



## **IMPLEMENTATION OF WATER RESOURCE MANAGEMENT TECHNOLOGY: EXAMPLES FROM THE RIO GRANDE**

Gail Stockton  
URGWOM Program Manager  
US Army Corps of Engineers, Albuquerque District

Tim J. Ward, P.E.  
Dept. of Civil Engineering, The University of New  
Mexico, & URGWOM Technical Steering Committee

The RIOFISH model was developed in the 1980s as a deterministic, numeric system simulation composed of hydrologic, ecological, and socio-economic components. Using historic and field collected data, it was developed first for the Rio Grande basin in New Mexico, but was extended to the San Juan, Pecos, Canadian, Gila, and selected closed river basins by the early 1990's. The model was funded primarily by the New Mexico Department of Game and Fish to assist that agency in its management of sport fisheries. At its completion, RIOFISH included 132 fishery sites comprised of individual reservoirs, streams, and river segments ranging in surface area from 10 to over 10,000 hectares. Computation periods varied from two weeks (hydrologic) to seasons (ecologic) based on the component.

The backbone of the Upper Rio Grande Water Operations Model (URGWOM) was completed in 2002 but continues to be improved as updates and modifications are incorporated. It is a set of daily time step, river and reservoir models, developed with historical hydrologic data from the Upper Rio Grande Basin to do "what if" scenarios for daily reservoir operations and long term planning related to management of water resources for a large number of stakeholders.

Like RIOFISH, URGWOM has a great potential for collaboration to help solve water management problems on a basin-wide scale. This presentation will discuss historic and current communication and coordination opportunities and impediments to using technology for collaborative problem solving, and strategies for removing roadblocks to broader utilization. Specifically, these are (1) stepped access levels; (2) links to other models or tools for more applications; (3) data portals and data sharing; (4) collaborative data collection; (5) education; and (6) documentation.

A number of reports on the development and use of the RIOFISH model can be found through the New Mexico Water Resources Research Institute (<http://wrii.nmsu.edu>), which provided a portion of the funding for the long-term study. URGWOM information, documentation, and other links are available at <http://www.spa.usace.army.mil/urgwom>. Current broad-scale application of URGWOM, in combination with other tools is the Upper Rio Grande Basin Water Operations Review and Environmental Impact Statement (<http://www.spa.usace.army.mil/urgwops/>). It is being conducted for selection of an integrated plan for basin water operations. Please see these web sites for more detailed information, URGWOM model runs, and links to RiverWare viewer to examine, export, and/or plot.

### *Examples from the Rio Grande*

- Overview of Resource Management Models
- Historical Perspective: RIOFISH
- Current Technology: URGWOM
- Strategies for Acceptance and Use

The objectives of this presentation are to acquaint the audience with resource management models in general, give a historical overview of the first comprehensive resource model developed specifically for NM, introduce current technology in the URGWOM, and highlight issues regarding model acceptance and long-term use.

The list of agencies and people who have supported development of resource models in New Mexico is quite extensive. Some of the support is financial, but as important is the assistance through data sharing, review of model operation and results, and acting as a concerned stakeholder in the process.

### ACKNOWLEDGMENTS

- US Army Corps of Engineers
- NM Department of Game and Fish
- NM Water Resources Research Institute
- NM Agricultural Research Station
- Many others —

Bureau of Reclamation  
 US Geological Survey  
 US Fish and Wildlife Service  
 Bureau of Indian Affairs  
 International Boundary and Water Commission, US Section  
 NM Interstate Stream Commission  
 City of Albuquerque  
 City of Santa Fe  
 Los Alamos National Laboratory  
 Sandia National Laboratories  
 Paso del Norte Watershed Council  
 Desert Research Institute  
 El Paso Water Utilities  
 Rio Grande Restoration  
 University of New Mexico  
 NM Water Resources Research Institute  
 & approximately 80 other individuals or entities who help with technical review

