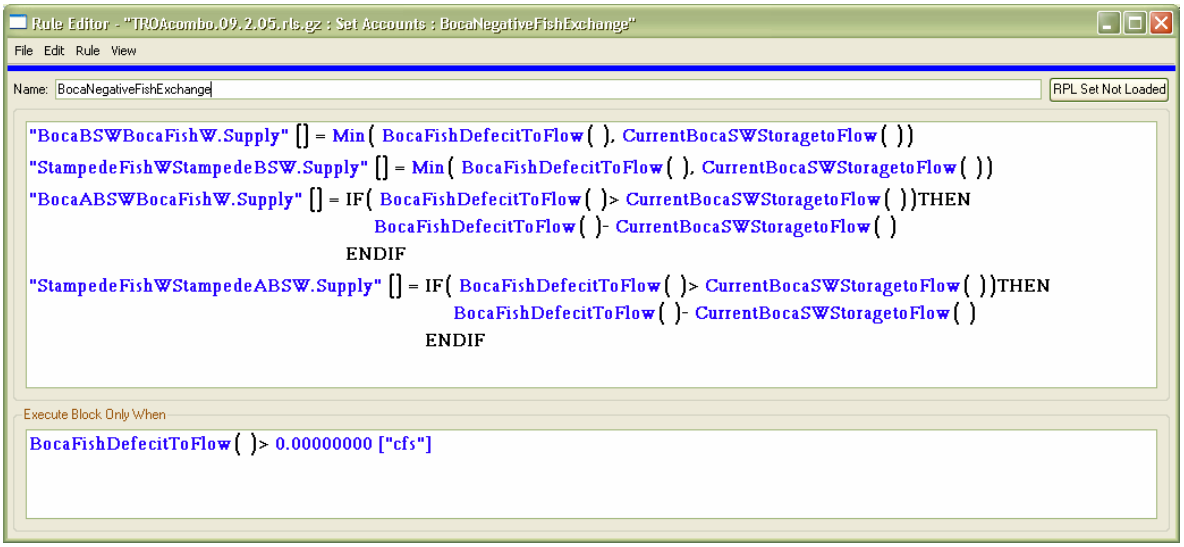

Figure 4. Example RiverWare rule.

Basin Operations

Operating policy within the Truckee-Carson Basin is a complex matrix of decrees, court orders, federal rules, and even informal agreements among the major basin water users. The primary policy documents that govern the operations within the basin and a brief summary of their contents are as follows:

1. 1935 Truckee River Agreement – Defines the Floriston Rate in its current form and how it is to be met.
2. 1943 Donner Lake Agreement – Divides Donner Lake storage rights between the TCID, and Sierra Pacific Power Company, now Truckee Meadows Water Authority (TMWA).
3. 1944 Orr Ditch Decree – Adjudication of all Truckee-Carson water rights. Assigned priority dates to water rights
4. 1959 Tahoe Prosser Exchange – Lake Tahoe minimum releases not needed to meet Floriston Rates are stored or exchanged for storage in Prosser Reservoir.
5. 1994 Interim Storage Agreement – Sierra Pacific (now TMWA) allowed to store private water in Federal Reservoirs (Boca and Stampede).
6. 1997 Adjusted Operational Criteria and Procedures (OCAP) – Governs diversions from the Truckee River to the Newlands project along the Truckee Canal. Minimizes use of Truckee River to meet Carson Division water rights.

Each of these operating policies and their entire contents are represented in the ruleset.

Floriston Rate Example

There are several major demands which in conjunction with the natural unregulated flow in the basin dictate the flows in the river. These demands are met according to a strict priority system among the sources of water. Some of the demands include endangered species flows, Truckee Canal entitlement, and Orr Ditch Decree water rights. Each of the seven upstream storage reservoirs has a designated purpose (or project water) that defines the demands for which

it can store and release water. As a result, the RiverWare model simulates operations using a generalized priority based algorithm for meeting demands. This procedure is summarized below.

