
**PROPOSAL FOR AN INTEGRATED MANAGEMENT PLAN
FOR THE RIO GRANDE/RIO BRAVO**

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ABSTRACT

The equitable allocation of the waters of the Rio Grande/Rio Bravo below Fort Quitman, Texas between the United States and Mexico pursuant to their 1944 Treaty is seriously hampered by the occurrence of periodic droughts and floods. The Treaty obligates Mexico to supply specific annual releases of water from the Rio Conchos to the Rio Grande/Rio Bravo, an obligation it has failed to meet since 1992. The resulting friction between Texas and the adjoining Mexican states has strained relations between the two nations, and demonstrates that a fuller understanding of the actual quantity of readily-available water, both surface and underground, is essential to developing a long-term, mutually-satisfactory resolution of the disputes surrounding the current and possible future shortages in water deliveries from Mexico to the Rio Grande/Rio Bravo. We propose the joint development, elements and implementation of a long-term binational plan to meet future water demands on both sides of the border, as well as possible short-term, interim measures and actions to meet current and possible near-future water shortages.

Introduction

The Rio Grande/Rio Bravo is one of the longest rivers in North America, and a renowned river basin to both the United States and Mexico, and the allocation of its water between the two countries is governed by a treaty signed in 1944. In recent years, Mexico has been unable to meet its required water deliveries to the River under the Treaty, resulting in significant impacts to Mexican and Texas farmers in the lower Rio Grande/Rio Bravo Valley, who depend on these water deliveries for agricultural irrigation, as well as problems for the municipalities that depend on the River for drinking water. This paper (1) presents information on demographic, hydrologic, and environmental conditions in the Rio Grande/Rio Bravo basin relevant to water management, (2) discusses the basic requirements of the 1944 Treaty regarding the water obligations of the two countries, (3) explores the basis for the unmet water deliveries from Mexico, and (4) offers both long-term and interim guidance regarding the River's sustainable use.

Hydrological Characteristics of the Rio Grande/Rio Bravo drainage basin

The Rio Grande/Rio Bravo Drainage Basin. The Rio Grande/Rio Bravo drainage basin begins near the U.S. Continental Divide in southern Colorado and extends through New Mexico, Texas and Mexico to the Gulf of Mexico. The portion of the River between El Paso, Texas, and the Gulf of Mexico, a distance of 1,250 river miles, forms the international boundary between the United States and Mexico. The drainage basin comprises an area of 355,500 mi², with the water-contributing area totaling 176,000 mi². The remaining portion of the basin drains into internal closed sub-basins, and does not contribute water to the River. About half of the River's water-contributing areas (about 89,000 mi²) is located in the United States, with the Texas portion encompasses about 54,000 mi² of the total.

The Pecos and Devils Rivers are the principal Texas tributaries of the Rio Grande/Rio Bravo, both flowing into Amistad Reservoir, about 600 river miles from the River's mouth. The largest Mexican tributaries draining to the river are the Rio Conchos, Rio Salado and Rio San Juan. The Rio Conchos drains about 26,000 mi², flowing into the Rio Grande/Rio Bravo near Presidio, Texas, about 350 river miles above Amistad Reservoir. The Rio Salado drains an area of about 23,000 mi², discharging directly into Falcon Reservoir, about 275 river miles upstream from the River's mouth. The Rio San Juan drains about 13,000 mi², entering the River about 36 river miles below Falcon Dam near Rio Grande City, Texas.

Most of the Rio Grande/Rio Bravo drainage basin is comprised of rural, undeveloped land used principally for farming and ranching. The major Texas--Mexico paired urban areas on the River are El Paso--Ciudad Juarez, Del Rio--Ciudad Acuna, Eagle Pass--Piedras Negras, Laredo--Nuevo Laredo, McAllen--Reynosa, and Brownsville--Matamoros. Substantial quantities of surface water are diverted from the River to meet municipal and agricultural demands in Texas and Mexico, with much of its demand being in the lower Rio Grande/Rio Bravo Valley. Although most of the cities in the Valley are located outside its contributing watershed, the River serves as their primary water supply. The lower Valley is characterized by extensive

irrigated agriculture of significant economic importance for the region. Most of the water diverted from the River in the lower Rio Grande/Rio Bravo Valley is not returned to the River as irrigation tailwaters or treated wastewater effluent because of the land's natural slope away from it. The return flows are instead discharged into interior manmade drainage channels and floodways that ultimately drain into the Laguna Madre estuary, and thence into the Gulf of Mexico.

Rio Grande/Rio Bravo Reservoirs. There are two major international reservoirs on the River's mainstem, Amistad and Falcon Reservoirs, which provide controlled water storage for over eight million acre-feet of water owned by the two countries. Of this quantity, 2.25 million acre-feet (one acre-foot is equivalent to about 326,000 gallons) are allocated for flood control and 6.05 million acre-feet are reserved for silt and conservation storage (water supply). Falcon Reservoir, completed in 1953, is considered to be the "lowest major international dam or reservoir" on the River, in accordance with the provisions of the 1944 Treaty. The United States owns 1.56 million acre-feet (58.6%) of the reservoir's silt and conservation and storage, with Mexico owning the remaining 1.10 million acre-feet. Amistad Reservoir, completed in 1968, is located on the River above Del Rio, Texas. The United States controls 1.77 million acre-feet (56.2%) of the total conservation storage capacity, with Mexico owning the remaining 1.38 million acre-feet.