Review and EIS Joint Lead Agencies: Corps of Engineers  
 Bureau of Reclamation  
 NM Interstate Stream Commission  
 Cooperating Agencies:  
 Bureau of Indian Affairs  
 US Fish and Wildlife Service  
 NM Department of Agriculture  
 NM Environment Department  
 Pueblo of San Juan  
 Agencies contributing staff time in support of technical teams or public involvement:  
 International Boundary & Water Commission, US Section  
 NM Game & Fish Department  
 Middle Rio Grande Conservancy District  
 City of Albuquerque  
 Rio Grande Restoration  
 City of Santa Fe  
 Colorado Division of Water Resources  
 Texas Natural Resources Conservation Commission  
 University of New Mexico  
 NM State University  
 NM Institute of Mining & Technology  
 NM Water Resources Research Institute  
 & approximately 20 other individuals or entities



## Resource Management Models

- Interdisciplinary
- Systematic quantitative approach
- Integrated focus
- Computer based
- Decision Support Mode
- Forecasting (prediction) Mode

For a complex system, there are a large number of resources that must be considered in any management model. Adequate consideration of the resources cannot easily be accomplished by one single discipline. Therefore, development of resource management models requires an interdisciplinary approach. Engineers, biologists, economists, and policy experts, to name a few disciplines, need to be working together to correctly depict complex systems. The interdisciplinary team needs to take a quantitative system-wide approach, because models run on numbers and decision points and the public needs quantitative information they can understand. The team must have an integrated focus, i.e., what are the problems or scenarios we need to be able to address, rather than each discipline taking its own approach to answering the problems. A model of a complex system must be computer based to process the large amount of information needed to enable the different processes that simulate the system. The model should be able to run in different modes. The most practical are a decision support mode to assist managers with regular operations, and a forecasting mode to permit planners to examine different scenarios stretching into the future.

## RIOFISH

- Team assembled in 1980
- Last Report in July 1995
- Focus is sport fisheries
- Started in Rio Grande Basin
- Expanded to entire state
- 132 sites – reservoirs, lakes, stream/river reaches
- Hydrology – Biology - Economics

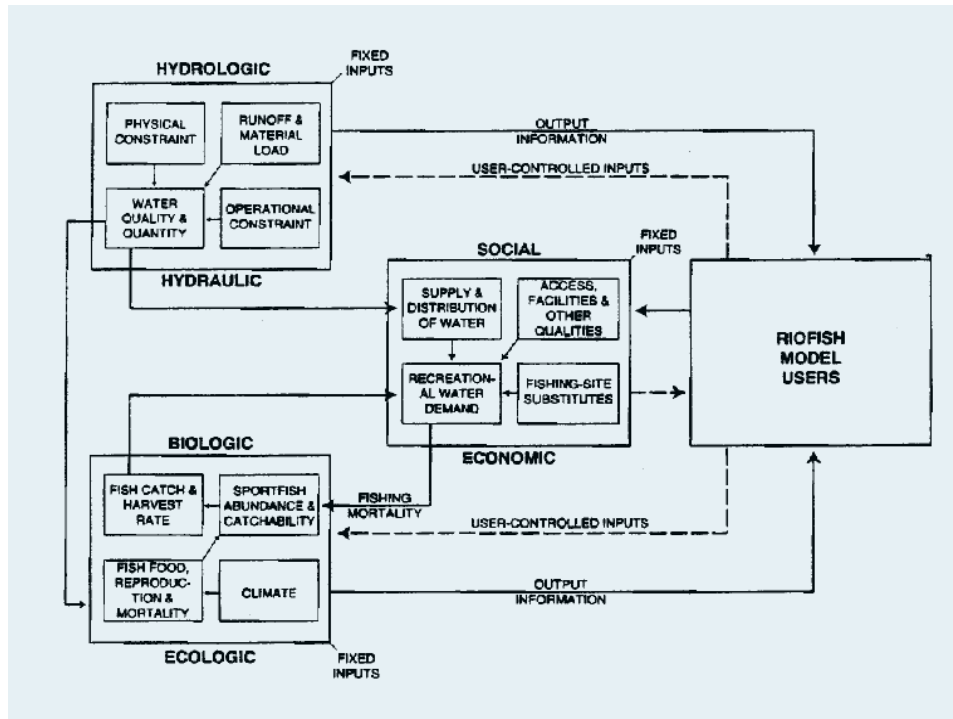
### RIOFISH Basics 1

- Historic data – 1975 through 1992
- Synthetic data – extremely dry to extremely wet years
- Mass balance routing on two week time step
- Quantity and quality at sites

