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A PHYSICAL ASSESSMENT OF THE OPPORTUNITIES FOR IMPROVED MANAGEMENT  
OF THE WATER RESOURCES OF THE BI-NATIONAL RIVER BASIN  
UNA EVALUACIÓN DE LAS OPORTUNIDADES PARA MEJORAR LA ADMINISTRACIÓN FÍSICA  
DE LOS RECURSOS HIDRÁULICOS BI-NACIONALES DE LA CUENCA DEL RÍO

## CONFERENCE MINUTES

### “State of the Knowledge” Conference at Instituto Tecnológico de Estudios Superiores de Monterrey (ITESM) — MONTERREY, MEXICO JUNE 4–5, 2001

The conference commenced with a welcome and opening statement by Eugenio García, representing the president of ITESM. The conference organizers provided brief orientation remarks. Enrique Castillo indicated that he would debrief Mexican government officials on the results of the conference the following week on behalf of ITESM. Meeting participants introduced themselves and the organizations they represented.

#### MEETING PARTICIPANTS

*Please see Attachment A*

#### BASIN OVERVIEW (JURGEN SCHMANDT, UNIVERSITY OF TEXAS & MITCHELL CENTER)

For this project, the reaches of the Rio Grande/Rio Bravo will be demarcated as follows:

- Upper Rio Grande — Headwaters within Colorado
- New Mexico Segment — Colorado-New Mexico state line to Elephant Butte Dam
- Paso del Norte — Elephant Butte Dam to Presidio [to encompass the “Forgotten Reach”]
- Lower Basin — Presidio to Gulf of Mexico, including the major tributaries, the Rio Conchos [Mexico] and the Pecos River [New Mexico and Texas, U.S.]

Dr. Schmandt’s presentation focused on population growth and water use patterns in the basin. The question of whether or not water resources can continue

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to support the booming population of the basin is particularly relevant to the Ciudad Juarez/El Paso area and the Lower Rio Grande Valley. In both sub-basins, population has doubled every 20 years since World War II, with no end in sight. Other factors contributing to the basin's water scarcity problems include the high evaporation rate, low runoff, and limited aquifer recharge throughout. A challenge for this project will be to make the rough estimates on population growth, water use, irrigation needs, etc. more precise and make this knowledge available to political entities in a neutral manner.

Dr. Schmandt then took us on a “walk down the river” to provide a brief synopsis of our current understanding of the basin, as follows:

### **Upper Rio Grande**

The Rio Grande begins in the Rocky Mountains of Colorado, on the east side of the Continental Divide, where there is relatively little rainfall (approximately 30 inches/year [76.2 cm/year]). Historic average annual stream flow at the Colorado-New Mexico border is 325,000 acre-feet (400 million m<sup>3</sup>). Close to 2 million acre-feet/year (approximately 2.5 billion m<sup>3</sup>/year) of surface water is withdrawn to support approximately 626,000 acres (253,333 hectares) of agriculture and a population of 32,436 (2000 census). Irrigation accounts for 92% of water use. To meet 1938 Rio Grande Compact obligations, Colorado must deliver to New Mexico and Texas: ~1/5 of stream flow during drought years; ~1/3 during normal years; and ~1/2 during high flow years. U.S. Bureau of Reclamation meets part of this obligation by pumping water from the shallow aquifer in Colorado's San Luis Valley. Colorado is the only U.S. basin state that has a specific provision for the protection of instream water uses.

### **New Mexico Segment**

Approximately 447,000 acre-feet (551 million m<sup>3</sup>) of water (677,000 acre-feet [822 million m<sup>3</sup>] if usable groundwater is included) is withdrawn per year to support approximately 55,000 acres (22,258 hectares) of agriculture and a population of 730,000 (mostly in Albuquerque). Irrigation accounts for 95% of water use. The major challenge in this segment is the transition in Albuquerque from dependence on groundwater to greater use of the surface water supply.

### **Paso del Norte**

This region, which includes the cities of Las Cruces, Ciudad Juarez, and El Paso, gives us the second law of the river — the 1906 treaty requiring U.S. water allocation of 60,000 acre-feet/year (74 million m<sup>3</sup>/year) to Mexico, largely used for irrigation within Chihuahua.

Historically, the cities of El Paso and Ciudad Juarez have pumped their drinking water from Hueco Bolson, a nonrenewable aquifer with an estimated 20 years' supply of water remaining. Las Cruces also relies 100% on groundwater for its drinking water supply, but this will be mitigated to some extent with completion of the El Paso-Las Cruces Regional Sustainable Water Project. Annually, the Paso del Norte segment uses 1.5 million acre-feet (1.85 billion m<sup>3</sup>) of water (2000 survey) from ground- and surface

water sources, with 71% going to agricultural uses. Elephant Butte Dam, located at the beginning of the segment, releases 800,000 acre-feet (986 million m<sup>3</sup>) of water per year from its high-evaporation reservoir to support these demands. The human population in this stretch of the basin has increased dramatically in recent years, creating what may be one of the largest desert communities in the world.

### **Lower Rio Grande/Rio Bravo**

The Rio Grande/Rio Bravo becomes a perennial river again with the contributions from the Conchos and Pecos Tributaries. The Conchos provides about 2/3 of Lower Rio Grande flow as high quality water, while the Pecos provides 1/3 of the flow as water that is naturally saline. The third law of the river, a 1944 treaty, assures a quantity of water to Mexico from the Colorado River basin in exchange for an assurance of 350,000 acre-feet (approximately 432 million m<sup>3</sup>) of Conchos waters to U.S. users on the Lower Rio Grande during normal years. In most years, Mexico has over-delivered Conchos water, sometimes by as much as four times. Since 1994, however, Conchos deliveries have fallen short of the treaty. There is an agreement and timetable between the nations for the deficit to be made up.

The same treaty led to the expansion of IBWC/CILA from a border arbiter to a water management agency in the Colorado and Rio Grande on the U.S.-Mexico border. In the Rio Grande/Rio Bravo basin the agency is responsible for distribution of river water between the two countries; joint construction, operation and maintenance of international reservoirs; hydroelectric power generation, as well as flood control. From the jointly operated Falcon and Amistad Reservoirs, roughly 57% of the water is allocated to the United States and 43% to Mexico. The important agricultural and population centers that draw on the river are located downstream of the Falcon Reservoir. The population in the Lower Rio Grande is expected to reach 4 million by 2030. The groundwater in this region is of poor quality and currently little used.

*Dr. Schmandt's presentation was followed by a Q&A session:*

*Q — What do we know about per capita use of water in the basin?*

*A — We know the U.S. uses too much water. El Paso has recognized this and has successfully reduced per capita water use. Per capita use in Mexico will probably increase as more people are connected to municipal distribution systems.*

*Q — How good is the information we have on the water issue? When you talk about refining the information, are you talking about projections or about current use and quality?*

*A — We will find there is much information available, but it is not always easily comparable. Projections differ greatly in how far into the future they project. More importantly, underlying assumptions may differ. For example, El Paso and west Texas assume that market forces will lead to a future decline in irrigation; Mexico does not make this assumption. Currently, population projections are fairly comparable; irrigation projections are not. This project's contribution will be to improve the scientific base of these projections.*

## **PROJECT OVERVIEW (GREG THOMAS, NHI)**

The goal of this conference is to pool our understanding of the basin in order to gain a system-wide understanding of how the river system operates as a physical reality. Ultimately we hope to create a tool that will assist decision-makers and stakeholders in planning a more sustainable future for the Rio Grande/Rio Bravo. This basin is a textbook example of why upper and lower riparian nations must find ways to share their common resource. The water system of the Rio Grande is already oversubscribed; current needs cannot be met, yet they continue to grow; and the border population is expected to double in the next 30 years. It is clear that the future of this basin cannot resemble the past. We need to set up the possibility of managing this river by choice and rational decisions, rather than by crises.