Anzalduas Dam, completed in 1960 and located near Mission, Texas, is used as a storage and flow regulation facility for partially controlling the United State's share of the water in this reach of the lower portion of the River. It also enables diversions into Anzalduas Canal, Mexico's main water delivery canal. The reservoir has a total storage capacity of 15,000 acre-feet at its normal maximum operating level, with between 3,037 and 4,214 acre-feet available as conservation storage for the United States.

Reservoirs on Tributaries in Mexico. Mexico has constructed reservoirs on its Rio Grande/Rio Bravo tributaries that have a combined water storage capacity larger than the total available to it in Amistad and Falcon Reservoirs. This water is used for municipal, industrial and irrigation purposes in the vicinity of the reservoirs and downstream along the tributaries. Pertinent features of the reservoirs located on the Mexican tributaries are summarized in Table 1. Much of the Mexican reservoir development has occurred in the Rio Conchos Basin in the State of Chihuahua, which flows into the Rio Grande/Rio Bravo upstream of Amistad Reservoir. The 1944 Treaty identifies the Rio Conchos as one of the six Mexican tributaries from which the United States is allocated a portion of the inflows to the Rio Grande/Rio Bravo. The combined conservation storage capacity of all the major Mexican tributary reservoirs is about 6,240,000 acre-feet (Table 1), equivalent to about 2.5 times Mexico's total available conservation storage capacity in Amistad and Falcon reservoirs. Mexico also is constructing a new reservoir (Las Blancas) on the lower reach of the Rio San Alamo, one of the Mexican tributaries flowing into the River below Falcon Dam. Its use apparently will be to capture flood and convey them by canal to the existing Marte R. Gomez Reservoir on the Rio San Juan.

Environmental Considerations for Lower Rio Grande/Rio Bravo Flows

Instream Flows and Riparian Impacts. The lower Rio Grande/Rio Bravo basin lies within the Tamaulipan biotic province, a semiarid, subtropical biogeographical zone (Blair, 1950). The impacts of clearing of vegetation on native brushlands, and of hydrologic modifications to the lower basin, have been dramatic over the decades. More than 95% of the lower basin's native brushland has been converted to agricultural or urban use since the 1920's (USBR, 1995), and there are very few undisturbed, natural communities remaining in the lower basin. Water development projects along this part of the River also have seriously disrupted natural flow regimes, affected wetlands and their aquatic fauna, and degraded native riparian plant communities.

The U.S. Fish and Wildlife Service (USFWS) and National Park Service, and the Texas Parks and Wildlife Department (TPWD) recognized the scarcity and significance of these riparian and instream ecosystems in the lower basin (USBR, 1995). Habitat preservation plans identified this region as a target for the acquisition of sensitive, natural lands. Much of the upland areas are critical habitat for federal-listed, endangered species. Habitat protection and restoration will require maintenance and, in some cases, restoration of the River's hydrologic regimes that support these systems.

The two major USFWS properties in the lower basin containing riparian brushlands critical to endangered species are the Santa Ana National and the National Wildlife Refuges. The latter is envisioned ultimately as a 132,000-acre corridor network, linking protected tracts of brushland and wetlands along the River from Falcon Reservoir to the River's mouth. Two national parks in Texas with riparian systems, Amistad National Recreation Area and Big Bend National Park, are also directly affected by the River's hydrology.

The TPWD also operates approximately 15 State Parks (SP), Wildlife Management Areas (WMA), recreation areas or historical sites in the lower basin of the River. The major state park system properties directly influenced by the River's flow are the Las Palomas WMA, Bentsen-Rio Grande Valley SP, Falcon State Recreation area, and the Boca Chica SP and WMA. The Sabal Palm Grove Sanctuary, located downstream from Brownsville, is owned by the National Audubon Society. This unique ecosystem, dependent on occasional flooding in the lower portion of the River, consists of a remnant stand of native palms from a 40,000-acre palm forest that existed in the 17th century. Clearing of the land for agricultural uses in the lower basin has eliminated almost all this lowland riparian jungle.

Table 1. Reservoirs on Mexican Tributaries to the Rio Grande/Rio Bravo

| River basin/name | River | State | Year completed | Storage capacity | |
|---|-----------------|------------|----------------|------------------------|------------------|
| | | | | million m ³ | acre-feet |
| Rio Conchos Basin: | | | | | |
| La Boquilla | Rio Conchos | Chihuahua | 1916 | 2,903 | 2,353,501 |
| La Colina | Rio Conchos | Chihuahua | 1927 | 24 | 19,538 |
| Francisco I. Madero | Rio San Pedro | Chihuahua | 1949 | 348 | 282,128 |
| Chihuahua | Rio Chuiscar | Chihuahua | 1960 | 26 | 21,079 |
| Luis L. Leon | Rio Conchos | Chihuahua | 1968 | 356 | 288,614 |
| San Gabriel | Rio Florida | Durango | 1981 | 255 | 206,732 |
| Pico de Aquila | Rio Florida | Chihuahua | 1993 | 50 | 40,536 |
| <i>Rio Conchos Basin total reservoir storage capacity</i> | | | | 3,962 | 3,212,127 |
| Rio San Diego Basin: | | | | | |
| San Miguel | Rio San Diego | Coahuila | 1935 | 20 | 16,214 |
| Centenario | Rio San Diego | Coahuila | 1936 | 26 | 21,322 |
| <i>Rio San Diego Basin total reservoir storage capacity</i> | | | | 46 | 37,536 |
| Rio San Rodrigo Basin: | | | | | |
| La Fragua | Rio San Rodrigo | Coahuila | 1990 | 45 | 36,482 |
| <i>Rio San Rodrigo Basin total reservoir storage capacity</i> | | | | 45 | 36,482 |
| Rio Salado Basin: | | | | | |
| Venustiano Carranza | Rio Salado | Coahuila | 1930 | 1,385 | 1,112,838 |
| Laguna de Salinillas | Rio Salado | Nuevo Leon | 1931 | -- | -- |
| <i>Rio Salado Basin total reservoir storage capacity</i> | | | | 1,385 | 1,112,838 |
| Rio San Juan Basin (1): | | | | | |
| Rodrigo Gomez | Rio San Juan | Nuevo Leon | 1963 | 41 | 33,239 |
| El Cuchillo | Rio San Juan | Nuevo Leon | 1993 | 1,123 | 910,512 |
| Marte R. Gomez | Rio San Juan | Tamaulipas | 1943 | 1,097 | 889,271 |
| <i>Rio San Juan Basin total reservoir storage capacity</i> | | | | 2,261 | 1,833,023 |
| TOTAL MEXICAN TRIBUTARY RESERVOIR STORAGE CAPACITY | | | | 7,699 | 6,242,006 |