### RIOFISH Basics 2

- Biologic – Link management tactics to fish production, density and angler effort based on “bottom up” habitat inputs and “top down” fishing inputs.
- Economic – Link fisheries, site, travel, climatic, and angler characteristics at and among sites to estimate at site and statewide benefits

An example of an interdisciplinary resource management model is the one, which resulted, over time, in RIOFISH. Dr. Richard Cole (Emeritus Professor) at New Mexico State University (NMSU) began a research project with the NM Department of Game and Fish (NMDG&F) in 1980 to model the hydrology, biology, and economics as they related to sports fisheries in the Rio Grande Basin of NM. Dr. Cole was responsible for the fisheries components of the model and overall model development. Dr. Frank Ward was responsible



for the resource economics component, and Dr. Tim J. Ward (no relation) was in charge of the hydrology and hydraulics (including physical habitat) of the system model. The hydrology and hydraulic components of the model used two-week time steps so simple routing could be used between river locations. This time step was finer than that needed for the fisheries or resource (recreation) economics components, but not so coarse as to miss variability in the system. All the components- Hydrologic/Hydraulic, Biologic/Ecologic, and Social/Economic - were linked together in the overall model framework. A user interface was developed and the correct feedbacks between the components were set in place. It was this model that the NMDG&F used in decision support.

The model was based on historic data starting in 1975, i.e., post Cochiti Reservoir closure. The first few years of model development had a limited database; so effort was put into code development and field data collection to parameterize the internal process models. For examples, channel geometry and substrate information was collected at key locations beyond that available from Federal agencies, and surveys were conducted with persons enjoying recreation activities at different river locations. By the time the final report was issued, in 1995, the model for the Rio Grande Basin had grown to encompass the five major drainages in NM – San Juan, Rio Grande, Pecos, Canadian, and Gila – as well as closed basins, e.g., Mimbres and Tularosa, and lakes not directly connected to these basins. In all, 132 sites – reservoirs, lakes, and stream/river reaches (anywhere a fishery existed) – were modeled in the final, RIOFISH. The time base extended from 1975 through 1992.

### RIOFISH Today

- Team is dispersed
- Model maintained by Dr. Katherine A. Green-Hammond
- Paper on model received the AWRA Best Paper Award for 1990
- Unique with no other models of this complexity

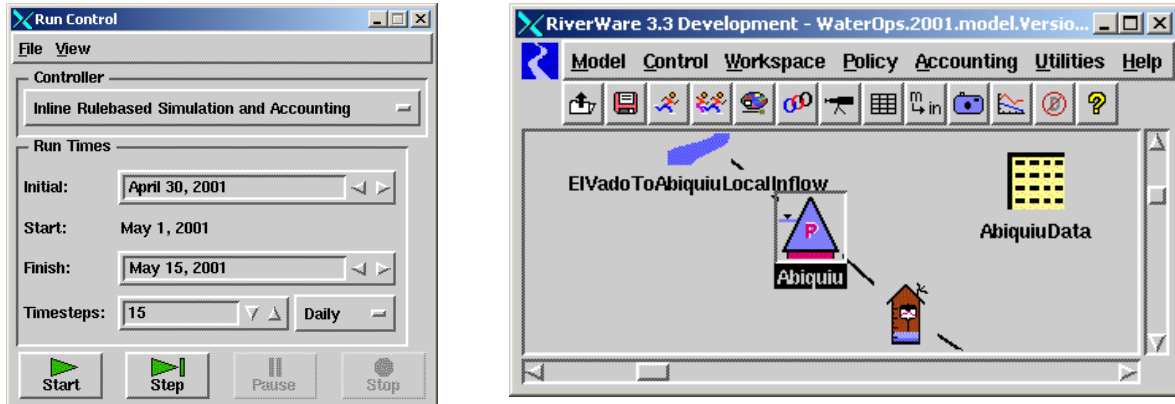
So what happens once a complex system resource management model is built? In the case of RIOFISH, the team dispersed over time: Dr. Cole retired, Professor Tim J. Ward moved to UNM, and Professor Frank Ward is still with NMSU. Dr. Katherine Green-Hammond (Albuquerque) still maintains the model. She was an invaluable member of the team that ported the code created by each discipline into APL and placed it on a PC platform. The model did not mature and grow as it may have given additional funding and wider use.

