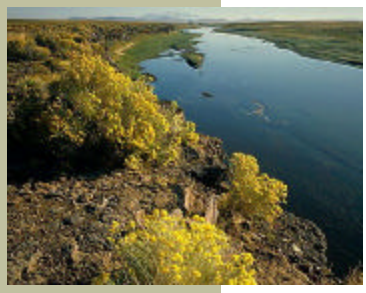
Rio Grande Rio Bravo

Designing a Common Future
Diseñando un futuro común

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



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FINDINGS AND CONCLUSIONS

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

The following findings and conclusions emanate from the conference of technical experts from Mexican and U.S. institutions who met in Monterrey, Mexico, on June 4 & 5. The purpose of the conference was to pool information regarding the availability and sufficiency of information needed to construct a system-wide water resource planning model for the entire bi-national Rio Grande/Rio Bravo Basin. The **Minutes** of that "State of the Knowledge" conference and the **Agenda for Action** are available as separate documents. These are all products of an initiative of non-governmental organizations and universities on both sides of the border to create a system-wide planning model and data management system to evaluate and compare proposals for improved water management that can provide benefits that transcend the jurisdiction-specific planning perspective of the past. This project is called **A Physical Assessment of the Opportunities for Improved Management of the Water Resources of the Bi-National Rio Grande/Rio Bravo Basin.** A project description and the products of the "State of the Knowledge" conference are available at www.n-h-i.org.

The Rio Grande/Rio Bravo is a Basin Approaching Crisis

- The shared and finite water resources of the Rio Grande/Rio Bravo basin are not sufficient in quantity or quality to meet the existing and future incremental demands of one of the fastest growing areas in North America without substantial improvements in the management of these resources. The question of whether or

NATURAL HERITAGE INSTITUTE
PH. 510.644.2900 (EXT. 101) • FAX 510.644.4428 • GAT@N-H-I.ORG • 2140 SHATTUCK AVE, FL 5 • BERKELEY, CA 94704

INSTITUTO TECNOLÓGICO DE ESTUDIOS SUPERIORES DE MONTERREY
TELS. DIR. 8.328.4032 • CONM. 8.358.2000 (EXT. 5275 Y 5019) • FAX 8.359.6280 • DLOZANO@CAMPUS.MTY.ITESM.MX
EDIFICIO CEDES 5 PISO • SUC. DE CORREOS "J" C.P. 64849 • MONTERREY, N.L. • MÉXICO

not water resources can continue to support the booming population and industrialization of the basin is particularly relevant to the Ciudad Juarez/El Paso area and the Lower Rio Grande Valley, where population has doubled every 20 years since World War II, with no end in sight. In the Lower Rio Grande Basin, it is estimated that municipal demand for water will more than double over the next fifty years. Other factors contributing to the basin's water scarcity problems include the high evaporation rate, low availability of runoff, and limited aquifer recharge throughout. It is clear that the future of this basin cannot resemble the past.

- A major water supply challenge in municipal water supplies for Albuquerque, Las Cruces, Ciudad Juarez, and El Paso is the transition from dependence on groundwater to greater use of the surface water supplies, perhaps in addition to treatment of the low quality groundwater. Historically, the cities of El Paso and Ciudad Juarez have pumped their drinking water from Hueco Bolson, a nonrenewable aquifer with an estimated 5 to 25 years' supply of water remaining.
- A major water flow challenge for the basin is recreating a more natural flow regime through the highly transformed "Forgotten River" reach between Ft. Quitman and Presidio.
- Because of drought and water management conditions, Mexico is having difficulty meeting its treaty obligations to deliver water out of the Rio Conchos to the Lower Rio Grande basin. Its ability to do so will require major improvements in water management in that sub-basin.
- There is a very pressing need to improve data acquisition and sharing in the basin through a cooperative approach.