(1) Flow from these reservoirs is dedicated to Mexico by the 1944 Treaty:

| Mexico's share of water conservation storage in Rio Grande/Rio Bravo international reservoirs | | | | | |
|---|------------|------------|----------------|------------------------|------------------|
| River basin/name | River | State | Year completed | Storage capacity | |
| | | | | million m ³ | Acre-feet |
| Rio Grande Basin: | | | | | |
| Falcon Reservoir | Rio Grande | Tamaulipas | 1953 | 1,355 | 1,098,674 |
| Amistad Reservoir | Rio Grande | Coahuila | 1969 | 1,703 | 1,380,278 |
| TOTAL RIO GRANDE RESERVOIR STORAGE CAPACITY | | | | 3,058 | 2,478,952 |

Rio Grande/Rio Bravo Estuary Water Needs. Although the Rio Grande/Rio Bravo flows directly into the Gulf of Mexico, its final 30 miles (essentially that portion below Brownsville) is a tidal river system. In combination with the offshore portion of the Gulf of Mexico directly influenced by the River's freshwater discharge plume, these two components comprise the River's estuary system. This somewhat atypical estuary lies in the semiarid, subtropical region in the northern Tamaulipan biotic province (Blair 1950). According to the TPWD (Randy Blankinship, personal communication), because of the generally low rainfall and small river flows, the River system is stratified, with freshwater at the surface down to river mile 10, and a saltwater wedge on the bottom extending upriver about 17 miles (average water conditions during the 1992 – 1997 period). Tidal exchange generally dominates the flow and mixing regime in this area, except when locally-heavy rainfalls occur in the late summer-early fall monsoon period. The flows in the lower portion of the River into the Gulf of Mexico are controlled by flows past the Anzalduas Dam at Mission, Texas. These downstream flows, in turn, depend on water diversions made for irrigation, industrial, and municipal uses throughout the lower basin of the River.

The Rio Grande/Rio Bravo estuary is biologically productive in its own right. Among Texas estuaries, it is renowned for some characteristic estuarine species, including an indigenous species of hypersaline-tolerant oysters (*Crassostrea equestris*). Some fish species with tropical affinities reach their regular northern occurrence in the western Gulf of Mexico, including snook (*Centropomus undecimalis*) and tarpon (*Tarpon atlanticus*). The relative abundance of other species, including blue crab (*Callinectes sapidus*) and white shrimp (*Penaeus setiferus*), compare favorably at times with other Texas estuaries. The ecological health and integrity of this fragile estuary is extremely dependent on quantifiable target levels of freshwater inflows (Longley, 1994; Pulich et al., 1998). These bay and estuary inflow requirements are two-fold, including (1) regular, minimum seasonal quantities of freshwater to maintain estuarine in-channel, open-water habitats, and (2) periodic flood events that flush the system and cause overbanking to the riparian wetlands.

The precarious nature of the Rio Grande/Rio Bravo estuary became especially evident in February, 2001, when the mouth of the River at Boca Chica was blocked by a sandbar, because of low-flow conditions resulting from the severe drought the lower River basin has been experiencing since 1995. The rivermouth remained closed until September, 2001, when it was dredged open temporarily by the International Boundary and Water Commission. Although the excavated rivermouth channel remained open months as a result of tidal water exchanges, it was again closed with silt. The mouth of the River remained closed until September 2002, when higher tides and slightly-increased inflows from rainfall events partially opened it. An analysis of the biological impacts to this estuary from the closing of the rivermouth indicated that the most important function of the freshwater inflows from the lower River is to provide reduced salinity habitat for post-larval and juvenile marine species to complete their life cycles. Based on preliminary TWPD data, lacking a means of ingress and egress to this habitat, the production of some aquatic species has decreased (Randy Blankinship, personal communication).

Two critical research needs for the River's estuary are determination of the minimum river inflows needed (1) to maintain a healthy, ecologically-sound environment capable of supporting characteristic, economically-important estuarine fisheries, and (2) to keep the rivermouth physically open to the Gulf of Mexico, thereby sustaining at least minimal estuarine functioning. Determination of the minimum flows for keeping open the rivermouth also has significant biological ramifications since, without periodic flushing, the tidal portion of the lower River could become a closed, hypersaline lagoon system. Water development projects in the lower basin (McAllen to Brownsville), including water diversion and wastewater treatment, also have the potential to seriously threaten the estuary's functionality. Water diversion projects can exacerbate freshwater quantity problems. Wastewater treatment projects can exacerbate water quality problems through discharges of polluted water into, or upstream of, the tidal portion of the River. Lower flows, coupled with increased nutrient and/or contaminant loads, will create eutrophic or noxious conditions deleterious to a healthy estuary (e.g., excessive nutrient loads could lead to harmful algal blooms or excessive growths of noxious plants such as hydrilla or water hyacinth).