RIOFISH was decades ahead of its time. Only now are we seeing the advent of truly interdisciplinary models that treat more than just the water, but also what the water can generate in terms of recreation and income. The importance of this effort was recognized by the American Water Resources Association when in 1990 it

conferred the annual Boggess award on the paper describing the model in the Journal of the AWRA, “Development of an Interdisciplinary Planning Model for Water and Fishery Management.” RIOFISH still remains a model ahead of its time.

But what do we have now? That question leads to a discussion of the current technology as incorporated in URGWOM.

## Upper Rio Grande Water Operations Model (URGWOM) Basics



### What Is URGWOM??

#### Upper Rio Grande Water Operations Model

- Rio Grande modeled in RiverWare™
- Four Daily Time-Step Models: Forecasting, Accounting, Water Operations, & Planning
- Eight USBR & CORPS-operated reservoirs
- 16 Accounts of trans-basin “San Juan-Chama” water
- Operational “Rules” \*\*
- Spring-runoff forecasts converted to daily time step
- Input from other models: ET-Toolbox, MMS
- HEC-DSS Database

**URGWOM:**  
**It's all about flow**

(or Volume)

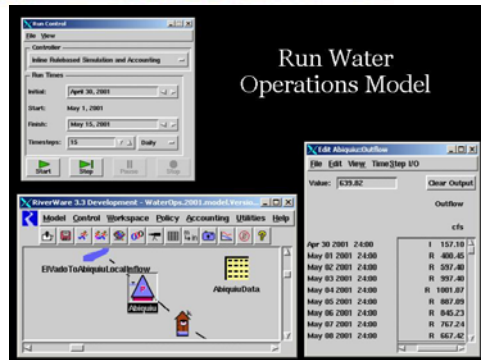
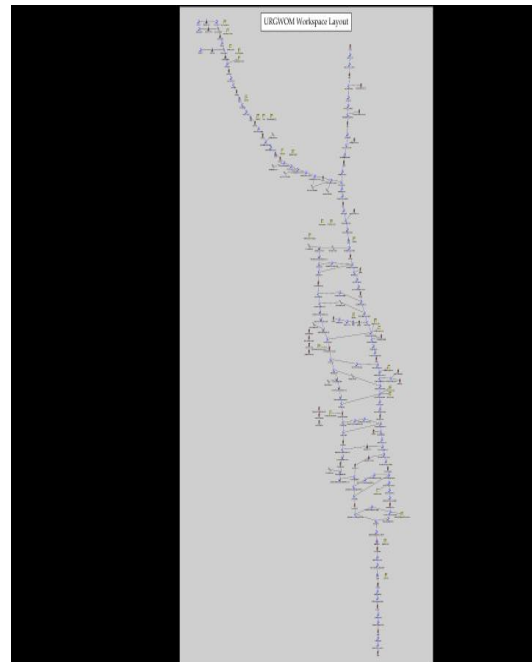
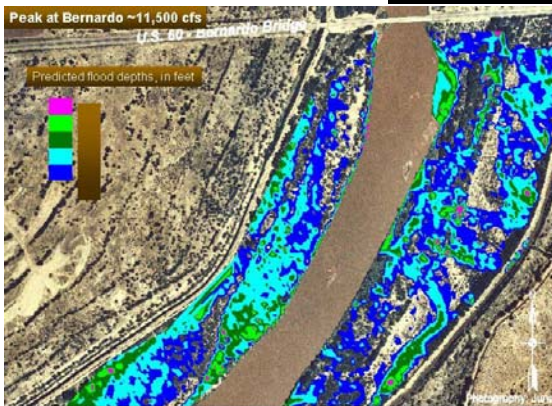
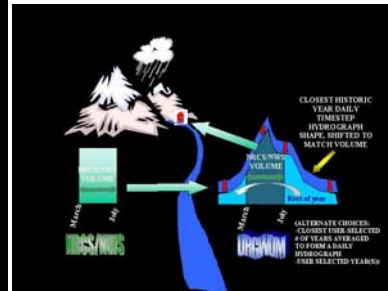
