

# The Upper Rio Grande Water Operations Model: One River, Two Countries, Three States, and Over 20 Years of Multi-Agency Collaboration

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## Extended Abstract

### URGWOM Overview:

The Upper Rio Grande Water Operations Model (URGWOM) is a mass balance model of water operations and water accounting in the Rio Grande basin from the headwaters in southern Colorado to Hudspeth County, Texas. URGWOM is built in RiverWare, a generalized river basin modeling environment that can be used to develop an operations model for any hydrologic configuration and to simulate operations to meet needs for flood control, water supply, recreation, water quality, navigation, or any other purpose incorporated into the ruleset. RiverWare is designed to provide river basin managers with a tool for scheduling, forecasting, and planning reservoir operations and includes extensive capabilities for rule-based simulations and water accounting. URGWOM tracks water movement by owner and simulates near and long-term water operations in the multi-state, multi-national Rio Grande basin. URGWOM is collaboratively developed, maintained, and run by multiple Federal and State entities.

URGWOM represents many physical processes including hydrologic travel times, reservoir evaporation and seepage, river channel evaporation, evapotranspiration by riparian and agricultural vegetation, municipal waste water return flows, irrigation return flows, surface water-groundwater interaction including crop percolation, canal leakage, river seepage and drain capture. URGWOM is used by multiple stakeholders for Accounting, Water Operations, and Planning applications.

- Accounting: Water accounting in URGWOM occurs as backward looking, data driven, daily timestep accounting of native and trans-basin (San Juan - Chama) water in the system from the beginning of the calendar year through the previous day. Accounting runs are typically completed daily by the Albuquerque office of the U.S. Bureau of Reclamation (Reclamation).

- Water Operations: Annual operating plans are developed with URGWOM using a forward looking daily timestep, rule-based, real-time (1-2 weeks out) and annual (calendar year) operating plan runs. The annual operating plan runs are typically run 5-6 times per year by the Albuquerque office of the U.S. Army Corps of Engineers (USACE) in conjunction with Reclamation and the New Mexico Interstate Stream Commission (ISC).
- Planning Application - Daily or monthly timestep, rule-based planning runs simulating water operations decades to centuries into the future. These long-term runs are executed as needed depending on planning needs and funding resources allowed by Reclamation, USACE, and ISC.)

### History of URGWOM:

In 1996, six federal agencies including USACE, Reclamation, the U.S. Geological Survey (USGS), the U.S. Fish and Wildlife Service (USFWS), the Bureau of Indian Affairs (BIA), and the International Boundary and Water Commission (IBWC) recognized the need for a unified water operations model for the Upper Rio Grande Basin. These agencies entered into a Memorandum of Understanding (MOU) to create URGWOM. During the initial phase of URGWOM development various potential software options were considered. A review of several reservoir and river simulation software packages within the context of the needs of water managers in the basin led to RiverWare being selected as the software package for URGWOM. RiverWare was developed by the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of Colorado at Boulder. A new MOU was signed in 2007 designating Reclamation, USACE, and ISC as lead agencies responsible for most funding of model maintenance and development. Contributing agencies including USGS, BIA, IBWC, and CADSWES among others are represented on an Advisory Committee and Technical Team, and provide data and technical review.

### Interesting Technical Details of URGWOM:

#### Geographic Extent

URGWOM started as a model of the Rio Grande in New Mexico upstream of and including Elephant Butte and Caballo Reservoirs. According to the Rio Grande Compact, Colorado delivers water at the Colorado-New Mexico state line, while New Mexico delivers its compact obligation at Elephant Butte Reservoir.

In 2012, the URGWOM Technical Team began development of a Colorado portion of the model which includes large portions of the Rio Grande, Conejos, Los Pinos, and San Antonio Rivers in Colorado. Consistent with management of the Rio Grande system in Colorado, this portion of the model is driven by prior appropriation administration of adjudicated water rights. The Colorado portion of the model was developed to help improve estimates of flows at the Colorado-New Mexico state line. In 2015, the Colorado portion of the model was added to URGWOM. The Lower Rio Grande portion of the model, extending downstream from Caballo Reservoir to Hudspeth County, Texas, was developed over many years and was also added to URGWOM in 2015.

## Surface Water – Groundwater Interactions

Surface water – groundwater interactions play a key role in mass balance in the Rio Grande downstream of Cochiti reservoir, particularly when flow in the river is low. URGWOM uses Groundwater Storage Objects to model shallow groundwater levels and resulting surface water – groundwater exchanges downstream of Cochiti Reservoir. Deep aquifer heads associated with each Groundwater Storage Object are extracted from regional groundwater models for use as boundary conditions for the URGWOM representation of the shallow aquifer. This process effectively couples groundwater models built by the USGS and other government agencies with URGWOM. One technical issue associated with this implementation is that the groundwater flow equations are explicit in time, meaning head values at the previous timestep are used to solve for flows between zones in the current timestep. This can and does lead to some numerical instabilities in cases where fluxes between the surface water and groundwater system are relatively large.

## Timesteps

URGWOM was initially built and is predominately used as a daily timestep model. High computational intensity and large data input and output requirements associated with decadal or longer daily timestep runs led to the development and implementation of a monthly timestep option in URGWOM. Interestingly, the monthly timestep option is not a separate model, nor is it implemented with a separate ruleset. The model itself can be run at a daily or monthly timestep, and the ruleset was rewritten to generalize logic so that rules could be used at either timestep.

The resulting capability allows URGWOM to be converted to a monthly timestep for the purpose of making many long runs from which a smaller subset may be run at the daily timestep. This timestep generalization has also laid the groundwork for URGWOM to be run at a sub-daily timestep, perhaps 6 hours, which may be helpful when a real-time forecasting application is developed. This real-time application would take precipitation and temperature forecasts several days into the future to run a short-term river system forecast that can be updated daily.

## Combined Accounting to Operations or Planning Runs

Originally, the URGWOM accounting, annual operations, and planning models were separate applications. This meant that the up to date historical data available in the accounting model was not readily accessible to the other model types. In 2013, URGWOM was updated to allow all three types of models to be run from a single model file. Specifically, this allows the model to be run in accounting mode from the beginning of the current year through the previous day, and then switched into a rule-based mode to project conditions in the system for the rest of the year or longer starting from the latest available data. Initial conditions for any operations or planning future-cast run are now automatically defined based on the latest observed data as incorporated into the hind-cast accounting run.