The return flows of water diverted from the Rio Grande/Rio Bravo currently pass down the Arroyo Colorado, emptying into the Laguna Madre, the estuary north of the River's estuary. If some of this diverted water were re-routed from the Arroyo Colorado via pipeline to the tidal portion of the River, it might be sufficient to satisfy the minimal target freshwater inflow requirements of the estuary.

Allocating the Water of the Rio Grande/Rio Bravo Upstream of Fort Quitman, Texas

Two Interstate Compacts determine how Texas, New Mexico and Colorado utilize River flows above Fort Quitman, Texas. Their actions also influence the availability of water below this location on the River. The only water Mexico receives from this stretch of the River is that portion going to Ciudad Juarez in the Mexican state of Chihuahua.

Rio Grande Compact. Ratified in 1939, this Compact is administered by a Commission composed of representatives from the states of Texas, New Mexico and Colorado. It prescribes the minimum flows that Colorado must release into New Mexico each year, as well as assigning the water quantities to which Texas and New Mexico are entitled. For waters from Elephant Butte and Caballo Reservoirs a "very complicated accounting procedure by which each states' share is calculated yearly" is followed by the Bureau of Reclamation (USBR) of the U.S. Department of the Interior to determine these quantities. The annual water releases below Caballo Reservoir in New Mexico average 790,000 acre-feet, with total diversions averaging 932,000 acre-feet. The 142,000 acre-feet difference between these two quantities consists of treated municipal wastewater, irrigation return flows, spills from upstream user operations, and precipitation runoff. Most of the water releases in a full allotment year are for irrigation, including 495,000 acre-feet to the Elephant Butte Irrigation District and 376,000 acre-feet to the El Paso County Water Improvement District #1. Mexico receives 60,000 acre-feet of water annually under the Convention of 1906. The City of El Paso, Texas, acquired surface water rights through annexation, and sufficient annual purchases of water from the irrigation districts, to obtain 56,500 acre-feet of water in 1999. In the event of drought, the USBR uses a prearranged schedule to reduce water allocations from Caballo Reservoir (Texas Water Development Board, 2002a).

Pecos River Compact. The Pecos River originates in New Mexico, flowing through West Texas into the Rio Grande/Rio Bravo upstream of Amistad Reservoir. The Pecos River Compact, developed by Texas and New Mexico, and approved by the Congress and the President, was effective in December 3, 1948, and is administered by a commission comprised of members from the two states. The water available for allocation is that which is "salvaged" or unappropriated

The terms of the Pecos River Compact can be summarized by the following four points:

- *New Mexico cannot decrease the Pecos flow at the New Mexico/Texas border to a point less than that of the 1947 condition. (When determining the quantity of Texas water for the 1947 condition, waters of the Delaware River [in Texas] is apportioned to Texas).*
- *Of the beneficial consumptive use of water salvaged in New Mexico on the river, Texas shall receive 43 percent and New Mexico 57 percent.*

- *Any water salvaged by beneficial use, but which is not beneficially consumed, shall be apportioned to New Mexico. Any water salvaged in Texas shall go to Texas.*
- *Beneficial consumptive use of unappropriated floodwaters shall go equally to Texas and to New Mexico* (Texas Water Development Board, 2002a).

Litigation between the two states over compliance with the Compact ended in March 1988, and “resulted in the appointment of a Pecos Rivermaster to oversee allocations.” (Texas Water Development Board, 2002a).

Texas’ share of the water of the Pecos River is distributed from Red Bluff Reservoir, located in Texas. The volume is highly variable, but this reservoir has a storage capacity of 300,000 acre-feet to serve permits with a total volume of 292,500 acre-feet. In 1996, the latest year for which data is available, 58,960 acre-feet were delivered to irrigators in Loving and Reeves Counties in Texas. (Texas Water Development Board, 2002b).

Allocating the water of the Rio Grande/Rio Bravo Downstream of Fort Quitman, Texas

Mexico and the United States established the International Boundary Commission, composed of a Mexican and United States Section, through a Convention dated March 1, 1889. The Commission was originally created to settle questions of boundary jurisdiction, especially when the border rivers (principally the Colorado and the Rio Grande/Rio Bravo) changed their courses. The name was changed to the International Boundary and Water Commission (IBWC) in the 1944 Treaty between the United States and Mexico, with the Sections of the IBWC being headed by an Engineer Commissioner. The United States Department of State and the Secretariat of Foreign Relations of Mexico parts of the IBWC are headquartered, respectively, in El Paso, Texas and Juarez, Chihuahua.

The water of the Rio Grande/Rio Bravo in the 89-mile boundary reach from El Paso, Texas downstream to Fort Quitman, Texas, was allocated in the Convention of May 21, 1906, with Ciudad Juarez, in the Mexican state of Chihuahua, receiving 60,000 acre-feet annually. Elephant Butte Reservoir was subsequently constructed in New Mexico, at U.S. expense, to guarantee this water allocation, and to provide irrigation water in New Mexico and Texas. Flood control, straightening of the channel, and bank stabilization to prevent erosion along a 155-mile reach of the river through the El Paso-Juarez Valley, was accomplished under a February 1, 1933, Convention.