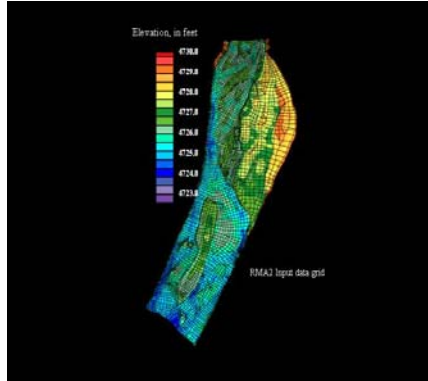
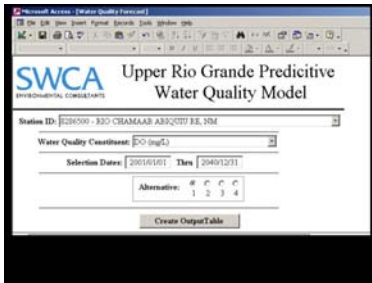
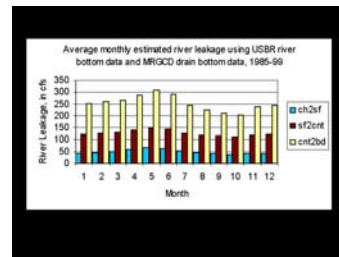
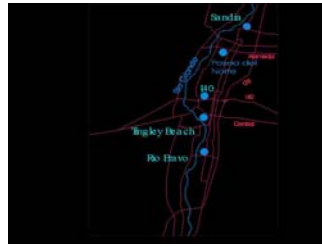
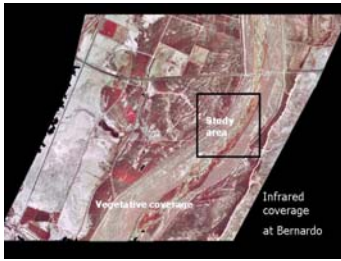
#### Upper Rio Grande Water Operations Model (URGWOM)

<http://www.spa.usace.army.mil/urgwom>

#### Upper Rio Grande Water Ops Review & EIS

<http://www.spa.usace.army.mil/urgwops>

A multi-agency water operations model, the “Upper Rio Grande Water Operations Model” or “URGWOM” has been developed and implemented to help manage a very complex accounting and operational decision-making collaboration of agencies. This tool is currently used to do water accounting, annual operating plans of the Rio Grande from the Colorado/New Mexico border to El Paso, Texas. It also provided 40-years of key flow and storage projections towards the development of “Upper Rio Grande Basin Water Operations Review and Environmental Impact Statement” (Review and EIS) which examines numerous alternatives within existing authorities for optimal future water management. More specifically, it is the upper Rio Grande modeled in RiverWare, and all the rest of the bullets you see below. Simplistically, it tracks river flow or volume through the river and reservoir system. Documentation and more detailed information on both URGWOM and the Review and EIS are available on the websites shown.



