Cooperative Decision Support Modeling for Water Planning in the Middle Rio Grande

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The New Mexico Office of the State Engineer initiated a statewide water planning process in the mid-1990s in response to mounting concerns over water issues in the state. Sixteen planning regions were formed, each with the responsibility of preparing a 50-year water management plan that balances sustainable water supply with projected demand in a publicly and politically acceptable manner. The planning process in each region was structured around a partnership among local governments with oversight responsibility and volunteer organizations that spearheaded the actual planning. For the Middle Rio Grande (MRG) planning region, the Mid Region Council of Governments (MRCOG) and the Middle Rio Grande Water Assembly (MRGWA), respectively, filled these roles.

The MRG planning region encompasses three counties in arid north-central New Mexico. This region is centered on the Rio Grande and has a total population of around 713,000, including Albuquerque, the principal metropolitan area in the state. The challenge facing this region involves balancing temporally variable supplies with the demands of irrigated agriculture, urban development, open-water evaporation, and in-stream/riparian uses.

Cooperative Modeling

In January 2002, the MRGWA and MRCOG requested the assistance of Sandia National Laboratory (SNL) in developing a decision support model (DSM) for the purposes of:

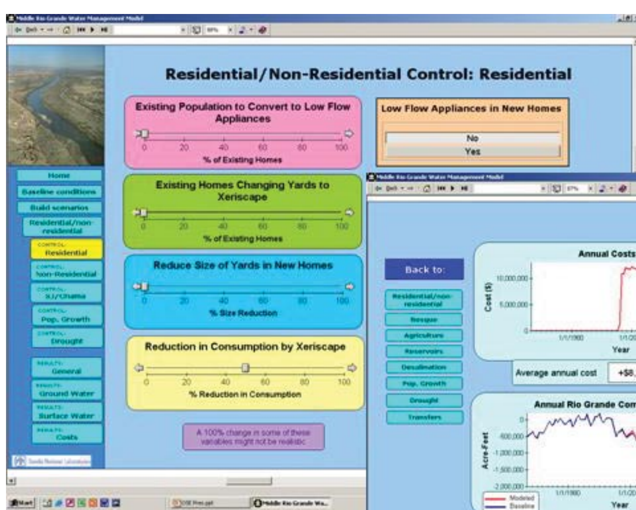
- quantitatively evaluating tradeoffs between alternative water conservation strategies in terms of water savings and costs;
- engaging the public in the planning process; and
- explaining the complexity in the regional water system.

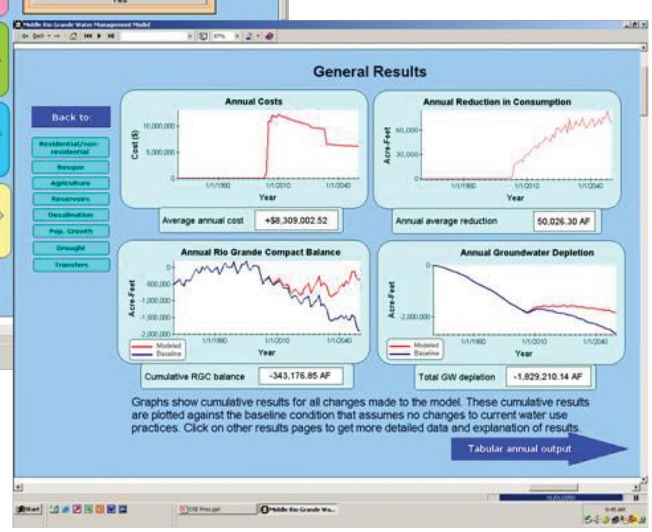
In order to build acceptance and confidence in the DSM, a community-based, participatory process was adopted. Specifically, a cooperative modeling team (CMT) was formed with team members representing the views of local government, irrigators, environmentalists, urban developers, and regional water managers, while group facilitation was provided by the Utton Transboundary Resources Center of the University of New Mexico. The CMT was responsible for system conceptualization, identification of sources of subject expertise and data, model interface design, and model review. This team met once or twice a month over a two-year period to develop the model.