Major allocations of the waters of the Rio Grande/Rio Bravo were prescribed in the “United States – Mexico Treaty for Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande,” signed in February 3, 1944, and effective as of November 8, 1945. Under this Treaty, the United States must deliver at least 1.5 million acre-feet annually from the Colorado River to Mexico.

In allocating the waters of the Rio Grande/Rio Bravo below Fort Quitman, Texas, the 1944 Treaty provides that:

- *One-third of the flow reaching the main channel of the Rio Grande/Rio Bravo from the Conchos, San Diego, San Rodrigo, Escondido and Salado Rivers and the Las Vecas Arroyo, provided that this third shall not be less, as an average amount in cycles of five consecutive years, than 350,000 acre-feet (431,721,000 m³) annually...*
- *The United States shall not acquire any right by the use of the waters of the tributaries named in this subparagraph, in excess of the said 350,000 acre-feet (431,721,000 m³) annually, except the right to use one-third of the flow reaching the Rio Grande/Rio Bravo from said tributaries, although such one-third may be in excess of that amount.*
- *In the even of extraordinary drought or serious accident to the hydraulic systems on the measured Mexican tributaries, making it difficult for Mexico to make available the run-off of 350,000 acre-feet (431,721,000 m³) annually.... allotted in subparagraph (c) of paragraph B of this Article to the United States as the minimum contribution from the aforesaid Mexican tributaries....any deficiencies existing at the end of the aforesaid five-year cycle shall be made up in the following five-year cycle with water from the said measured tributaries. (International Boundary and Water Commission, 1944).*

Nowhere in the Treaty is there a definition of the term, “extraordinary drought.”

Article 5 of the Treaty allows the two countries to construct dams on the river, with the following condition in Article 4:

Whenever the conservation capacities assigned to the United States in at least two of the major international reservoirs, including the highest major reservoir, are filled with waters belonging to the United States, a cycle of five years shall be considered as terminated and all debits fully paid, whereupon a new five-year cycle shall commence. (International Boundary and Water Commission, 1994).

IBWC Minute No. 234 identified October 1, 1953, as the beginning date for the five-year accounting periods for water deliveries from the six named Mexican tributaries, and provided the method for repayment of any delivery deficits from the Mexican tributaries, as follows:

That in the event of a deficiency in a cycle of five consecutive years in the minimum amount of water allotted to the United States from the said tributaries, the deficiency shall be made up in the following five-year cycle, together with any quantity of water which is needed to avoid a deficiency in the aforesaid following cycle, by one or a combination of the following means:

- a. *With water of that portion of the said tributary contributions to the Rio Grande allotted to the United States in excess of the minimum quantity guaranteed by the Water Treaty.*
- b. *With water of that portion of said tributary contributions to the Rio Grande/Rio Bravo allotted to Mexico, when Mexico gives advance notice to the United States and the United States is able to conserve such waters; and*
- c. *By transfer of Mexican waters in storage in the major international reservoirs, as determined by the Commission, provided that at the time of the transfer, United States storage capacity is available to conserve them.*

A provision of the 1944 Treaty committed the two countries to solve border sanitation problems. IBWC Minute No. 261, titled "Recommendations for the Solution of the Border Sanitation Problems" was signed September 24, 1979.

Current (October, 2002) Status of Delivery of Mexican Tributary Waters to the United States pursuant to the Treaty of 1944

The United States has consistently delivered at least 1.5 million acre-feet annually from the Colorado River to Mexico in compliance with the Treaty. Delivery of water from the six Mexican tributaries of the Rio Grande/Rio Bravo for use in the United States pursuant to the Treaty, however, has been uneven. At the end of the first five-year cycle (1953-1958), there was a Mexican water deficit of 476,461 acre-feet, which was rectified during the next five-year cycle, 1968-1973. (International Boundary and Water Commission, 2002). Minute 234 declared that deliveries to the United States satisfied the Treaty requirements to September 30, 1968. The third five-year cycle ended with a surplus in excess of required deliveries, and with Falcon and Amistad "conservation capacities assigned to the United States" in these two reservoirs "filled with waters belonging to the United States". A similar condition as of October 2, 1992 erased all prior deficits to the United States (Texas Water Development Board, 2002c).

During the period between October 1, 1992 and September 30, 1997, Mexico delivered 726,151 acre-feet of water toward fulfillment of its obligation under Article 4, Paragraph B of the Treaty. This resulted in a deficit of 1,023,849 acre-feet of water owed to the United States from that cycle (Texas Water Development Board, 2002c). Subsequent negotiations 1998, 1999 and 2000 to increase water deliveries from Mexico to the Rio Grande/Rio Bravo were unsuccessful, because Mexico generally claimed "extraordinary drought" in the six tributaries under Article 4 of the 1944 Treaty. This claim would allow Mexico to make up the 1992-1997 deficit in the "following five-year cycle" (1997-2002) (Texas Water Development Board, 2002c). During this same period, the lower Rio Grande Valley in both countries was experiencing serious drought conditions.

