Technical and Physical Feasibility Fact Sheet
Alternative 38: Surface Modeling

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1. Definition of Alternative

A-38: Increase monitoring and modeling of surface water system to improve water management at the watershed level, and retain excess water flow from entering Elephant Butte Reservoir during wet cycles.

2. Summary of the Alternative Analysis

The improvement of hydrologic and predictive modeling, and the supporting monitoring network can lead to more precise management of water stored in a system of reservoirs, which *could* result in water savings. The opportunities for improved water management are not limited to a single reservoir (i.e., Elephant Butte Reservoir), nor limited hydrologic cycles. Furthermore, it would be erroneous to couple improved monitoring and modeling to a reduction of releases of excess flows, or spills, from Elephant Butte Dam.

Please see Exhibit 38A for additional details regarding the analysis for this alternative.

3. Alternative Evaluation

3.1 Technical Feasibility

Enabling New Technologies and Status

Modeling: New developments and technologies are constantly improving climatologic and hydrologic modeling, providing water managers with better forecasting and routing tools. Some of these advances are being generated in the Upper Rio Grande Basin, while others are simply being tested or applied. The Upper Rio Grande Water Operations Model (URGWOM), a

reservoir/river routing model using RiverWare, is scheduled to be operational in 2003, and has served as an effective avenue to bring many of the related modeling improvements into the basin. (See Exhibit 38A for additional discussion of these and other models.)

- *Climatologic forecasting*: Advances are being realized in short- to long-term forecasts and spatially from a global scale down to a local/subregional scale.

- *Inflow modeling*: Snowmelt runoff forecasts are of particular importance to the Upper Rio Grande Basin. Improvements in modeling include the Moderate Resolution Imaging Spectroradiometer (MODIS), which uses satellite imagery to map snow, and more recently, to estimate snow-water equivalency. The Snowmelt Runoff Model developed by the U.S. Department of Agriculture is being developed to integrated numerous advances, while the U.S. Geological Survey's (USGS') Modular Modeling System (MMS) enables both runoff and precipitation forecasts to be made for smaller hydrologic units and incorporates the physical attributes of the watersheds.

- *Outflow modeling*: The Evapotranspiration (ET) Toolbox is being developed by the Bureau of Reclamation in partnership with many others, to estimate and forecast consumptive uses of vegetation, including crops, in conjunction with state-of-the-art mesoscale weather data.

These activities (and many others), pursued by a multitude of public and academic interests, are amazingly well-coordinated and have a synergistic effect on one another.

Monitoring: The essential technology for effective snowpack, streamflow and weather monitoring is in place. Satellite telemetry technology, a relatively recent development, is being applied throughout the Upper Rio Grande Basin system, allowing real-time access to the data. Additional features, such as snow depth sensors, are available and are being integrated into the systems. Doppler technology has been developed for manual stream gaging, and is more efficient and accurate than the standard Price-type® meter. Research to apply this technology to fixed-site stream gage stations is ongoing.

Infrastructure Development Requirements

None for modeling. For monitoring, the installation or upgrading of fixed-site data collection stations is required to improve the monitoring complex in the Upper Rio Grande Basin. Of the 24 snow monitoring stations in the Upper Rio Grande Basin, 11 have yet to be converted to SNOTEL (Snowpack Telemetry). Currently, 51 of the basin's 99 official USGS stream gaging stations are not equipped with telemetry equipment.

Total Time to Implement

Modeling: Incremental improvements in modeling activities are being incorporated continuously. An interagency team began development work on URGWOM in 1997; the accounting model has been in use for several years and the forecast model is completed and now in use. Portions of the water management model are being used, although enhancement and testing of this model continues. The planning model is scheduled to be operational in 2003 and its primary application will be for the Upper Rio Grande Water Operations Review.

Monitoring: The addition or upgrading of monitoring sites is dependent upon funding. Once funding is secured, the upgrades or new site installations generally can be done within a year.

3.1.1 Physical and Hydrological Impacts

Effect on Water Demand

None.

Effect on Water Supply (surface and groundwater)

None.

Water Saved/Lost (consumption and depletions)

Improvements in monitoring and climatological and hydrologic modeling will not, in and of themselves, result in any additional water savings. Improved tools will allow water managers to make better decisions, especially in the realm of predicting future conditions. However, assuming that water right holders will continue to abide by the principle of as storing as much water as possible for future *use within existing hydrololologic and legal constraints*, improved tools

will allow them to be more knowledgeable, thereby reducing the amount of water that passes downstream that they would otherwise have the right to use.

Elephant Butte Reservoir has spilled seven times since the existing complex of upstream reservoirs has been in place, discharging a total of 782,700 acre feet of usable water in excess of demands downstream from Elephant Butte (RGCC, various). Although spills are the cumulative results of years of climatic/hydrologic conditions, presumably more numerous and sophisticated monitoring stations and more sophisticated models could have reduced the volumes spilled by an unknown amount.