Model development also benefited from interactions with the community outside the CMT. Data and system understanding were gained from numerous meetings with water professionals and scientists from regional, state, and federal agencies. Additionally, community feedback was gathered by way of public meetings in which draft versions of the model were previewed at such venues as MRGWA meetings, water forums, children's water fairs, state and county fairs, civic and professional groups, and various schools and universities.

Decision-Support Model

The DSM was created within a system dynamics framework using an object-oriented modeling package, Powersim Studio 2003. The model is structured as a dynamic water budget in which the various water supply, demand, and conservation terms are aggregated over the three-county planning region. While the focus of the model was Bernalillo, Sandoval, and Valencia counties, some calculations like the Rio Grande Compact balance required the modeling of features located outside the planning region. The model operates on an annual time step encompassing the period from 1960 to 2050. This includes a 39-year calibration period (1960–1998) and a 52-year planning horizon (1999–2050).





User interface for the MRG decision support model. Shown are pages for selecting alternative water conservation measures and for display of simulation results.

Sample Model Sectors	Sample Management Actions	Scenario Settings Default	Preferred
Residential	Convert existing homes to low-flow appliances	0%	80%
	Low-flow appliances installed in all new homes	no	yes
	Convert existing homes to xeriscaping	0%	30%
	Xeriscaping for all new homes	no	yes
	Reduce size of irrigated yards in new homes	0%	40%
	Reduce consumption by xeriscaping	50%	50%
	Convert existing homes to water harvesting	0%	25%
	Roof-top harvesting in all new homes	no	yes
	Convert existing homes to on-site gray water use	0%	5%
	On-site gray water use for all new homes	no	yes
Non-Residential	Convert existing properties to low-flow appliances	0%	80%
	Low-flow appliances in new construction	no	yes
	Convert existing properties to xeriscaping	0%	30%
	Xeriscaping for all new construction	no	yes
	Reduce landscaping for new construction	0%	5%
	Reduce future per capita growth rate for parks and golf courses	0%	80%
Bosque	Remove non-native phreatophytes from all public bosque lands	no	yes
Agriculture	Line public conveyances, from a total of 1,230 kilometers	0 km	1,230 km
	Laser-level farmland, from a total of 20,235 hectares	0 ha	10,117 ha
	Install drip irrigation	0 ha	1,011 ha
	Change crop type distribution	no	no
	Reduce agricultural croplands	no	no
Reservoirs	Increase storage capacity in Abiquiu Reservoir	no	yes
	Maximize upstream storage/minimize Elephant Butte Res. storage	no	yes
	Minimum Elephant Butte Reservoir storage volume	400 Mm^3	493 Mm^3
	Build a new northern reservoir	no	no
	Implement artificial recharge	no	yes
Desalination	Desired quantity of desalinated water	0 Mm^3	27 Mm^3
	Water source	NA	Tularosa
	Year desalinated water becomes available	NA	2010

Comparison of model default settings (no change scenarios) versus settings for the preferred scenario used in the regional water plan. Note: Table does not include all options available in the model.

Basic model elements include surface water and groundwater supplies balanced against municipal, agricultural, evaporative, and riparian demands. Specifically, the surface water system is comprised of the Rio Grande and three area reservoirs. Inflows include the main stem of the Rio Grande, tributary inflows, interbasin transfers from the Colorado River, and wastewater returns. Losses from the surface water system include evaporation from the river and reservoirs, agricultural consumption, transpiration from the riparian corridor along the Rio Grande, pumping-induced river leakage, and municipal diversions. Groundwater inflows include mountain-front recharge, interbasin flows, and river leakage, while withdrawals include municipal pumping and discharge to the river/shallow aquifer system. Municipal demand is driven by population growth and per capita use, disaggregated by residential, commercial, industrial, and institutional demands. Evaporative losses are a function of climatic conditions and open-water surface area, while transpiration losses depend on vegetation type, acreage, and climate.