From October 1, 1997, through September 30, 2000, Mexico had delivered 407,087 acre-feet, but still retained water in storage in its Rio Conchos reservoirs. There was a total water deficit owed by Mexico to the United States of 1,381,362 acre-feet as of the end of the third year of this five-year cycle (1997-2002). Despite negotiations, including Minute 307 signed on March 16, 2001, the fourth year of the 1997-2002 five-year cycle ended with a water deficit of 1,303,819 acre-feet still owed by Mexico to the United States (Texas Water Development Board, 2002c). Water deficits for the 1992-1997 cycle and the water years (October 1, though September 30) from 1997 through April 6, 2002, are shown in Table 2. The United States Secretary of State Colin Powell subsequently "raised the issue" with Mexican Foreign Secretary Jorge Castaneda on September 30, 2002, at a Washington, D.C. meeting. The U.S. Department of State also issued a "public reminder" to Mexico on October 2, 2002 of its Treaty obligation. At the close of the 1997-2002 cycle, the total water deficit owed by Mexico to the United States was approximately by 1.5 million acre-feet (Dallas Morning News, 2002).

During 2002, Rio Grande/Rio Bravo irrigators on both sides of the boundary have continued to suffer from the water deficits. Farmers on both sides of the river also have complained, with demonstrations occurring at various border crossings. Although the President of Mexico has cancelled several trips to the United States for other reasons, the issue of water deliveries owed under the 1944 Treaty has been on the discussion agendas. Various state and federal political leaders in Mexico and the United States also have joined the fray. A history of this evolving issue is provided by the Texas Center for Policy Studies (2002a).

Table 2. Current Five-Year Cycle Water Deliveries and Accumulated Deficits, Pursuant to the Treaty of 1944 (Oct. 3, 1977 – Apr. 6, 2002; expressed in acre-feet)

| Period | Treaty tributaries | Unmeasured tributaries | Storage transfer | Total | Accumulated total | Accumulated deficit |
|-------------------------------|--------------------|------------------------|------------------|---------|-------------------|---------------------|
| Oct. 3, 1992 – Oct. 2, 1997 | 726,151 | | | 726,151 | 726,151 | 1,023,849 |
| Oct. 1, 1997 – Sept. 30, 1998 | 120,283 | | | 120,283 | 120,283 | 1,253,564 |
| Oct. 1, 1998 – Sept. 30, 1999 | 165,117 | | | 165,117 | 285,400 | 1,438,447 |
| Oct. 1, 1999 – Sept. 30, 2000 | 105,720 | 163,547 | 137,821 | 407,088 | 692,485 | 1,381,362 |
| Oct. 1, 2000 – Sept. 30, 2001 | 125,376 | 302,168 | 0 | 427,544 | 1,120,032 | 1,303,819 |
| Oct. 1 – Apr. 6, 2002 | 7,912 | 0 | 0 | 7,912 | 1,127,944 | 1,476,181 |

Source: International Boundary and Water Commission (2002).

Diverse Water Rights Systems in the United States and Mexico

All users of Rio Grande/Rio Bravo water must have permits from some governmental agency to legally divert and use it. The exercise of these rights also determines the quantity and quality of water available downstream for other users in other states or nations. Because these rights have evolved differently in the several jurisdictions, an understanding of the legal framework for water permit granting and oversight will help readers understand the issues related to the available quantities of water. The subject is complex in each jurisdiction. In the interest of brevity, therefore, only a general description of each system is presented here.

Mexican Water Rights. The legal framework for management of water resources in Mexico is contained in Article 27 of the Mexican Constitution. Most surface and groundwater is owned by the federal government, which issues permits pursuant to a 1992 federal law. Prior authorizations must be registered with the Public Rights Registry to remain in effect. For a permit to be granted subsequent to 1992, the requested quantity must be available, that is, surplus to total previously-granted permits. However, the technical analyses of water availability and complete recording of outstanding permit quantities have not been conducted. In times of water supply shortages in a basin or groundwater aquifer, therefore, all permit holders may have their permitted quantities reduced by the same percentage. The statute grants the federal government wide discretion in these circumstances. Irrigation districts are generally established by presidential decree. Districts are often operated by user associations, which also hold the water rights (Kelly, 2001).

Texas Water Rights. In the United States, water management is performed by state governments. There are no federal water rights, except those granted by a state, or those secured for performance of a particular function or installation. There also are Indian Water Rights for native American reservations or lands; these rights are a federal responsibility.

For surface water, Texas applies the “appropriative water rights” system generally in use in some form in the twelve western U.S. states. All surface water is owned by the state, but may be granted to permit applicants for beneficial use. Permits have a chronological priority order, the “first in time is first in right”, with the date established by adjudication or by perfecting an application. The permits specify the allowed water allocations and the water withdrawal points, and normally are granted in perpetuity. The second maxim in prior appropriation law is “use it or lose it.” A permit theoretically may be cancelled or reduced if it is not fully exercised within a certain time span. In fact, no permits have been involuntarily cancelled for non use for a very long time.

While this is the system generally applied elsewhere in Texas, the water rights in the Texas portion of the Rio Grande Valley below Amistad Reservoir were established in a court judgment (*State of Texas vs. Hidalgo County Water Control and Improvement District No. 18 et al.*; 443 SW2d 728, 1969). The Appeals Court in this instance declined to apply the “first in time is first in right” principle. Instead, it established two classes of rights holders: (1) “those based on legally executed claims and permits of any type as established by [prior] statute, and (2) those awarded on the basis of good faith use,” which the court terms “equitable” rights. After reserving 60,000 acre-feet of storage space in Falcon Reservoir for municipalities and other domestic users, 155,000 acre-feet in annual water rights were granted to municipal, industrial and domestic users (Texas Water Development Board, 2002c). Class A irrigation rights holders were allocated 1.7 times more water than Class B irrigation users. In the event of a shortage, all irrigation rights holders are subject to percentage reductions, whereas municipalities begin each year with their full allocations available (Hurlbut, 1999).