The fundamental policy driving operations within the system is maintenance of the Floriston Rate. The Floriston Rate is a minimum rate of flow in the Truckee River at the California / Nevada state line. During the times of the year when unregulated flows in the California portion of the Truckee basin are not sufficient to maintain Floriston Rates, releases from the seven upstream storage reservoirs must make up the difference, subject to numerous restrictions and sub-policies. In order to model this process, a priority system to meet this demand is invoked. In RiverWare, each of the seven storage reservoirs is placed in a priority and assigned a priority according to policy. With regards to the Floriston Rate demand, there are several different scenarios, each of which has a different set of priorities based on the time of year of the current timestep and the current storage within Lake Tahoe (see table 1).

Table 1. Floriston rate demand priority table

Scenario	Martis	Donner	Prosser	Tahoe	Boca	Stampede	Independence
TahoeFirst	1	2	4	5	7	6	3
BocaFirst	1	2	4	7	6	5	3
TPXW	1	2	6	7	5	4	3
AugmentedRatingFlows	1	2	4	5	7	6	3

The model first calculates the difference between the required Floriston Rate and the natural unregulated flow at the state line. It then takes this deficit and references the priority table in order to meet the demand fully. There are two reservoirs which can store water adverse to the Floriston Rate, Independence (first 3000 acre-ft), and Donner. When the model gets to these in priority, it counts what is already being released for drawdown or minimum flows toward meeting the deficit. The remaining reservoirs in the basin must pass their inflows (i.e., they cannot store any water) to meet the Floriston Rate, so the model will go through these in the order prescribed in the table and release water to eliminate any remaining Floriston Rate deficit. Finally when this does not result in enough flow to meet the demand, the model releases storage from Tahoe and Boca. The Truckee River Agreement of 1935 authorized the construction of Boca Reservoir as a supplement to Tahoe for meeting the Floriston Rate. It also mandated that when the Tahoe pool elevation is below 1897.5 m (6225.5 ft), Tahoe storage is used first for meeting the Floriston Rate and when the Tahoe pool elevation is above 1897.5 m (6225.5 ft), Boca is used first. This is reflected in the priority table as different rows with headings "TahoeFirst," and "BocaFirst." The model goes through the same basic process in meeting each of the demands on the system. This priority system is the primary mechanism at work within the Operations model. It provides a framework that is most compatible with the policy that governs the operation of the Truckee River. The flows at the state line for 2005 are shown in figure 5. The blue plot represents the Floriston Rate target while the gray line is the actual flow in the river.