Impacts to Water Quality (and mitigations)

None.

Watershed/Geologic Impacts

None.

3.1.2 Environmental Impacts

Impact to Ecosystems

There would be no direct environmental impacts associated with increasing modeling efforts in the Upper Rio Grande Basin. Water management decisions that rely on the expanded or improved models could, however, have environmental impacts. Increasing and improving monitoring, such as the installation of new on-the-ground measurement stations would have insignificant localized effects on ecosystems.

Implications to Endangered Species

Improved monitoring and modeling could be used to improve the timing and releases for aquatic and riparian ecosystems, which could be beneficial for endangered species such as the silvery minnow and willow flycatcher. Conversely, water management decisions could be made which would be detrimental to endangered species.

3.2 Financial Feasibility

3.2.1 Initial Cost to Implement

Modeling: Because of the seamless improvements in the fields of climatologic and hydrologic modeling and the innumerable independent, but related, activities, it is not possible to quantify initial costs to implement improved modeling within the Upper Rio Grande Basin. Over the past five years, the development of URGWOM alone has cost the participating federal agencies approximately $1 million per year.

Monitoring: The conversion of a snow monitoring station to SNOTEL costs between $15,000 and $20,000. The installation of a new USGS stream gaging station costs between $10,000 and $35,000, depending on the site and the need to construct a cable way. Automation of the remaining 13 non-SNOTEL snow monitoring sites and approximately the same number of the remaining 51 stream gages would be desirable.

3.2.2 Potential Funding Source

Modeling: All significant improvements to, and expansion of, hydrologic modeling in the Upper Rio Grande Basin are being made by governmental agencies at various levels, funded by public monies. Involved agencies and entities ultimately rely on taxpayer funding, with the exception of some public-private partnerships that are being developed by agencies such as the Department of Energy.

It is principally federal public agencies that have taken the organizational and financial lead in modeling activities, often with significant support from state and local public agencies. Advancements in modeling would be hastened by increasing the funding earmarked for the sponsoring and contributing agencies. The public can help secure additional funds through the appropriate legislative process, in coordination with the benefiting agencies.

Monitoring: Both the Natural Resources Conservation Service (NRCS), which is the federal agency responsible for the snow monitoring program, and the USGS currently require funding from outside their agencies to upgrade or install monitoring stations. In the past, such funding has come from federal agencies (e.g., U.S. Army Corps of Engineers and Bureau of Reclamation), state agencies (e.g., New Mexico Interstate Stream Commission [ISC]), municipalities, water districts, etc. Improvements in the Middle Rio Grande Conservancy District monitoring network have been made possible largely through funding from the ISC and Bureau

of Reclamation. Public and quasi-public agencies at all levels are potential funding sources for expanded monitoring. Expanded NRCS and USGS monitoring budgets would also benefit the programs.

3.2.3 Ongoing Cost for Operation and Maintenance

Modeling: Because of the seamless improvements in the fields of climatologic and hydrologic modeling, it is not possible to quantify costs for operation and maintenance. However, as a point of reference, once URGWOM is fully operational it may cost about $250,000 per year to operate and maintain, including upgrades to the model.

Monitoring: The NRCS absorbs the cost for continued operation and maintenance of SNOTEL sites. The sponsor's annual cost for operation and maintenance of a USGS stream gage is about $12,000.

References/Bibliography

Brower, Albert L., C.L Hartzell, and S.P. Meyer. 2000. Evapotranspiration toolbox for the Upper Rio Grande Water Operations Model.. In *Proceedings, 2nd conference on environmental applications, 80th American Meteorological Society Annual Meeting, Long Beach California.* January 2000

Gensler, D. 2002. Personal communication between David Gensler (Middle Rio Grande Conservancy District) and Robert Leutheuser (Leutheuser Consulting). December 16, 2002.

Hirsch, R.M., J.M. Norris. 2001. National streamflow information program. US Geological Service Fact Sheet 005-01. February 2001.

Leavesly, G. Date unknown. *The Modular Modeling System (MMS) - a modeling framework for multidisciplinary research and operational applications.*

Leavesly, G. 2002. Personal communication between George Leavesly (U.S. Geological Survey, Water Resources Division, Central Region Research, Denver Colorado) and Robert Leutheuser (Leutheuser Consulting). November 13, 2002.

Matthews, D. 2002. Personal communication between David Matthews (U.S. Bureau of Reclamation, River Systems and Meteorology Group, Technical Service Center, Denver Colorado) and Robert Leutheuser (Leutheuser Consulting). November 12, 2002.