In addition to the Review and EIS, there are other URGWOM applications, which use output from URGWOM or provide input to URGWOM, or link to other related projects. Instead of a model that does everything, URGWOM links to other models or provides data to other applications, thereby increasing the chance to fully utilize URGWOM. Some of these applications or links are: FLO-2D hydraulic models of the Rio Grande and Rio Chama, vegetation mapping for assessing effects of over bank flooding, aquatic habitat model, water quality models, shallow groundwater/surface water data collection program, coordinated database for the Rio Grande project area, snowmelt runoff models, etc. There is also work in progress to develop a linkage between RiverWare, the software that URGWOM uses, and the Corps Water Management System (CWMS), which contains another whole selection of various modeling tools.

To increase use of a new tool, **make it accessible and useful through expansion to appropriate applications and linkages to other models.**



## UTILIZATION

- **PROGRESSIVE ACCESS**
- **APPLICATIONS**
- **LINKAGES**

**There is no perfect model;** however, you can develop a tool that encompasses most of the attributes listed below. A flexible and expandable model is more likely to meet needs and challenges as they arise. All of which add to acceptance by more and more users and viewers. No one can anticipate everything a model should be able to do at the beginning of development. The Rio Grande is a complex and highly variable system; both modeling and management require flexibility.

### ACCEPTANCE

- **CAPABLE**
- **FLEXIBLE**
- **ADAPTABLE**
- **MAINTAINABLE**
- **EXTENSIBLE**

A corollary to this: **If you wait to release a model until it's perfect, it will never get used.**

Although there are always confidentiality and quality issues involved with sharing data, **not sharing data erodes trust and collaborative problem solving** which rules out use of a common model.



## DATA

- **MANY NEEDS**
- **DATA COLLECTION**
- **DATA PORTALS**
- **DATA SHARING**

The URGWOM model, like many models, is only as good as the data that goes into it. A significant part of building a better model is filling data gaps and holes. As more data are collected, shared, and linked, models can be recalibrated and improved (and we can collaboratively refine our interpretations and assumptions.) A commitment to collecting additional hydrologic and other data in the Rio Grande basin is required for realistically modeling and understanding the physical system. The Paso del Norte Watershed Council and others are developing data portals for improved data sharing. The Bureau of Reclamation is developing HDB, a hydrologic database for water management and accounting data storage. There is also another cooperative data collection program among the URGWOM and Middle Rio Grande Endangered Species Act Collaborative Program agencies who are just beginning to collect shallow groundwater and surface water data through the middle valley.



- **DOCUMENTATION**
- **EDUCATION**
- **ASSUMPTIONS**
- **LIMITATIONS**

**Trust requires disclosure.** Nothing must be hidden, distorted, soft-pedaled, or made purposely confusing. Education in the existence, use and limitations of a new technology tool must be fully disclosed. URGWOM development has progressed “in a fishbowl.” Since utilization is the goal, documentation is where one must explain why and how the model is not perfect. In cooperation with Sandia National Labs, a public outreach model is under development that will use output from URGWOM to better illustrate the differences between water management strategies evaluated in the Review and EIS. Most models that have had broad utilization like the Corps HEC models have also been developed in a very open process and are fully documented.

### **MAINTENANCE**



- **REMODELING**
- **NEW CONSTRUCTION**
- **ELIMINATING BUGS**
- **FUTURE PLANS**

A lack of commitment to maintenance is the single largest roadblock to continued use of a model. Just like a house that has grown too small, not changed with a family’s lifestyle changes, started to fall down around their ears, or has systemic problems (like termites, etc.), a model requires maintenance to fit contemporary needs, eliminate “bugs”, expand to include new developments, or re-calibrate to include better data. Sufficient funding to continue maintenance into the future is one of the most important factors in the longevity of a model. Without maintenance, there is less confidence or trust in the tool. It is then a vicious circle: When confidence in a model’s results decreases, use decreases. When use decreases, there are fewer agencies willing to kick in funds for maintenance. Thought and care during development should be given to how to fund model maintenance for the future.