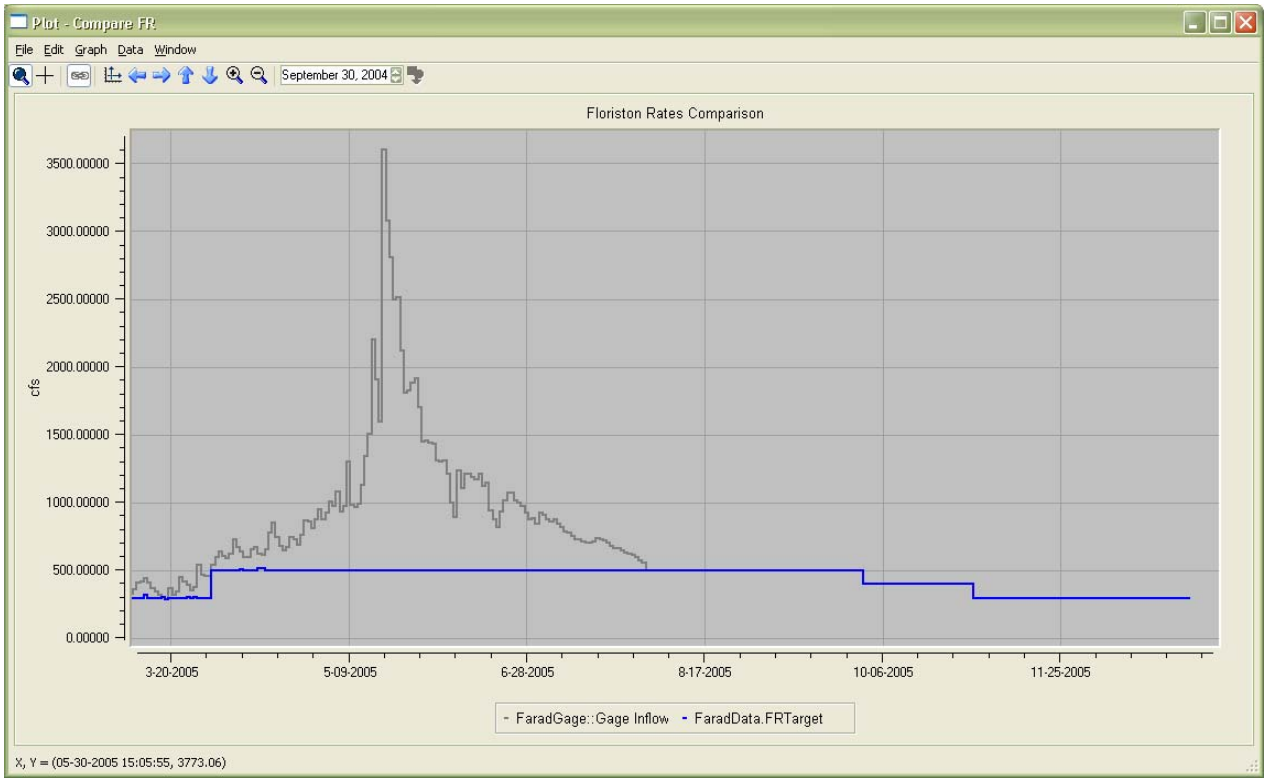

Figure 5. Floriston Rate target and actual flow at CA/NV state line in 2005.

CURRENT DEVELOPMENT

The Lahontan Basin Area Office technical staff is continuing to develop the suite of RiverWare models. TROA is nearing completion and its adoption as the operative agreement within the basin is imminent. A RiverWare model of TROA will be used by the TROA administrator to implement this agreement.

Combo-Model

The RiverWare modeling suite requires a significant amount of data to be passed from model to model via a database. It was determined that much of the overhead associated with data transfer and maintenance of three separate models could be reduced by merging the Accounting and Operations model. The new system includes a combination Accounting/Operations model which invokes the RiverWare Forecast Model mid-run. The schematic of the new modeling system is shown in figure 6.

The Combo-model begins its simulation at the start of the current water year and proceeds by simply doing daily accounting up to the “current time,” the time at which gage flow and reservoir storage data ends. Typically the current time is the actual date that the model is being run or the most recent time when data for all required sites are available. At this point the Combo-model sends out all hydrologic data to the RiverWare forecast model which generates daily inflow forecasts for all of the headwaters and sideflows in the model. The forecasted hydrology is sent back to the Combo-model which then enters an operations mode. Then, based

on the forecasted hydrology, the model operates the system according to basin policy and does accounting through to the end of the following calendar year. This streamlining of the modeling process reduces the amount of data that is being moved in and out of models, and provides a better foundation for the continued development of the TROA ruleset.