During the litigation, the court appointed a Watermaster to administer water distribution under the Judge's direction until the litigation ended. This position and function were transferred to the Texas water rights administrative agency once the final decision was rendered. When the Amistad Reservoir was subsequently completed, the agency established a Deputy Watermaster to administer water rights between Amistad and Falcon Reservoirs.

Texas groundwater law was established by its Supreme Court in *Houston & Central Texas Railway Co. vs. East* (81SW. ZD279, 1904). The court's reasoning was taken from an 1843 ruling in a British Court (*Acton vs. Blundell*, 12 Meeson & Welsby 324, 152 Eng. Rep. 1223, 1843).

Another precedent was a case in Ohio, *Frazier vs. Brown* (12 Ohio St. 294, 1861). The concept has been named the "English rule," "the rule of capture," "the rule of the largest pump," or "the rule of absolute ownership." In its purest form, no permit is required to drill a well and pump water. Furthermore, the well owner can pump as much water as he wishes, so long as he doesn't waste it, even if the pumping dries up his neighbors' wells. The rule is applicable only to "percolating" groundwater; it does not apply to underground streams or the underflow along surface water courses.

The "rule of capture" has gradually been modified through the creation of groundwater districts, which can restrict pumping, as authorized by the district's charter. Such districts, however, have little impact in the U.S. portion of the lower Rio Grande/Rio Bravo Valley.

New Mexico and Colorado Water Rights. For New Mexico and Colorado, both states have their individualized forms of the appropriative rights system applicable to both surface and groundwater (Henebrey, 1999; Hurlbut, 1999).

Framework for a Binational Rio Grande/Rio Bravo Drainage Basin Plan for Sustainable Water Use

The current shortage (November, 2002) in deliveries from the Mexican tributaries is not an isolated, one-time event. The continuing population growth along both sides of the Rio Grande/Rio Bravo has resulted in increasing water demands on this finite water source. There have been many years in which the river was unable to meet all the demands placed on it. Anticipated future growth along the border, with predictable intermittent drought suggests that the water shortages in the basin will worsen over time. There are measures and actions that can be taken over time to address the problems in a comprehensive manner, as well as a series of interim actions that could be considered.

Long-term Measures and Actions. There are two primary ways to increase the available water supplies over the long term, including (1) redistributing, or using the existing water supplies more efficiently, and/or (2) increasing the supply of water.

Binational cooperation is essential to finding a long-term solution to this problem. Crises demand bold steps, and the fate of Rio Grande/Rio Bravo drainage basin inhabitants is worthy of heroic efforts. The United States faced a similar situation, for example, with continuing depletion of the Ogallala Aquifer, which underlies parts of the states of Texas, New Mexico, Oklahoma, Kansas, Colorado and Nebraska. To analyze the problem and seek solutions, the U.S. Congress established the "Six State High Plains Ogallala Aquifer Regional Resources Study," under the direction of the U.S. Secretary of Commerce, acting through the Economic Development Administration (EDA). A High Plains Council was established, consisting of the governors of the six states and the EDA, with the chair rotating among the states. A Liaison Committee, with one member from each state, chaired by a Council member, interacted with the chosen contractor on behalf of the Council. The contractor (actually a consortium of consulting firms) established a Technical Consulting Panel, consisting of national and international experts in the various disciplines necessary for the study (High Plains Associates, 1982). The results of this effort defused a heated controversy over the use of the Ogallala Aquifer, and provided a means to enlighten all parties as to the facts and realities. We propose a similar effort for the Rio Grande/Rio Bravo.

The Presidents of the two countries should name an outstanding and experienced water professional, who will alternate as chair of the planning effort. The two Presidents will then determine, separately, which federal agencies in their respective countries will be represented on a technical advisory group. Each of the governors of the states in the Rio Grande/Rio Bravo drainage basin could name a representative to a technical advisory group. These two individuals, in consultation with their respective Governors, could select representatives to act as expert technical advisors to each of the state's designated representatives. There would be two tiers of technical advisors, including those from the federal agencies in both countries, and one each from each affected state within the two countries. Further, each state representative would have a technical advisory group for its member on the advisory group. In selecting representatives, care must be exercised to select appointees who can represent all the groups interested in the use of the waters of the Rio Grande/Rio Bravo, including water planning agencies, environmental groups, non-governmental organizations, irrigators, public interest groups, industries, municipalities, academia, the media, etc. These advisory groups should be as small as possible, consistent with adequate representation.

The first assignment of the Binational chairs and their respective advisory groups would be to formulate a procedure for conducting its affairs, including hiring staff and contracting with professional and academic consultants. The resulting work plan should address, as a minimum, the following water-related elements in the Rio Grande/Rio Bravo Drainage Basin:

- (1) The planning horizon --- one, two and three decades;
- (2) Identification of basin planning areas, if deemed necessary;
- (3) Necessary hydrologic and economic planning criteria;
- (4) Economic forecasts for the planning horizon;
- (5) Population projections for the planning horizon;
- (6) Present and future environmental water needs;
- (7) Present and future municipal water requirements;
- (8) Present and future industrial water requirements;
- (9) Present and future irrigation and agricultural water needs;
- (10) Summary of present and future water requirements for all major water uses;
- (11) Inventory of available freshwater resources
 - (A) Surface water – quantity and quality;
 - (B) Groundwater – quantity and quality;
- (12) Development of an accurate water balance to identify areas of shortages or surpluses;
- (13) Realistic options for meeting water deficits;
- (14) Comprehensive, basin-wide drought management plan;
- (15) State and local water rights issues;
- (16) International water rights issues; and
- (17) Plans for financing measures and actions to overcome water deficits.