Our project goals are as follows:

- To design a system-wide, state-of-the-art integrated data management system (DMS). Integrated into this management system will be the existing river models and research projects that are currently underway.
- To set up the DMS so it is widely available and able to evolve instantaneously as our knowledge improves.
- In the scenarios that are developed and compared, to capture all useful opportunities for management intervention.

In the end, this is meant to be an investigation driven not by researchers or policy institutions, but by the stakeholders themselves — the private sectors, users, and government agencies with missions in the basin. Although this project is set up as a non-governmental initiative, we welcome and solicit cooperation in this effort by government officials and experts. This is necessary for three reasons:

- Government agencies are repositories of the data and expertise necessary to accomplish this project.
- We will be assessing water management scenarios generated by these agencies, in addition to those generated by other stakeholders.
- We will be looking to these agencies, especially in the United States, to provide financial resources for this project. This amount will be small in comparison to the money that is currently spent on river basin planning.

Why, then, is this project being implemented as a non-governmental undertaking? First, it is difficult for government agencies to engage in this type of planning without a strong political slant. Second, government agencies are limited in their planning to whatever facilities or responsibilities are within their mission and to the legal and institutional *status quo*.

This project will comparatively evaluate water management scenarios for physical feasibility, economic feasibility, and finally legal and institutional feasibility. In the process of screening scenarios, we may discover that changes in current allocations or institutional arrangements may be desirable to all stakeholders. These changes may be

feasible if they can benefit all parties to the contracts and treaties. In some cases, the benefits may be monetary rather than hydrological. The final product will be an understanding of the most viable course of action for engineering a better future for this river basin.

*Dr. Schmandt made the point that we have changing priorities in water management — sustainability wasn't an issue when Elephant Butte was first built, but now there are calls to rework water management to look at other benefits, such as environmental benefits. This led to the point that there are cultural differences between the U.S. and Mexican definitions of "environment"— in Mexico, the human element in environmental interactions may be more prominent.*

### **CONFERENCE OBJECTIVES (ENRIQUE CASTILLO, ITESM)**

Mr. Castillo highlighted the fact that the Rio Bravo provides multiple benefits to stakeholders, yet it is a river in crisis. Among the main problems that need to be solved are the need to recover water flows and the need to achieve reasonable and sustainable use of the water. In this task, we have to consider the general information and the demands on the water, including agricultural, municipal and industrial, environmental, and recreational. The challenge is to integrate the team of technical analysts with water user stakeholders who are willing to participate.

Objectives of this conference are:

1. To integrate enough information to, ultimately, generate a hydrological planning model.
2. To provide a long-term sustainable solution to water management in the basin.
3. To achieve initiatives in both parts of the countries to solve existing problems.

*A conference participant suggested that another goal of this conference should be to increase awareness among communities of the limitations and potentialities of the river. Government agencies generally keep information largely to themselves. One reason that people don't collaborate in water management campaigns is because they don't understand the limitations we have — this is why we are now facing a crisis. If people have greater knowledge, more people may help in the campaign.*

### **BRIEFING ON RIVERWARE (EDIE ZAGONA, CADSWES)**

RiverWare is a multi-objective river and reservoir modeling system developed at the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES), through a collaborative effort with the Bureau of Reclamation and the Tennessee Valley Authority. CADSWES is an interdisciplinary center for the research and development of decision support tools for management of water and environmental resources. Established in 1986, CADSWES is housed in the Department of Civil, Environmental and Architectural Engineering (CEAE), College of Engineering and Applied Sciences at the University of Colorado at Boulder.

Objectives in managing a river basin include flood control, water supply, navigation, water quality, aquatic and riparian habitat, recreational flows, recreational lake levels, and hydropower. Models provide many different approaches for operating to meet these multiple objectives. For example, objectives can be weighted (but how do you weight non-commensurate objects?) or, more simply, prioritized through a ranking system. RiverWare uses a ranking system, allowing objectives to be solved in a priority order.

### **Why RiverWare?**

- It can be used in multiple ways — planning, operational scheduling, short- and long-term forecasting, EIS and policy studies.
- Can do optimization, rule-based simulation, uncertainty modeling, and water accounting.
- Expresses operating policy as data in a form that stakeholders can understand. In the older Fortran models of the 1970s, operating policies were included in the programming code and, therefore, difficult to modify.
- Easy to use — The user does not need to create or compile his/her own code. RiverWare has a Graphical User Interface (GUI) that allows users to view and analyze model results easily.
- Automatic Data Management Interface (DMI), so data can be imported/exported quickly from any source. The DMI can be tailored to your database system or your historical data.
- Extensible — users can add new features easily and reproduce results of old models.
- Supported and maintained through new releases, user-support systems, and user training.

But RiverWare does not include physical process elements such as sediment transport and deposition. Where such models exist, however, it will usually be possible to integrate them with RiverWare.

### **Object-Oriented (OO) Modeling**

RiverWare uses an object-oriented modeling approach. Objects contain their own data and physical process model algorithms. Each object has a selection of physical process algorithms from which the modeler can choose. For example, Reach objects have many routing algorithms. The choice depends on timestep size, data requirements, and institutional preference.

Double clicking on an object brings up all the variables associated with it. For example, you can “open” a particular river reach to see the inflow, outflow, lag time, etc. Examples of other RiverWare objects include reservoirs, confluences, canals, agricultural diversion sites, water users, other diversions, groundwater storage (to model conjunctive use, for example), agricultural distribution canals, stream gages, thermal objects, in-line power plants, and data objects (e.g., policies). CADSWES can easily add new objects and physical process methods to the library of objects supported by RiverWare.

## **Solution approaches**

RiverWare uses the following solution approaches:

- Simulation — model physical processes for input/output combinations
- Rule-based simulation — driven by user-specified operating rules (water policies). This is what we will use in this project.
- Optimization — a linear goal programming solution

### **Simulation**

Each object has categories of calculations you can choose from, based on the timestep you're interested in, available and required input data, and institutional requirements. There are many possible levels of simulation modeling, depending on your model objectives and what data you have on the system. For example, if you have the data, you can model evaporative losses from reservoirs.

Objects are linked together on a workspace, so data calculated by one object can be used as input for another object. When data is given to an object (either by a user or from a linked object), the object completes all the equations it can solve with the information it has. Every object can get link results from upstream or downstream, and there may be multiple links between objects, allowing iterations.

### **Rule-based simulation (RBS)**

Operating policies are set as IF/THEN prioritized rules, e.g., IF outflow < minflow THEN outflow = minflow (to ensure that flow never falls below a specified minimum). In this solution approach, the rules provide the additional information needed to solve the system. RBS solves the system at each timestep, using prioritized rules. Variables are set based on the state of the system after the previous rule has “fired”. After each rule is executed, the simulation propagates the effects of the rule. In RBS, the higher priority rules represent special conditions and dominate the lower priority rules, which represent ideal conditions. RiverWare has a special analysis tool that shows, at every timestep and for every object, which rules influenced the final decision. This would allow you, for example, to see where environmental rules made the final decision.