Murray, D. 2002. Personal communication between Daniel Murray (Natural Resources Conservation Service, Albuquerque New Mexico) and Robert Leutheuser (Leutheuser Consulting). December 10, 2002.

Murray, R. 2002. *Integrated modeling of the Rio Grande Basin*. Los Alamos National Laboratory, Center for Nonlinear Studies. July 2001. (Available at <http://www.cnls.lanl.gov>).

National Aeronautics & Space Agency, Land Data Assimilation Systems. 2002. *LDAS overview and description.* <http://ldas.gsfc.nasa.gov>. (Accessed January 2003).

National Aeronautics & Space Agency. 2002a. The MODIS Snow and Sea Ice Mapping Project, project description. <http://modis-snow-ice.gsfc.nasa.gov>. Last modified January 14, 2003.

National Center for Atmospheric Research. 2002. National Center for Atmospheric Research website. <http://www.ncar.ucar.edu>. (Accessed January 2003)

National Oceanic and Atmospheric Administration. 2002. Advanced hydrologic prediction service: water information for a stronger and safer America. <http://www.noaanews.noaa.gov>. Last updated January 21, 2003.

Pagano, T. 2002. Personal communication between Thomas Pagano (Natural Resources Conservation Service, Portland Oregon) and Robert Leutheuser (Leutheuser Consulting). November 25, 2002. (E-Mail November 26, 2002)

Rio Grande Compact Commissioners (RGCC). 1942, 1985, 1986, 1987, 1988, 1995, and 1996. *Report of the Rio Grande Compact Commission to the Governors of Colorado, New Mexico, and Texas*.

Roark, M. 2002. Personal communication between Michael Roark (U.S. Geological Survey, Albuquerque District) and Robert Leutheuser (Leutheuser Consulting). December 12, 2002.

SAHRA. 2002. *Sustainability of semi-arid hydrology and riparian areas*. 2002. <http://www.sahra.arizona.edu>. Copyright 2001, Arizona Board of Regents (Accessed January 2003).

SonTek/YSI. 2002. Water velocity measurement instruments <http://www.sontek.com>. Last updated January 17, 2003.

U.S. Army Corps of Engineers (USACE). 1989. *Reevaluation of the Rio Grande Operating Plan*. U.S. Army Corps of Engineers, Albuquerque District. July 1989.

U.S Army Corps of Engineers (USACE). 2002. URGWOM. <http://www.spa.usace.army.mil/-urgwom>. Last updated December 24, 2002.

.U.S. Department of Agriculture Natural Resources Conservation Service, National Weather & Climate Center (USDA). 2002a. *National water and climate center—SNOW*. <http://www.wcc.nrcs.usda.gov/water/w_data.html>

U.S. Department of Agriculture Natural Resources Conservation Service, National Weather & Climate Center (USDA). 2002b. *SNOTEL data collection network fact sheet*. <http://www.wcc.nrcs.usda.gov/factpub/factpub.html. (Accessed January 2003)

U.S. Department of Agriculture Natural Resources Conservation Service, National Weather & Climate Center (USDA). 2002c. *Snowmelt runoff model development and testing*. <ftp://ftp.wcc.nrcs.usda.gov/ data/snow>. (Accessed January 2003)

U.S. Bureau of Reclamation. 2002. WaRSMP - Watershed and River System Management Program. <http://www.usbr.gov/rsmg/warsmp>. River Systems and Meteorology Group, Denver, CO. (Accessed January 2003)

U.S. Bureau of Reclamation Bureau of Reclamation. 2002. Watershed and river systems management programs. <http://www.usbr.gov/rsmg>. River Systems and Meteorology Group, Denver, CO. (Accessed January 2003)

U.S. Bureau of Reclamation. 2000. *RiverWare fact sheet*. River Systems and Meteorology Group, Denver, CO. April 2000.

U.S. Geologic Service, Water Resources Division (USGS). 2002a. NWIS web data for New Mexico. <http://nm.waterdata.usgs.gov>. (Accessed January 2003.)

U.S. Geologic Service (USGS). 1997. Streamflow information for the nation. USGS Fact Sheet FS-006-97.

U.S. Geologic Service (USGS). 1998. Water resources data, Colorado, water year 1997. USGS Water Data Report CO-97-1.

U.S. Geologic Service (USGS). 2002. Water resources data, New Mexico, water year 2002. USGS Water Data Report NM-01-1.

Wilson, L. 1999. Surface water hydrology of the Rio Grande Basin. In *WRRI conference proceedings, the Rio Grande Compact: its the law."* December 2-3, 1999. Santa Fe, New Mexico.

Yuska, Ma. 2002. Personal communication between Mark Yuska (U.S. Bureau of Reclamation, Upper Rio Grande Water Operations Model Team) and Rob Leutheuser (Leutheuser Consulting). November and December 2002.