Goals Suggested for the "Physical Assessment" Project

- The ultimate goals of the project are to:
    - Provide a long-term sustainable solution to water management in the basin. We need to set up the possibility of managing this river by choice and rational decisions, rather than by pressures and crisis.
    - Achieve initiatives in both countries to solve existing problems.
    - Increase awareness among communities of the limitations and potentialities of the river.
- Specific steps to reach these goals include:
    - Designing a system-wide, state-of-the-art, bi-national integrated data management system (DMS) that incorporates or that can interface with the segment-specific databases and models that are contemplated or currently under way.
    - Setting up the DMS so it is widely available and able to evolve as our knowledge improves.

- Developing and comparing scenarios that capture opportunities for management improvements.

Participation

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 led by non-governmental organizations, the initiative welcomes and solicits the cooperation of government agencies and experts. This is necessary for two reasons:

- Government agencies are repositories of much of the data and expertise necessary to accomplish this project, and they already have significant modeling efforts underway in the basin. Our role will be to expand and bridge efforts already underway in the basin. 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 matching grants to support this project. This amount will be small in comparison to the money that is currently spent on river basin planning.

Data Requirements for River Basin Planning Using 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-surface water interactions.
- Physical system — reservoir characteristics, changes in channel geometry.
- Demands — including projections for changes in demand.
- Operating policies — reservoir storage and release regimes, water rights and allocations.

Data Sufficiency and Availability

In general, the data needed to construct a basic system-wide planning model are available and sufficient. On the U.S. side of the border, the several segment-specific models and decision support systems currently underway (itemized below) either utilize the RiverWare software or are compatible with it so that they can be linked into a system-wide model into which the data can be incorporated. On the Mexican side of the border, the available information on the Conchos Tributary is limited; on the Ciudad Juarez area is probably sufficient for our purposes; and on the Lower Basin is quite good.

To emphasize the work that remains to be done to develop a complete data set, this document itemizes the data deficiencies rather than the information that is already available. The most significant data deficiencies for our purposes, which were identified by the conference, are as follows:

All Segments

- **Ungaged tributaries and return flows:** More flow gages are needed throughout the system.
- **Groundwater-surface water interactions:** Groundwater-surface water interactions and interactions between shallow and deep aquifers are not well understood.
- **Environmental and recreational demands:** Environmental and recreational water needs are not adequately quantified. Methods to estimate flow requirements for ecosystem health need to be developed. At present, we only have information for individual species.
- **Evapotranspiration:** There is a need for additional evapotranspiration data for native and non-native riparian vegetation.

Headwaters and New Mexico Segments

- **Hydrologic inflows:** There is limited precipitation data to reliably forecast runoff. In addition, drought duration and frequencies cannot be predicted accurately.
- **Stream flow records:** 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.
- **Points of inflow:** More information is needed on agricultural return flow.
- **Groundwater:** In general, we need a better understanding of the groundwater systems 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.
- **Stream and watershed conditions:** Water quality information is scarce, including information on relationships between flow, water quality, and watershed health.
- **Agricultural demands:** Future agricultural demands are difficult to forecast. There is no consolidated irrigation acreage database.
- **Water rights:** Virtually the entire Rio Grande in New Mexico is not adjudicated below Taos. In many places there is little information on points-of-diversion, use, etc. Native Americans' water rights have not been quantified. In addition, we do not have accurate knowledge of how much water agriculture actually uses in New Mexico.

Paso del Norte

- **Hydrologic inflows:** There is a glaring deficiency of hydrological 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.
- **Groundwater:** The most serious data deficiency relates to incomplete knowledge about remaining water supply in the Hueco Bolson, the main source of drinking water for Ciudad Juarez and an important source for El Paso.
- **Operations:** 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.

Lower Rio Grande/Rio Bravo

This segment of the Rio Grande has been studied more than others. Historical data and projections to 2030 for water supply and demand and population growth from both countries are available.

- **Stream and watershed conditions:** More water quality data are needed. Salination, particularly within 500 miles (804 km) of the river mouth, is a problem on which we need more data.
- **Environmental and recreational demands:** More data on instream flow requirements are needed.