## **Data requirements for RiverWare**

For the Rio Grande Physical Assessment project, the necessary data for incorporation into the RiverWare model include:

- Water balance — 1) hydrologic inflow data, either from historic gage data or runoff predictions; 2) gains and losses, e.g., evapotranspiration, seepage, groundwater interactions
- Physical system — timestep, reservoirs, changes in channel geometry
- Demands — projections for changes in demand
- Operating policies

## **Current BOR Applications of RiverWare**

- Colorado River (CRDSS)
- Lower Colorado EIS
- San Juan River
- Yakima
- Upper Rio Grande (URGWOM—multi-agency collaborative effort)
- Pecos River
- Gunnison River
- Truckee River

*Ms. Zagona's presentation was followed by a Q&A session:*

*Q — Does RiverWare model sedimentation processes?*

*A — Currently, no. At the basin level, sedimentation modeling is not very meaningful. It would be better to model sedimentation using a different model and just for the specific areas where it is a problem.*

*Q — Is the U.S. importing water from another basin to the Rio Grande, and are current models accounting for that?*

*A — In Colorado, a limited amount of water (not to exceed 1,350,000 acre-feet [1.66 billion m<sup>3</sup>] in any period of 10 consecutive years or 270,000 acre-feet[333 million m<sup>3</sup>] in any one year) is pumped from the San Juan River Basin (based upon the authorizing legislation for the San Juan-Chama Project) on the other side of the Continental Divide, to the Rio Grande. Gail Stockton confirmed that imported water is accounted for in URGWOM, but conference participants agreed that depending on water imports is not a good solution to the problem of meeting high water demands. In Mexico, there is a similar situation — water is brought up thousands of feet from the Plateau to Mexico City. This requires a large energy investment and is an unsustainable use of water.*

*Q — How will modeling incorporate uncertainty about geomorphic and ecological response to hydrological changes?*

*A — (response from another conference participant) We need to identify where the data gaps and uncertainties are, then make educated guesses about how long we will need to resolve these uncertainties. In the meantime, we should approach these scenarios incrementally and in an adaptive management framework. The experiments that we set up should have learning values as much as they have biological values. We cannot use uncertainty to promote a No Action stance.*

## **URGWOM, WATER OPERATIONS REVIEW, AND ENVIRONMENTAL IMPACT STATEMENT (GAIL STOCKTON, USACOE)**

Ms. Stockton gave several suggestions for the Rio Grande Physical Assessment project, based on her experience with URGWOM, a RiverWare model:

- **Represent existing policies and institutional constraints in the model, so they will be visible to all stakeholders.** For example, tribes or pueblos have prior and paramount water rights — storage priority for release of their water should be represented in a planning model through model rules or methods. Similarly, compacts and international treaties should be in the model so the existing condition is represented as accurately as possible. It is not possible to accurately represent current hydrology without representing existing water operations.
- **Engage in open, collaborative model development.** The metadata (data about the data that were used) in the development of the URGWOM model, for example, will be available on the web within the next six months.
- **Model the existing** (“no action” or “no change”) **reality**, in order to have a yardstick against which to compare alternatives. The base case in the model must reflect the current water allocations as specified in water rights, compact allocations and treaty obligations.

Ms. Stockton gave a brief explanation of URGWOM and the Water Operations Review, in response to questions from conference participants. URGWOM is a daily water operations RiverWare model that is a physical representation of, and simulates the operation of reservoirs and other facilities in, the Rio Grande from the Colorado-New Mexico border to El Paso, Texas. URGWOM is a partnership of the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and the New Mexico Interstate Stream Commission. The Rio Grande Decision Support System (RGDSS), a suite of Colorado water model(s) and associated databases, etc., is currently in development and will be linked to URGWOM to provide hydrologic inputs to URGWOM at the Colorado-New Mexico state line. Below El Paso, there are plans for Texas to build a water planning model that may also be linked to URGWOM. It would make sense for the Physical Assessment project to not re-invent these developments but to link and integrate these models into the system-wide metamodel that will be created. There is a very pressing need to improve data sharing in the basin through such a cooperative approach. Data for the URGWOM model were calibrated against the years 1985–1997 and validated against 1998–1999. All extant Rio Grande compacts and treaties are included in the rules of the URGWOM model. The model represents daily reservoir storages and releases for water supply and flood control (below Elephant Butte, only flood control is modeled at this time). It is currently being tested in-house. All project documents can be downloaded from the URGWOM website (<http://www.spa.usace.army.mil/urgwom/>).

The Water Operations Review (and EIS), which will use the URGWOM model, is a collaborative, comprehensive review of Rio Grande water operations activities under existing water operations laws and authorizations. The joint lead agencies, with approximately 10 other cooperating agencies, are conducting the review and will prepare the EIS. The U.S. Section of the International Boundary Water Commission (IBWC), which is responsible for flood control below Caballo Dam (NM), has been a participant in URGWOM development and may choose to be a cooperator in the Water Operations Review and EIS. Nine public scoping meetings have been held to get stakeholder input in the process. A similar round of public meetings will be held when alternatives are

formulated. Currently, interdisciplinary technical teams (each representing a specific resource, e.g., the aquatic habitat, or riparian and wetland systems) are formulating single-emphasis water operation changes (a “wish list”) that would best benefit their resource. The criteria for looking at potential operations changes include: 1) what is physically possible to achieve, 2) what is within the constraints of existing laws, and 3) what will improve the resource but at least “do no harm” to the resource. The next step will be to develop multi-objective alternatives of the single-emphasis water operation changes, compare them to the existing system, and see where changes can be made to meet those objectives. Interdisciplinary team meetings are held every month, open to the public, and meeting notes are posted on the project website (<http://www.spa.usace.army.mil/urgwops/>).

### **PROVISIONAL WATER MANAGEMENT SCENARIOS (GREG THOMAS, NHI)**

In this project, scenario generation will be the domain of the stakeholders. However, to assist in the initial assessment of data sufficiency for modeling, we compiled a list of potential scenarios generated from other planning processes and research efforts on the Rio Grande/Rio Bravo. These are not proposals by anyone associated with the Physical Assessment project, are not meant to be exhaustive of the types of scenarios that might be of interest to particular stakeholders, and only scratch the surface of the many planning efforts underway in the basin.

Scenarios fall into several major categories:

#### **Reduce losses from the system**

- Evaporative losses
  - transfer water from high-evaporation reservoirs such as Elephant Butte to lower-evaporation reservoirs such as Abiquiu or to aquifers
  - increase efficiency of on-farm water applications techniques, e.g., use drip irrigation instead of sprinklers or flooding
  - use vegetative controls, e.g., remove salt cedar from the “Forgotten Reach”
- Reduce agriculture evapotranspiration — switch to higher value crops
- Reduce percolation of surface water to unusable groundwater
  - use more precise irrigation application techniques
  - line conveyance facilities, especially in areas with poor groundwater
- Reduce production of untreatable municipal waste
- Capture excess outflows to the estuary (but these may have benefits in themselves)

#### **Change timing of water benefits, e.g., to provide more water during dry periods**

- Increase interannual storage through groundwater banking
- Increase surface storage capacities, e.g., in San Luis Valley of Colorado

- Reoperate dams to increase flood retention or create pulse flows (for channel formation)
- Execute drought response plans in times of scarcity

### **Recycle/reuse water**

- Encourage municipal reuse projects, especially when coupled with groundwater banking
- Recover tail water for use on salt tolerant plants
- Desalinize brackish water

### **Augment groundwater**

- Increase infiltration of runoff
- Reduce agricultural water depletions that affect base flows

### **Enhance the environment**

- Allow periodic pulse releases, for channel forming purposes. These pulses may then be picked up downstream for consumptive uses.