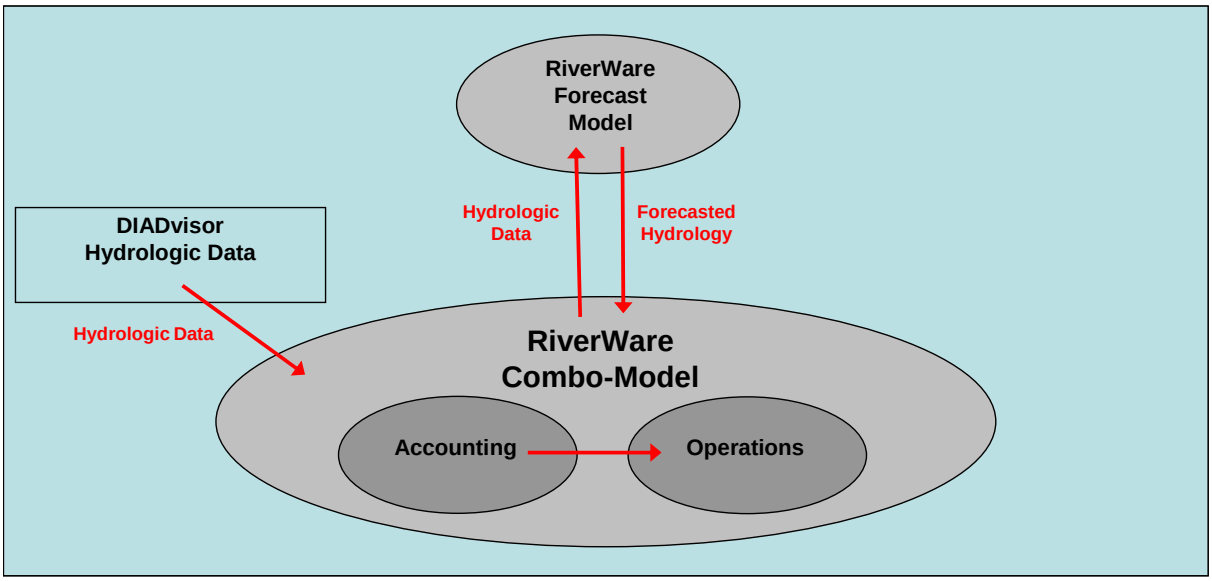

Figure 6. Combo-model schematic.

Hydrologic Database (HDB)

The LBAO technical staff and the TROA implementation coordination office have recently completed the deployment of a new data base to support the TROA modeling effort. The previous suite of models employed three separate DSS databases using the US Army Corps of Engineers' HEC_DSS format. However, with the transition to TROA imminent, it was determined that a new database would be needed to implement TROA and to serve as the "database of record" in the Truckee-Carson basin. The new database is an HDB. HDB was developed by Bureau of Reclamation water managers in conjunction with the center for Advanced Decision Support for Water and Environmental Systems (CADSWES), and is currently being used within the Upper Colorado and Lower Colorado Regions in their management of the Colorado River. HDB is an Oracle-based database that provides all of the functionality that the administration of TROA requires.

TROA

Currently the LBAO technical staff is developing the TROA model and ruleset. TROA is an innovative, flexible operating agreement that requires a highly sophisticated model of the basin and the policy to implement. It provides for the establishment of credit water within the basin and allows for its flexible management by the owners of the credit water. TROA will greatly increase the complexity of the physical operation of the system as well as the accounting. The number of accounts in the system grows from seven to around twenty. Each reservoir goes from storing the water for which it was constructed, its project water, to being able to store all types of credit water, its project water, and even other basin reservoirs' project water. Additionally,

trades, exchanges, and in-lieu of releases are provided for throughout the basin. All of this contributes to a substantial increase in the number and complexity of the modeled processes within the basin.