Conchos Tributary

For the Conchos and Pecos tributaries, information on data availability is presented below. There needs to be additional work done to determine data insufficiencies in each of these categories.

- **Climate:** CNA has rainfall data for the last 100 years. The Universidad Autónoma de Ciudad Juárez (UACJ) Center of Geographical Information has digitized climatological information (including rainfall data) at the state and local levels. 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 Investigaciones y Estudios Superiores en Antropología Social (CIESAS) in Mexico City has also carried out studies on drought within the country and the Conchos basin.
- **Stream flow records:** CNA has stream flow data from 1920 to the present. UACJ and Junta Central de Agua y Saneamiento 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 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.
- **Reservoir characteristics:** 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 the Chief Plan on Water Management, Plan of Development, Instituto Mexicano de Tecnología del Agua (IMTA), and Paso del Norte Water Task Force. Junta Central de Agua y Saneamiento (JCAS Central Water and Sanitation Council) has information on municipal and industrial water demands. CNA and the National Institute of Statistic and Geography (INEGI) have information on agricultural water demands. UANL has partial information on environmental water needs.
- **Operations:** The operating rules for this region are defined by the "Ley de Aguas Nacionales" (available from UACJ Center of Geographical Information) and the 1944 Treaty, and enforced by CNA and GASIR.

Pecos Tributary

- **Hydrology:** 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. The 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 within the vicinity of the Pecos. Data that are 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. Data are available electronically from http://cfpub1.epa.gov/surf/locate/index.cfm.
- **Groundwater:** Several groundwater studies have been noted in the conference minutes.
- **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:** The Bureau of Reclamation has evapotranspiration data in the form of an "ET Toolbox". The data are available electronically.

- **Demands:** Three Texas Regional Water Plans detail water demands on the Pecos as it flows south from the New Mexico-Texas border to its confluence with the Rio Grande east of Amistad Reservoir. The three planning groups are Region F, the Far West Texas Regional Water Planning Group (covers El Paso to Terrel County), and the Plateau Regional Water Planning Group (includes Val Verde and Kinney Counties).
- **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.

Current Data Management and Modeling Efforts That Should be Integrated into the System-Wide Model

On the U.S. side of the border, there are several segment-specific modeling and data management programs now underway or contemplated. In due course, these will provide data sets that can be integrated into a system-wide model. In addition, most of the models that are currently under development use compatible modeling software and can therefore be linked together. It would make sense for the Physical Assessment project to not re-invent these developments but to link and integrate these models into a basin-wide planning model that will also include the Mexican tributaries. There is a very pressing need to improve data sharing in the basin through cooperative efforts.

The most notable ongoing or completed modeling efforts are these:

- 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 **Upper Rio Grande Water Operations Model (URGWOM)** and the **Water Operations Review** and **EIS**, to be completed by the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and the New Mexico Interstate Stream Commission, evaluate water operations under existing authorities from the Colorado border to El Paso (but below Elephant Butte Dam, URGWOM only accounts for flood control at this time).

- The Texas Natural Resources Conservation Commission's (TNRCC) **Water Availability Model (WAM)**, which will cover Ft. Quitman to the Gulf.
- A **RiverWare model** constructed for the Pecos tributary, from the headwaters in New Mexico to the New Mexico-Texas state line, in a joint effort by U.S. Bureau of Reclamation and the New Mexico Interstate Stream Commission.
- The Center for Nonlinear Studies (CNLS) at LANL has developed a modeling system called the **Los Alamos Distributed Hydrologic System** (LADHS). 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.
- **"Marketing Western Water: Can a Process-Based GIS Improve Allocation 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. The physically-based watershed model will encompass both climatological and hydrological processes. It will be coupled with an economic input-output model and institutional water rights, which will enable the evaluation of the interplay among climate change, land use, hydrology, economics, and water rights.
- **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.
- **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.
- **Falcon-Amistad reservoir operation model and water budget models** (developed by George Ward).
- A **reservoir model** developed for the Region M Regional Water Planning process (Bob Brandes).