### **Reconfigure infrastructure**

- Eliminate the Low Flow Conveyance Channel (LFCC)
- Breach or set back levees that are not needed for urban flood control. Re-establish floodplains
- Remove diversion dams and substitute with perforated pipe collectors

### **Promote water transfers**

- Allow transfers from agriculture to municipal, as dry year leases or permanent transfers of rights
- Purchase buy back allotments from water users
- Lease water from Indian tribes
- Allow transfers from agriculture to instream flows

### **Restrict land use**

- Restrict non-essential land use, such as for golf courses

### **STRATEGY FOR OUTREACH TO STAKEHOLDER COMMUNITIES (JURGEN SCHMANDT, MITCHELL CENTER)**

Dr. Schmandt proposed using the Policy Delphi methodology for bringing stakeholders into this process. Policy Delphi originated in the 1960s for technological forecasting, and has been applied to policy issues since the 1970s. It is an iterative process aimed at getting information from informed stakeholders. Briefly, it involves taking the information from the researchers to the stakeholders and having the stakeholders rank what they like, add to it, and delete what they don't like. The stakeholders we should involve in this process are: 1) agricultural, municipal and tribal water managers and users, and conservationists seeking to protect or restore aquatic and riparian ecosystems; 2) water management and regulatory officials at the federal, state and local levels (e.g.,

from USBR, ACOE, CNA, the State Engineers offices, TNRCC, TWDB); and community representatives. For this project, the steps would be as follows (for each river segment):

### **Step One**

1. Identify 20–50 stakeholders. Carefully inform them of project objectives, particularly of this phase.
2. Develop 10–15 questions relating to how we can improve the use of water. Divide questions into a) those about the basin as a whole and b) those specifically addressing the environment in which the stakeholders live.
3. Mail the first round of questions to the chosen individuals. Inform recipients that they have one week to respond, or they will be substituted. Recipients can add to the list, delete items from it, and write comments.
4. Summarize results from Step One.

### **Step Two**

Get the summary to respondents so they can rank which they like best/least and why.

### **Step Three**

Two options:

1. Send a mail-in survey, to get more comments, additions, and deletions; OR
2. Set up a workshop to bring people together in order to get a consensus on the main priorities for this segment of the river. Dr. Schmandt reports good success with this type of workshop.

*Dr. Schmandt's presentation was followed by a Q&A session:*

*Q — Would it be possible to work with the recently-assembled Mexican Basin Councils in execution of this stakeholder consultation process so we will not be duplicating their efforts?*

*A — Yes, as soon as they are operational. My understanding is that they are not yet funded. In the meantime, we already have a small bi-national group (Paso del Norte Water Task Force) for the Las Cruces to Fort Quitman stretch. We are attempting to establish a second bi-national group in the Lower Basin.*

*Q — To what extent do the Basin Councils and the PDN Water Task Force represent environmental concerns (via, for example, NGOs)? Do they largely represent agriculture and M&I?*

*A — For the Mexican Basin Councils, there is a parallel organization focusing on ecological concerns. For the PDN group, the focus is mostly on agriculture and M&I, but Environmental Defense (ED) is a part of the group.*

*Gail Stockton suggested that the Pueblos and Tribes (New Mexico), as well as the three states, farmers, and other stakeholders who are not participating in this conference should be included in any planning process (as is intended). It would be better to collaborate with already active and established planning groups in many parts of the*

*basin who already have collaborative planning processes in place than to start yet another group.*

**COLORADO HEADWATERS AND NEW MEXICO SEGMENT DATA SUFFICIENCY (MICHAEL CAMPANA, UNM; STEVE MARKSTROM, USGS; ELIZABETH SODERSTROM, NHI; GAIL STOCKTON, USACE; BREAK-OUT GROUP MEMBERS)**

**Data Sufficiency Review**

Although gaps in data sufficiency exist in the upper segments of the Rio Grande, there is a significant amount of information available. In addition to hydrologic data that has been collected for decades to meet Compact requirements, several modeling efforts are underway in the upper basin. These modeling efforts and the data availability are categorized below with insufficiencies in data availability represented in italics.

**Hydrologic Inflows**

Climatological — Climatological data, which is collected by U.S. Department of Agriculture's Natural Resources Conservation Service in coordination with the National Weather Service, appears to be adequate for most of the sub-basin in the Colorado section of the river. In New Mexico, USGS reports data on average annual precipitation, snowfall, and temperature.

*Louis Scuderi (UNM) has identified a 72–75 year drought cycle in the southwestern U.S., based on 2000 years of tree-ring data. He predicts that the southwestern U.S. is now in a drought phase, which should bottom out between 2020 or 2025.*

Stream Flow Records — For the Colorado section of the river, USGS and CDWR have stream flow data dating from 1889. There is an extensive stream gage network on the mainstem and the major tributaries, with satellite monitoring systems on many of the stream gages. Seven index gaging stations are used to determine inflows and outflows in accordance with the Compact. NM OSE provides flow data and USGS has a website that provides real-time and historic data on surface water, groundwater, and water quality for streams, lakes, and springs in New Mexico. USGS also maintains gaging stations in New Mexico.

*There is a need for naturalized flow data for both the Colorado and New Mexico sections of the river, and hydrological data for the smaller tributaries. For example, there is inadequate gage coverage for the smaller streams draining the Sangre de Cristo Mountains in the Colorado section of the river. In addition, more return flow gages are needed throughout the system. The URGWOM riparian team is considering information on naturalized flows, but this will not be available until the EIS is complete.*

Points of Inflow — For transbasin inflow, water from the San Juan River Basin is imported to the Rio Grande Basin. The mean value for the period 1990–1998 was approximately 75,000 acre-feet (92.5 million m<sup>3</sup>) per year. In addition, the Closed Basin Project in Colorado pumps water from 170 production wells from the unconfined aquifer to the Rio Grande to help meet compact requirements. The Closed Basin Project has extensive groundwater data from production wells and observation wells.

*There is little information on agricultural return flow.*

Groundwater — There is an unconfined and a deeper confined aquifer in the Colorado section of the river. CDWR administers groundwater withdrawals and quantifies demands met by groundwater in this segment. The RGDSS will generate information on future groundwater demand and on groundwater-surface water interactions. In New Mexico, horizontal hydraulic conductivity has been evaluated along the Rio Grande.

*In general, there is a poor understanding of the groundwater system in both Colorado and New Mexico segments of the river. There is a need to analyze aquifer storage and recovery. Groundwater pumping from individual domestic wells is also poorly documented and represents an unknown portion of the water budget, especially in the Albuquerque basin. There is a deficiency of available information on groundwater-surface water interactions in this part of the Rio Grande.*

### **Physical System**

Land Use/Land Cover/Soils — Agro Engineering and the “Hydrologic Unit Modeling of the United States” project (on-going at the Blackland Research Center) have GIS coverages and satellite imagery for land use/land cover and soils in the Colorado section of the river. They also have digital elevation models. In addition, USGS has data related to topography, and BLM and USFS have looked at soils and cover in some areas of the upper basin.

Stream Condition — BLM and USFS have looked at stream condition in some areas of the Colorado reach of the river. We have learned that there is more information available for river morphology, riparian health, and aquatic habitat than we have yet compiled.

*Water quality information is scarce, as well as information on relations between flow and water quality.*

Channel Characteristics — USGS has GIS data related to topography and routing algorithms, which were developed for the Upper Rio Grande Water Operations Model. In New Mexico, USGS reports channel profiles, sediment transport, and hydrologic data between 1970 and 1975.

Reservoir Characteristics — USBR has data (including elevation, evaporation, discharge, and storage) for the larger reservoirs in the Colorado and New Mexico sections of the river, but the parameters covered may not be comprehensive.