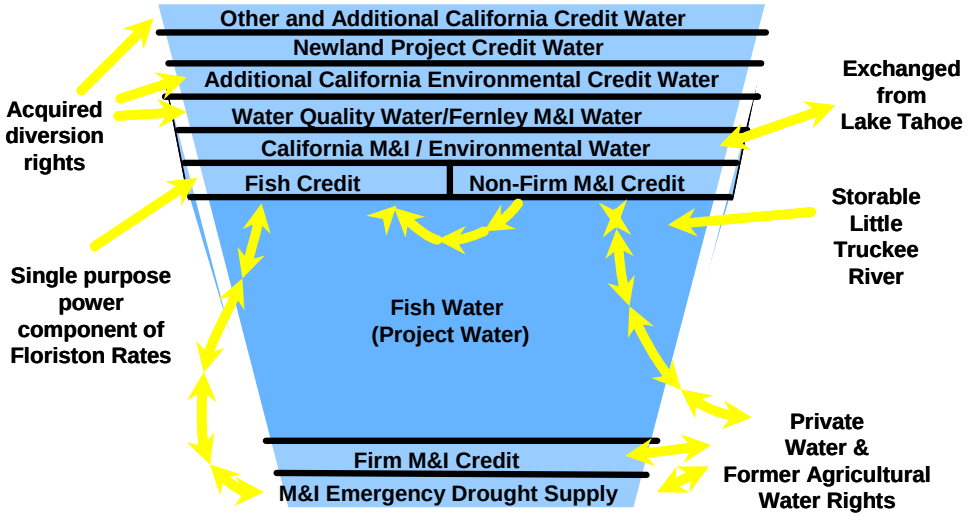

Figure 7. Schematic of storage accounts in Stampede Reservoir under TROA.

The benefits of TROA are significant. It provides for improved drought protection for the Truckee Meadows (Reno and Sparks), Upper Truckee basin (California), and Fernley, NV. Capacity to meet the needs of the threatened and endangered fish in Pyramid Lake and the Lower Truckee River is enhanced. Recreation interests are better served. Water quality, especially in the low-flow periods of the year will be improved. Newlands Project diversions will be more precise. No new facilities are necessary to accomplish these measures and all storage fees paid to the United States for the capacity to store water in Federal Reservoirs will be used for wetlands and fish habitat restoration.

In practice, TROA will be administered by a federally appointed administrator; however each of the parties in the basin with credit water will have the responsibility to manage the storage and release of their credit water. It is being described as “operation by committee.” Consequently, the model is being designed to facilitate easy interaction among the parties in the basin with the model. This is a requirement that makes TROA and the TROA RiverWare model unique within the water resource management community.

SUMMARY

A RiverWare Operations Model for the Truckee-Carson Basin has been developed by the technical staff of the Lahontan Basin Area Office of the Bureau of Reclamation. The model consists of a workspace with linked objects and a ruleset which captures the operating constraints and basin policy. This model is part of a larger modeling system which includes an Accounting Model, a Forecasting Model, a realtime data collection system, and a set of databases. The modeling system is used to provide annual operational forecasts to Truckee basin stakeholders. The Operations model takes the updated accounting data from the Accounting Model and a distributed hydrologic forecast from the Forecasting Model and then simulates the operations of

the Truckee-Carson system through to the end of the year. The primary mechanism at work in the Operations Model is a priority based system according to established basin policy for meeting the major demands in the basin. The modeling suite for the existing conditions is complete and functioning. In development is a suite of RiverWare models to model TROA, a new operating agreement. To this end, the Accounting Model and Operations Models have been combined into a single model and a new ruleset is being developed for the new TROA policy. The new modeling system will be used to administer TROA and will facilitate the collective operation of the system by basin stakeholders.

REFERENCES

Boyer, J.T., 2006, Water Accounting in the Truckee Basin RiverWare Model: Proceedings of the 2006 Federal Interagency Hydrologic Modeling Conference.

Mann, M.P., 2006a, Hydrologic Forecasting in the Truckee-Carson RiverWare System: Journal of the Nevada Water Resources Association, v. 3, no. 1, p. 12-27.

Mann, M.P., 2006b, Hydrologic Forecasting in the Truckee-Carson RiverWare System: Proceedings of the 2006 Federal Interagency Hydrologic Modeling Conference, 8 p.

Rieker, J.D., Coors, S., Mann, M., and Scott, T., 2005, Modeling in Support of Water Operations in the Truckee River Basin: Proceedings of Watershed Management 2005, EWRI and ASCE, Williamsburg, VA, July, 2005, 7 p.

Zagona, E. A., Fulp, T. J., Shane, R., Magee, T., and Goranflo, H. M., 2001, RiverWare: A Generalized Tool for Complex River System Modeling: Journal of the American Water Resources Association, v. 37, no. 4, p. 913-929.