- **Water quality modeling** using a modified version of QUAL-TEX and bi-national data compiled from a number of sources (Neal Armstrong, UT-Austin).

The scope of all of these models is limited geographically and in terms of the issues and alternatives to which they will be applied.[1] Notably, while the models are currently being built for separate geographic areas, they can be interfaced together and the rules can be changed in RiverWare to look at alternatives that transcend these geographic areas or particular management units. The Physical Assessment project can add value to and beyond current modeling efforts by:

- As a first important step, establishing a system for sharing the data among the basin states and countries;
- Linking the segment-specific models into a system-wide model that will be utilized to identify and evaluate improved water management opportunities at the trans-jurisdictional level, i.e., options that can only be accomplished between and among the various segments;
- Augmenting the U.S. modeling efforts with equivalent models on the Mexican tributaries, that would also be linked in a shared, comprehensive, readily accessible, state-of-the-science information management system; and
- Augmenting the scope of the segment-specific models. In some cases, these are scoped to account for less than the full array of facilities, water routing options, and management options that exist within their particular segment. The Physical Assessment project can fill these gaps in constructing a system-wide model.

Protocols for Constructing and Using the Basin-Wide Model

- The model should be constructed to reflect the existing ("no action") water allocation, routing, and operational realities, in order to have a yardstick against which to compare alternatives. Thus, the model will incorporate the "law of the river" as embodied in water rights, compact allocations, and treaty obligations. It will also incorporate the current operations rules for the storage and conveyance facilities in the basin. Constructed in this

[1] For instance, we understand that URGWOM at present covers the segment from the Colorado-New Mexico border to El Paso. Below Elephant Butte Dam, however, the Water Operations Review and EIS currently only use the URGWOM model to account for flood control releases. Secondly, the model only tracks inflows and outflows from the river; it does not track the movement of the water through the users' distribution or utilization system. Third, the current planning model version is being constructed to assess operational alternatives for federal facilities, not for alternatives that involve non-federal facilities or non-federal initiatives. Fourth, the Water Operations Review and EIS will look at opportunities that could be accomplished within the existing operational laws, including compacts and treaties; however, some stakeholders may also be interested in looking at opportunities to improve operational laws in ways that could provide benefits to all three basin states.

manner, the model will represent policies and institutional constraints in the model, visible to all stakeholders.

- The system-wide planning model should incorporate data and functions that will enable it to evaluate all feasible scenarios for improved water management that may be proposed by the water user stakeholders and the public agencies with management or regulatory responsibilities in the basin. Some such scenarios may only be accomplishable through voluntary, compensated exchanges of existing water allocations. Where such arrangements would require a modification of existing compact or treaty provisions, this project would assume that such scenarios are feasible — and therefore worthy of evaluation with the planning model — only if they have the potential to provide net benefits to all of the parties to such compacts or treaties such that it is possible to imagine consensual modifications. Such benefits may be in the form of monetary compensation as well as hydrologic improvements.
- The Project will produce a shared, state-of-the-science, widely accessible, comprehensive and definitive data management system for the entire basin. This will include the types of information necessary to construct the system-wide RiverWare model and to use it for management decisions and planning purposes. The shared information management system will include data reliability standards and peer review processes to assure that the data that is incorporated is as accurate and reliable as possible.
- The model must be developed in an open, collaborative fashion. One way to do this is to make the data that goes into the model promptly available on the Internet.
- The Project will work with already established bi-national planning groups and, as soon as they are operational and funded, with the recently-assembled Mexican Basin Councils in execution of this stakeholder consultation process so we will not be duplicating their efforts.

Action Recommendations

The action agenda emanating out of the "State of the Knowledge" Conference will be the subject of a separate paper.