### **Losses**

Evapotranspiration — The RGDSS will provide evapotranspiration data for crop and non-crop coefficients for the Colorado section of the river. In addition, some work has been done on evapotranspiration (ET) rates for bare soil and grass-covered areas, and USBR has a Nexrad ET Toolbox. New Mexico State and Los Alamos both have ET work underway.

*There is a need for additional evapotranspiration data on native and non-native riparian vegetation.*

Infiltration — Some infiltration data has been generated for the Rio Grande canal and the San Luis Valley Irrigation District.

GW-SW Interactions — USBR did a study on the relationship of groundwater to the Rio Grande, estimating river seepage losses to groundwater. In addition, some work is being done by Los Alamos and Institute for Groundwater Studies (IGS).

*Groundwater-surface water interactions are not well quantified. Likewise, interactions between shallow and deep aquifers are not well understood.*

Diversions — CDWR and Agro Engineering have maps of all diversions (60 main diversions in the Colorado segment). In Colorado, head gates and measuring flumes are on all diversions; most large diversions also have satellite-monitoring equipment that provide real-time data.

### **Demands**

Municipal and Industrial — USBR (1997) reports non-agricultural water use within the Middle Rio Grande. In addition, the New Mexico Office of the State Engineer (OSE) has studied the daily estimated water requirements for livestock, dairies, schools and indoor water use in New Mexico. CH2M Hill has also completed a study for the City of Albuquerque that considers options in relation to future water demand and supply.

Agricultural — In Colorado, diversions to irrigation districts are well documented. In New Mexico, annual irrigated agriculture withdrawals by county and by irrigation type are reported by the OSE.

*Future agricultural demands have not been quantified. In addition, there is no consolidated irrigation acreage database.*

Environmental — San Luis Valley has an extensive complex of wetlands that are important for migratory waterfowl. USGS has looked at fish communities and stream habitat in some segments of the river. USBR reports on water consumption by riparian vegetation. Also, CH2M Hill reports on water demands for the silvery minnow. There is archived data from research conducted at Sevilleta National Wildlife Refuge in the Central Rio Grande Basin.

*Environmental and recreational water needs are not adequately quantified. There is no known method to estimate instream flow requirements for the riparian ecosystem — we only have this information for individual instream species. Alliance for the Rio Grande Heritage is working on a study that will begin to define environmental demand.*

Recreational — Recreational demand for water has been quantified in some modeling efforts (e.g., severe drought model), but how extensive this effort has been is unknown.

## **Operations**

### **Existing Institutional Constraints**

- The Rio Grande Compact is the overriding constraint on water management of the Colorado headwaters. In any given year, the Compact requires Colorado to deliver between 20 and 50 percent of the water (generated in the Rio Grande and Conejos River basins) to the Colorado-New Mexico state line. There is some flexibility in the system in that deliveries to the state line are not required to strictly adhere to the Compact's delivery schedule on an annual basis—under- and over-deliveries are allowed, with restrictions.
- There are two separate accounting and administrative systems for the Rio Grande and Conejos River basins.
- The system is run primarily as a run-of-the-river system. Less than 20% of the combined annual discharge of the two headwater rivers is stored in reservoirs.
- In Colorado, all water rights have been fully adjudicated and have been assigned priority dates—claims to the river exceed supplies under all runoff conditions.

*Water rights are not completely adjudicated in New Mexico and consequently, there is little water rights information on point of diversion, use, etc., especially in the Albuquerque area. In addition, we don't know how much water is actually being used by agriculture in New Mexico.*

### **Modeling Efforts**

Significant modeling efforts are underway in the Colorado and New Mexico segments of the Basin:

- **URGWOM and Water Operations Review (and EIS)** — Please see Ms. Stockton's presentation (above) on these models.
- The **Rio Grande Decision Support System (RGDSS)** will enable simulation of the river system from the headwaters in Creede, CO, to the Colorado-New Mexico border (estimated completion June 2002). Project outputs will include three models:
  1. Basin simulation model to evaluate river and reservoir operations and allow examination of present and future interstate compact policies and operation criteria.
  2. Water resources planning model to evaluate existing and proposed water systems, including reservoir operations, water rights transfers, exchanges, and impacts of instream flows on other resources.
  3. Consumptive use model to calculate the amount of water used by agriculture, municipalities, industry, etc.
- The **Integrated GIS Framework for Water Allocations Decision-Making in the Upper Rio Grande Valley** is used for water allocation and decision-making from the headwaters to Elephant Butte.

- **Flo-2D** is a two-dimensional flood routing model that simulates the progression of a flood hydrograph. It is a useful tool for delineating flood hazards, regulating floodplain zoning, and designating flood mitigation.
- **“Marketing Western Water: Can a Process-based GIS Improve Reallocation Decisions?”** describes a model being funded by the U.S. National Science Foundation and the Environmental Protection Agency. The GIS-based model will simulate the Upper Rio Grande basin, defined as the region from the headwaters in Colorado to Elephant Butte Reservoir. The integrated modeling framework utilizes a raster-based distributed water balance approach in which each raster element represents a bucket through which inputs and outputs may be routed.

The physically based watershed model will encompass both climatological and hydrological (surface and groundwater) processes. It will be coupled with an economic input-output (I-O) model and institutional water rights, which will enable the evaluation of the interplay among climate change, land use, hydrology, economics and water rights. Additional information is at <http://www.unm.edu/~wpr/urg.htm>

Completed water planning models for this segment of the Rio Grande include the following:

- The Center for Nonlinear Studies (CNLS) at LANL has developed a modeling system called the **Los Alamos Distributed Hydrologic System (LADHS)**. The CNLS is using its system to perform integrated modeling of the Rio Grande Basin, modeling of interfaces between system components, and evaluation of the uncertainty of model predictions. LADHS is a physically based, fully coupled, interactive modeling system that simulates the hydrologic cycle in the Rio Grande Basin of New Mexico by linking a suite of environmental models including RAMS (Regional Atmospheric Modeling System), SPLASH (a land surface model), and FEHM (a subsurface model). LADHS is currently being used to simulate the 1992–1993 Rio Grande water year. Additional information is at <http://cnls.lanl.gov/Highlights/2001-07/summary.htm>
- **Hydrologic Modeling of the Rio Grande/Rio Bravo Basin** is a GIS-linked hydrology and water quality model that simulates the hydrology and sediment transport in the Basin. It was a joint Mexico-U.S. modeling effort (1995–1997) and much of the effort of this project was dedicated to creating comparable maps and databases on both sides of the border. More information can be found in: *Matthews, O.P., L. Scuderi, D. Brookshire, K. Gregory, S. Snell, K. Krause, J. Chermak, B. Cullen and M. Campana, 2001. Marketing Western Water: Can a Process-Based Geographic Information System Improve Reallocation Decisions? Natural Resources Journal 41(2): 329–371.*

- **Institutional Adjustments for Coping with Prolonged and Severe Drought in the Rio Grande Basin** is a USGS-funded effort to examine options facing river basin managers when confronted with the extenuating circumstances of a major drought. A fully integrated hydrologic-economic model was developed to identify hydrologic and economic impacts of possible changes in institutional structure for coping with drought.