Also built into the model were 24 water conservation strategies that the public identified through community meetings held as part of the planning effort (see table). Specifically, the model allows the user to explore potential consequences of such actions as:

- removing non-native vegetation from the Rio Grande riparian corridor,
- implementing urban conservation measures such as conversion to low-flow appliances,
- changing agricultural irrigation practices, and
- modifying reservoir operations.

The model operates on a PC and takes less than 10 seconds to complete a simulation. Results are expressed in terms of the Rio Grande Compact balance (the key legal institution for the basin), groundwater depletions, water savings, and costs for infrastructure construction, operation, and maintenance. The model interface was designed to be user-friendly and accessible to a wide range of users. The interface spans approximately 80 computerized pages that include pictures, explanatory text, 66 slider bars and buttons for exploring alternative water conservation strategies, and graphs and tables for visualizing simulation results (see screen shots, opposite page). A complete description of the model can be found in Tidwell et al. (2004).

Model Use in Planning

In spring 2003, a working model was delivered to the MRGWA and used to develop scenarios that integrate various combinations and intensities of the 24 conservation alternatives. Ultimately, a series of five "scenarios" intended to represent perspectives from each of the five constituency groups (agriculture, environment, urban, specialists, and managers) were developed. These scenarios were then vetted with the public to gather their preferences and perspectives. Working closely with the MRCOG, the MRGWA used the decision-support model to combine individual scenarios along with public feedback into a "preferred scenario" which then formed the basis for the regional water management plan (Middle Rio Grande Water Assembly, 2003). Once the public had commented, the plan was finalized and submitted. The Interstate Stream Commission formally accepted the plan in August 2004. Currently, some articles of this plan are in the process of being implemented while others are being studied in more detail.

Post-project interviews were performed with the general public and CMT members to gauge perceptions on modeling, identify strengths and weaknesses of the cooperative modeling process, and determine if and how the model

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Cooperative Modeling in Southwestern New Mexico

The Arizona Water Settlements Act of 2004 provides New Mexico the right to an additional 140,000 acre-feet of Gila Basin water in any ten-year period and grants New Mexico between $66 million and $128 million (depending on the type of project pursued) to be used to meet water demand in southwestern New Mexico. Additionally, the Consumptive Use and Forbearance Agreement (CUFA) establishes diversion terms among various parties. Decisions are now needed on how to allocate the funding and use the water, in compliance with the CUFA, by 2014. Ultimately, the New Mexico Interstate Stream Commission (NMISC) will make these decisions in consultation with the Southwest New Mexico Water Planning Group (SWNMWPG), the citizens of southwest New Mexico, and other affected interest groups. To assist in this decision process, Sandia National Laboratories in cooperation with the NMISC and SWNMPG are working to develop decision support tools within a system dynamics framework. Representatives from the southwestern region as well as state and federal agencies have established a collaborative modeling team. This team has been meeting twice a month since October 2005 with the intention of producing an operational model by the end of 2006.

Additional details can be found at https://waterportal.sandia.gov/nmstateengineer.

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facilitated the planning process. Results overwhelmingly support using models in developing solutions to complex public policy issues and using models to educate and engage the public in such processes. CMT team members believed that it was appropriate to use the model in planning and that the planning process would have been more difficult without it. This is not to say the process did not face its share of challenges, but from these, important lessons were learned concerning the needs for expert facilitation in the collaborative process, transparency and clear communication throughout the process, and careful definition of the role of modeling in the planning process. Additional details can be found in Cockerill et al. (2004 and 2006).

An operational version of the model can be accessed at nmh2o.sandia.gov/ExTrainSD/ or obtained on CD from the authors. Contact Vince Tidwell at vctidwe@sandia.gov. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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