## ACTION LIST

- **Link and integrate URGWOM, DSS, and other modeling efforts** into a system-wide metamodel. There is a very pressing need to improve data sharing in the basin through such a cooperative approach. Determine scope and timelines for on-going efforts and coordinate with and build on these efforts. In particular, there is a need to build on URGWOM's EIS analysis, incorporate additional scenarios, and fill gaps as needed.
- **Set up a basin-wide standardized database** and determine options for maintaining and operating it.
- **Set up a process for quality control** to ensure that the modeling effort incorporates the best available science.
- **Analyze the potential for reoperating reservoirs** to better represent natural hydrologic flows of the river, especially on the non-federal dams not considered by URGWOM (check with Albuquerque USGS district office regarding their work on this).
- **Determine sufficiency of crop ET and riparian ET data.** There is also a need to figure out an ET interface with the model (consider URGWOM DSS option or HDB used by Riverware).
- **Meet with existing river restoration groups**, including ESA Work Group, Whole Pie Group, Pueblos, Bosque Improvement Group, the river flow subgroup, and the Alliance for Rio Grande Heritage, to discuss current riparian and wetland restoration efforts, including vegetation control (also, talk to Bureau of Reclamation about this). Also discuss removing or modifying the San Acacia and/or Isleta diversion dams (also meet with the Middle Rio Grande Conservancy District about this possibility).
- **Identify levees that are important for flood control and ones that might be appropriate for breaching** between San Marcial and Elephant Butte. Also, identify appropriate levees to move/lower to widen the river channel and accommodate overbank flooding.
- **Analyze the potential of modifying reservoir operation scenarios** for Caballo/Elephant Butte, and conservation storage in upstream flood control reservoirs.
- **Analyze groundwater withdrawals.** From the State Engineer's Office, determine the largest users, and simulate impacts and benefits of reducing pumping. Discuss with USGS (Jim Bartolino) their MODFLOW model for Albuquerque, and other areas (Sante Fe, San Luis Valley).

- **Compile baseline for water quality data.** Check with EPA and USGS NAWQA.
- **Discuss** with the New Mexico Office of the State Engineer (Water Rights Division) **the status of modernization of water rights records.**
- **Review available information on agricultural and municipal/industrial withdrawals** beginning with existing EIAs, EISs, and the Water Operations Review.
- **Review the work being done on groundwater-surface water interactions** at Los Alamos and IGS.

**PASO DEL NORTE (OSCAR IBAÑEZ, UACJ-IIT; JIM STEFANOV, IBWC; BETH BARDWELL, WWF; BREAK-OUT GROUP MEMBERS)**

**Data Sufficiency Review**

There is a large collection of data available from IBWC and relevant to this project for the U.S. side of the Rio Grande/Rio Bravo from Elephant Butte to the Gulf of Mexico. IBWC has been around since the late 1800s and has conducted large-scale detailed engineering studies on the river from just below Elephant Butte to just below Brownsville, largely for flood control purposes. In addition, the Rio Grande Water Bulletin, published annually since 1931, contains information on mean daily flows, daily reservoir storage, monthly diversions, and monthly climate data including precipitation, temperature, evaporation and humidity.

In Mexico, much of this same information is available from CILA and is accessible via the Internet. Mexico's data for this segment of the Rio Grande/Rio Bravo includes, at a minimum, the following parameters: areas of influence, number of water accounts, population, land use, water availability, water use trends, annual water use, water quality, number of water accounts for particular services, rates charged, property rights and legal obligations, and operating policies and legal structures.

Other general sources of data for the Paso del Norte segment include:

- University of Ciudad Juarez's Geographic Information Center, which has been involved in several Rio Bravo projects, including a state program to identify data availability for 13 different subsystems of the river. This project compiled data accumulated over the years by five Mexican governmental institutions. Additionally, the university has worked on more than 40 GIS projects covering, collectively, all of Chihuahua state.
- Paso del Norte Water Task Force, which recently produced a report summarizing basic information regarding water in the tri-state region. The report is available in both Spanish and English, and can be accessed on the web at [http://www.sharedwater.org/water\\_planning.html](http://www.sharedwater.org/water_planning.html).

Data for the Paso del Norte segment can be categorized as follows:

### **Hydrologic Inflows**

Climatological — Climate data appear to be adequate for most of this sub-basin. Gross estimates of storm water inflows can be based on gage responses to storm events.

Stream Flow Records — There are no significant tributaries in this reach (except groundwater pumped for irrigation that ends up in the river), so the bulk of stream flow information can be acquired from mainstem gaging.

*There is a glaring deficiency of general data in the “Forgotten Reach” between Ft. Quitman and Presidio. There are large arroyos in this reach that drain large expanses of the sub-basin and none are gaged, so we have no measured data on runoff inflows. We also have little information on pre-development stream flow regime in this reach.*

*We will need to be able to track water quality. During low flow periods, TDS and sulfate levels rise and can exceed EPA water quality standards. At these levels the water is also too salty for standard treatment for drinking water. In the future, we expect water efficiency to improve and for recycling/reuse programs to increase. These may cause increases in total salinity that must be assessed. We also have little data on sediment transport. What little information is available will have to be extrapolated for larger areas.*

Groundwater — IBWC has groundwater data from two large aquifer studies:

1) Transboundary Aquifer Bi-national Database for the Hueco Bolson and 2) Middle Rio Grande Transboundary Aquifer Study.

*We need to know what proportion of the total stream flow can be attributed to return flows that originate as groundwater that has been pumped for agricultural or domestic use. More information on current and future groundwater pumping rates is needed.*

### **Losses**

Evapotranspiration — Evaporation losses have been estimated by IBWC and USBR.

Infiltration — Gross estimates of seepage and infiltration losses can be determined by back calculating from changes resulting from the concrete lining of canals. These estimates can then be compared to the results of on-going research on seepage and infiltration losses in the Lower Rio Grande Valley.

GW-SW Interactions — We are not aware of studies on this issue.

*Losses to shallow groundwater aquifer are not known. Likewise, interactions between shallow and deep aquifers are not known.*

### **Demands**

New Mexico State University developed a bi-national model to assess demands on the Hueco Bolson aquifer.

Municipal and Industrial — Diversions to cities are well documented.

Agricultural — Diversions to irrigation districts are well documented.

Environmental — Two studies are in progress by FRAC (Forgotten River Advisory Committee) and Alliance for the Rio Grande Heritage.

*There is insufficient data available on environmental water needs.*

Recreational — The only current recreational demand may be Caballo and Elephant Butte Reservoirs.

*There is little information available on recreational water needs.*

### **Operations**

IBWC has policy information from treaties and meetings minutes.

*We will need more information regarding the way the different irrigation districts carry over their water allotments from year to year in order to set those rules.*

### **Modeling Efforts**

IBWC has built a number of **hydraulic models (HEC)** to model large flood events. The data used to run these models, e.g., river cross-sections and profiles, has been made available.

## **ACTION LIST**

- **Organize a training course for Riverware software.** Each workgroup needs to know how the data are utilized in the model and what the model can and cannot do. This will help us refine our data gathering efforts and will help us define appropriate scenarios.
- **Compile available data from both sides of border.**
- **Conduct side projects to fill data gaps:**
  1. Groundwater-surface water interaction — A 1-month study can be conducted in-house using existing information to extrapolate usable approximations; additional funding can be sought to conduct longer duration projects of 1–5 years.
  2. Irrigation efficiency — World Wildlife Fund and Texas A&M will be conducting studies in the near future.
  3. State of knowledge in Ft. Quitman-Presidio reach:
    - Use remote sensing to get rough estimate of ET losses associated with salt cedar.
    - Get rough estimate of sediment transport by examining changes in excavated channel of Boundary Preservation Project channel over last 25-30 years.
    - Get rough estimate of potential runoff flows from large arroyos by estimating sub-basin size and precipitation data.
    - **Assess data quality and comparability.**
- **Conduct preliminary model runs, identify data gaps, and refine assumptions.**

**LOWER BASIN (ISMAEL AGUILAR, ITESM; MITCH MATHIS, MITCHELL CENTER; BREAK-OUT GROUP MEMBERS)**

**Data Sufficiency**

The presentation from the Lower Basin group largely focused on data insufficiencies. Please refer to the SK Matrix Lower Rio Grande conference handout for more information on available data.

Much of the basic data available for this section of the basin comes from the IBWC (see Jim Stefanov's comments under Paso del Norte above). In addition, the Mitchell Center at the Houston Advanced Research Center recently completed a study of the bi-national Lower Rio Grande/Bravo basin that presents comparable data from Mexico and the United States on population growth, water supply and demand, hydrology, water quality, socio-economics, ecology, and the institutional context of water management. The report is available on the web at <http://www.harc.edu/mitchellcenter/mexico/lrgv.html>.

In general, there is currently less data available for the Mexico side of the basin than for the U.S. side.

**Hydrologic Inflows**

Stream Flow Records — George Ward (University of Texas) transcribed most of IBWC's older paper data from stream flow gauges into electronic format. The IBWC/CILA has conducted recent bi-national water quality studies.

*There is insufficient data available on water quality. Salination, particularly within 500 miles (804 km) of the river mouth, is a problem that we need more data on.*

*Water lilies and aquatic plants are useful for bioremediation, and their removal may decrease water quality (but will likely increase river flow since they represent big water losses). This issue should be studied.*

Groundwater — *There is little available data on groundwater-surface water interactions, particularly losses of surface water to saline aquifers.*

**Losses**

Evapotranspiration — *Information on land use needs to be updated, e.g., using satellite images. This information would be useful in calculating water losses due to evapotranspiration.*

**Demands**

The Texas Water Development Board systematically gathers data on water use on the Texas side of the basin (including projection under a range of scenarios).

Environmental — Data exists regarding fish populations in the Rio Grande, and an Indices of Biological and Bioecological Integrity has recently been developed.

*There is insufficient data available on environmental and recreational water demands.*

### **Modeling Efforts**

Some existing models relevant to this project are **George Ward’s Falcon-Amistad reservoir operation model and water budget models**, and **Bob Brandes’ reservoir model** that was part of the Region M Regional Water Planning process. Some **water quality modeling (Neal Armstrong, UT-Austin)** has been done using a modified version of QUAL-TEX and bi-national data compiled from a number of sources.

This segment lacks a management model for drought events.

### **ACTION ITEM**

- **Generate a common data bank** that is accessible by the public.

### **CONCHOS AND PECOS RIVERS (BETH BARDWELL, WWF; BREAK-OUT GROUP MEMBERS)**

#### **Data Sufficiency**

The following general data sources were identified for the Conchos and Pecos Rivers:

1. Petroleos Mexicanos (PEMEX) has databases on geophysics of the region.
2. There are area-specific theses and research projects available from Universidad Autónoma de Chihuahua (UACH).
3. The Universidad Autónoma de Ciudad Juárez (UACJ) Center of Geographical Information has a system of information geographical bases of general data including physiography, geography, floors, hydrology, superficial, soils, precipitation and runoff, physical-chemical covering, and classification of soils.

Two completed studies on the region are:

- Texas Center for Policy Studies (TCPS). 2001. The Rio Conchos: A Preliminary Review. This study analyzes, among other things, water availability, reservoirs, aquifers, droughts, water quality, and current and future water demand.
- A preliminary analysis of Mexico’s Rio Conchos water deficit under the 1944 treaty. This is an analysis of the historical records on deficits of water that should be given to the United States.

Other publications and hydrological studies include:

- Comisión Internacional de Límites de Agua (CILA). Estudio Binacional sobre la Presencia de Sustancias Tóxica en el Rio Bravo/Rio Grande y sus afluentes, en su porción fronteriza entre México y Estados Unidos. 1994.
- CILA. Boletines Hidrométricos del Río Bravo. Números 60, 61,62, y 63. 1990 1 1993.
- CNA Programa Estatal Hidráulico 1995-2000. 1996.
- Pacheco, G. A. et al. Estudio Tectónico Estructural de Sonora-Chihuahua . Proyecto C-1143 Subdirección de Tecnología de Explotación. Instituto Mexicano del Petróleo. 1982.

- Servicios de Prospección Geohidrológica en el Valle de Los Lamentos, Municipios de Praxedis G. Guerrero y Coyamé en la porción Nororiental del Estado de Chihuahua. 1982.
- Estudio Geohidrológico de la Zona Cuenca Alta del Río San Pedro, Chihuahua. 1985.
- Modelo Matemático del Acuífero de Jiménez-Camargo, Chihuahua. 1990.
- Hidrología Física y Química de la Porción Centro-Occidental del Valle Tabalaopa-Aldama, Chihuahua. 1993.
- Resumen de Condiciones Geohidrológicas de Diversos Valles del Estado de Chihuahua.

Data for the Conchos and Pecos Rivers can be categorized as follows:

***For the Conchos River***

**Hydrologic Inflows**

Climatological — CNA has rainfall data for the last 100 years. The UACJ Center of Geographical Information has digitized climatological information (including rainfall data) at the state and local level.

Centro de Investigaciones Sobre la Sequia(CEISS) carries out studies on drought in the area, and Comisión Nacional de Zonas Aridas (CONAZA) has historical information on the socioeconomic impact of the droughts. Centro de Investigación y Estudios Superiores Antropología Social (CIESAS) in Mexico City has also carried out studies on drought within the country and the Conchos River Basin.

Stream Flow Records — CNA has stream flow data from 1920 to the present. UACJ and Junta Central de Saneamiento de Agua also have stream flow information. Instituto Mexicano de Tecnología del Agua (IMTA) has information on water quality and sedimentation in reservoirs. Universidad Autónoma de Nuevo León (UANL) has records of fish species (possible bio-indicators for water quality) in the Conchos River from 1970 to present.

Groundwater — The UACJ has information on number of wells, localization, and groundwater volumes. CNA and the Junta Central de Agua y Saneamiento also have significant information on this feature.

**Physical System**

Reservoir Characteristics — CILA has information on water storage in La Amistad reservoir from 1953 to the present. CNA has digital data on reservoirs of Mexico, including reservoir sedimentation.

**Losses**

The Gerencia de Aguas Superficiales e Ingeniería de Rios (GASIR) of the CNA has information on evapotranspiration and infiltration.

**Demands**

Demand data for municipalities, agriculture, and the environment can be obtained from these sources: Chief Plan on Water Management, Plan of Development,

Instituto Mexicano de Tecnología del Agua (IMTA), and Paso del Norte Water Task Force.

Municipal and Industrial — the Meeting of Central Water and Reparation has information on municipal and industrial water demands.

Agricultural — CNA and the National Institute of Statistic and Geography (INEGI) have information on agricultural water demands. Colegio de Posgraduados recently completed a study on agricultural users' inventory for Irrigation District 025.

Environmental — UANL has partial information on environmental water needs.

### **Operations**

Existing Institutional Constraints — The operating rules for this region are defined by the “Ley Nacional de Aguas” and the 1944 Treaty, and enforced by CNA and GASIR. Universidad Autónoma de Ciudad Juárez (UACJ) Center of Geographical Information has information on river operating rules and the legal structure.

### ***For the Pecos River***

#### **Hydrologic Inflows**

Climatological — The New Mexico State Climatologist has an automated weather data network (1983 to present) that can provide hourly and daily summaries of air temperature, relative humidity, soil temperature and moisture, precipitation, solar radiation, wind speed, and direction (<http://weather.nmsu.edu/>).

Texas Cooperative Observer Program (obtain from Texas State Climatologist) has data from 1948–1966. There are a total of 10 stations dispersed in several counties (Loving, Ward, Crane, Crockett, Pecos, and Val Verde Counties) within the vicinity of the Pecos River. Data collected include daily measurements of temperature, precipitation, daily snowfall, and snow depth.

Stream Flow Records — The Bureau of Reclamation’s Albuquerque area office collects data from gages on the Pecos River. Data are available electronically from <http://cfpub1.epa.gov/surf/locate/index.cfm>. Contact Jaci Gould, USBR engineer, at (505) 248-5381 for more information.

Groundwater — The following groundwater studies are available:

- Fiedler, A.G., and Nye, S.S. 1933. Geology and groundwater resources of the Roswell artesian basin, New Mexico. U. S. Geological Survey Water-Supply Paper 639. 372 p.
- New Mexico Bureau of Mines and Mineral Resources. Geology and groundwater resources of Eddy County, New Mexico. Groundwater Report 3. 169 p.
- LaFave, J.I. 1987. Groundwater flow delineation in the Toyah Basin of Trans-Pecos Texas: unpub. M.A. thesis. The University of Texas at Austin. 160 p.

### **Physical System**

**Reservoir Characteristics** — The Bureau of Reclamation has data on reservoir characteristics for New Mexico (Santa Rosa, Sumner, Brantley, and Avalon Reservoirs) and Texas (Red Bluff Reservoir).

### **Losses**

**Evapotranspiration** — The Bureau of Reclamation has evapotranspiration data in the form of an “ET Toolbox”. The data is available electronically.

### **Demands**

The Far West Texas Regional Water Planning Group produced a regional water planning report that details water demands for the segment from Ft. Quitman to Presidio. The Plateau Regional Water Planning Group produced a similar plan for the segment from Presidio to the mouth of the Pecos River.

**Environmental** — The Pecos Bluntnose Shiner Recovery Plan (USFWS 1992) provides information on water needs of this endangered species. USFWS and New Mexico Game and Fish also developed a programmatic EIS on modification of dam operations for this species.

### **Operations**

**Existing Institutional Constraints** — The 1948 Pecos River Compact governs New Mexico's delivery of Pecos River water to Texas.

### **Modeling Efforts**

A **water operations model** for the Pecos River was developed by the Interstate Stream Commission and Bureau of Reclamation. The project included a 5-year data collection program and uses RiverWare for scenario evaluation.

## **ACTION LIST**

- **Identify a modeling team** with the following sub-teams: hydrology, demand, ecology, socioeconomic, and operating rules/legal (estimated 30 days).
- **Define tasks** (estimated 11 days).
- **Train project partners in RiverWare** (estimated 14 days).
- **Collect data and prepare a report** (estimated 180 days).
- **Conduct a RiverWare meeting** on progress (estimated 1 day).

### **INTERACTIVE DATA MANAGEMENT (STEVE MARKSTROM, USGS—PRESENTATION CREATED BY BOB HARRISS, NCAR)**

Dr. Markstrom stressed that a solid data foundation is essential to the success of this project. He proposed the following steps in creating a shared, interactive data management system:

## Steps in Data Management

1. **Assess data requirements and availability** — Focus on the problem at hand, develop specific case studies, and identify data sources.
2. **Design the database** — Issues to consider include data type, software preferences, database performance (i.e., some databases are geared more toward GIS vs. time series, some work better with websites, etc.), and experience (is someone already trained in a particular database?).
3. **Implement the database and make it web accessible** — Decide on the web tools to include, keeping in mind that different stakeholders may have different needs. Also consider the merits of “controlled access” to limit user access to certain data.
4. **Collect data, engage in quality control, and populate the database** — Consider how data from different sources will be put entered into the database. Decide at the start how this data will be queried for retrieval. Test the database before going on-line.
5. **Analyze data — Highlight trends.** Consider how users will want to view results. If analysis results will be exported to other programs, use the appropriate data management interface (DMI).
6. **Model the data and refine data requirements** — As the pool of questions gets bigger, more models and data may need to be added. You can’t fully specify from the start what is needed for a database, because it will evolve.
7. **Post-process and analyze model results** — Scenarios represent different multiple runs of a model. The database needs to be able to keep track of different runs and model results. Depending on objectives, it may be necessary for a system to have map-producing capabilities for visualization of model results.
8. **Maintain the database** — This is not cheap, but it is extremely important. You need trained individuals to fix the database when it goes down and to continually add to the database as the project grows. Steve suggested that, for this project, the database should be installed at multiple sites in case one site goes down and also because locals should be able to manage the data they collect.

*In the discussion that followed, several valuable points were made:*

- *Gail Stockton added that model documentation is another important step in data management, in order to allow repeatability of a study. Documentation should include information on how the model was developed, how the data was calibrated, etc.*
- *It will often be necessary to translate data because different parameters and measuring systems have been use before populating the database;*
- *It would be helpful to prepare a bi-national demonstration of what can be accomplished with RiverWare, using data that is already available (Dr. Lozano suggested using bi-national Lower Basin data for this). The first step would be to develop a functional data methodology for sharing data that would be widely*

*accessible. Then, set up a bi-national scoping team to look at the results of this workshop and begin outlining all the tasks necessary to put together a basin model.*

**ECONOMIC SUPPORTS AND NEXT STEPS (GREG THOMAS, NHI; JURGEN SCHMANDT, UNIVERSITY OF TEXAS & MITCHELL CENTER; FABIAN LOZANO, ITESM)**

The intended products of this conference are:

1. A summary of the proceedings
2. A statement of the findings and conclusions from the conference
3. A draft of a stakeholder outreach process, to be prepared by Dr. Schmandt
4. A checklist of action items to be accomplished after the conference. This can serve as a short-term workplan of steps to be taken in the next 6 months to 1 year.

The action list will be distributed to conference participants for review and comment before being finalized. Subsequently, NHI will ask project partners to volunteer themselves and their institutions to take on various duties from the action list and provide an estimate of the effort (and cost) required to complete these duties. This information will all be included in proposals for funding for Phase I project funding, which are to be submitted this fall. Six large national foundations have indicated interest in this project. However, matching funds from government agencies will also be necessary to qualify for the foundation funding and to complete the necessary funding pool. Creating the funding pool will be a priority activity over the next 6 months.

Over the next few months, we will also need to make progress in these areas:

1. Set up a website on which to post all project information, including documents created from our research efforts and workshops.
2. Get RiverWare installed at ITESM and also somewhere in the U.S. (possibly a university).
3. Set up remote access connections to RiverWare so all project participants will be able to manipulate data in the software to see results. Actual changes to the data will not be recorded unless a special procedure is carried out.
4. RiverWare training — CADSWES will schedule a special training session for project participants. Ultimately, we would like every participating institution to have at least one trained RiverWare operator.
5. Discuss with ACOE the possibility of setting up a workshop for an URGWOM demonstration.
6. Recruit to the planning team someone to assist with the task of ensuring the quality of data that is used in the model.
7. Coordinate efforts in data collection. Develop a strategy for broadening contacts and accessing information, particularly from Mexican institutions and agencies.

All participants agreed that the bi-national nature of this project should be strongly represented in all planning and proposal-writing efforts. On a similar note, Dr. Lozano

asked that Mexican partners make an effort to address Mexican authorities and the private sector for funding to supplement U.S. funding.

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