The objective should be a plan to use the water of the river more efficiently. The first step should entail an audit of water delivery systems and the application of Water Availability Models to the aquifers and tributaries that feed the Rio Grande/Rio Bravo. Leaks and pilferage of the river's water supply should be located. Major water uses that would benefit the most through the application of water conserving technologies should be identified. Since most water is used for irrigation, efforts to reduce on-farm application will be a focus. Studies in the United States and elsewhere have shown that technologies for increasing irrigation efficiency can reduce water consumed by greater than 25 percent with no decrease in crop yield. Similarly, studies of urban water use have shown that application of more efficient technologies can produce substantial water savings.

Current water planning and development activities typically focus on identifying water supplies for human consumption, and for the industrial and agricultural activities essential to human survival. The water needs for maintaining aquatic ecosystems, minimum instream flows, and freshwater for bays and estuaries, are often omitted or given scant attention in planning efforts. The various current water needs are then extrapolated to account for predicted future ecosystem health, population growth and economic development. The totals are then compared with the total existing water resources. If there is a deficiency between the current water supplies and the future water needs, attention typically focuses on developing new water supplies to address the deficiency, based on the assumption that the existing and potential water supplies are inexhaustible. The primary emphasis often is on developing new water resources, rather than considering optional use of the existing water supplies.

We suggest a radical shift in the existing approach for freshwater resource planning and use. Rather than seeking ever-greater quantities of water necessary to continue the current, and often unnecessarily wasteful, practices, the focus of the Rio Grande/Rio Bravo basin planning process should first be to identify the smallest quantity of water necessary to sustain humans and their economic activities, as well as to maintain the natural environment. To facilitate this fundamental shift in the water planning paradigm, we propose that data from specific climatic regions around the world be compiled, to determine the lowest achievable water use rates for human sustenance, commercial and manufacturing activities, irrigated agriculture, maintenance of important aquatic ecosystems and other uses. Because conservation is the least expensive means of extending available supplies, water uses in the basin should be examined to determine whether the most effective measures are being applied. Basin-wide integrated operations for all Rio Grande/Rio Bravo reservoirs should be developed, to optimize the use of stored surface water and foster integrated use of surface and groundwater. Environmental water needs (e.g., instream, bay and estuary flows) should be documented. Measures to enhance precipitation (e.g., cloud seeding) or to increase groundwater recharge should also be identified. Planning for inevitable drought conditions should be emphasized.

Where appropriate, consumptive water use by exotic or invasive water-consuming plant species should be identified. Flows in the Rio Grande/Rio Bravo also can be increased through watershed brush management and a reduction of riparian phreatophyte vegetation. Strategies should be formulated for identifying the brushlands and stream reaches suitable for application of such methods to determine the water increases that brush and phreatophyte management to those areas can provide.

The resulting reduced water consumption rates from such analyses can provide the basis for establishing reasonable estimates of the *minimum* daily water needs for human sustenance, manufacturing, irrigation and ecosystem maintenance, as the logical approach for determining sustainable water needs for the Rio Grande/ Rio Bravo basin. The objective should be to develop solutions for achieving sustainable freshwater resources for reasonable future needs that are both less costly and friendlier to the environment.

Interim Measures and Actions. There also are several actions, as listed below, that could be taken now to moderate the severity of the current irrigation water shortage in the lower Rio Grande/Rio Bravo basin, as follows:

- (1) The most unpredictable event would be torrential rainfall in the Rio Grande/Rio Bravo basin that filled “the conservation capacities assigned to the United States...with waters belonging to the United States” in both Amistad and Falcon Reservoirs. In that case, “a cycle of five years shall be considered as terminated and all of the debts fully paid, whereupon a new five-year commences,” under Article 4 of the 1944 Treaty. Relief would last only until the next drought.
- (2) Perhaps the most difficult solution for Mexico would be the release of most of the water in storage in the Mexican tributaries of the Rio Grande/Rio Bravo as a gesture of good will. This may be politically impossible for the Mexican government. Texas citizens and political leaders have generated considerable pressure during the 2002 nationwide election campaigns for members of Congress and Texas elective offices. Once generated, this pressure is difficult to deflect and may continue at the Texas and national levels during the new congressional session. The actions that might be taken in Washington, D.C. are unpredictable. At the same time, the issue has clouded resolution of other issues of mutual interest between the two countries, such as the status of Mexican immigrants in the United States.
- (3) There is already some clamor to deduct the deficit in water deliveries due the United States from the Rio Conchos drainage basin in Mexico from the annual deliveries of water from the Colorado River to Mexico required under the 1944 Treaty. As a practical matter, however, determining what to do with the withheld Colorado River water, and deciding where to store it, are not easy questions to resolve. Further, such action would expand the issue to the Colorado River drainage basin states in the United States and Mexico, making a resolution considerably more complicated.
- (4) Where this action has not already been taken, there should be an immediate end to granting permits for irrigation in the entire Rio Grande/Rio Bravo drainage basin by the federal government in Mexico, and the states of Texas, New Mexico and Colorado in the United States. Along the Rio Grande/Rio Bravo in Texas, approximately 85% of Texas’ diversions from the river are used for irrigation (Hurlbut, 1999). In the Rio Conchos basin in Mexico, 90% of the diverted water is used for irrigation (Kelly, 2001b). It is evident from these figures that most of the surface water in the Rio Grande/Rio Bravo drainage basin is used for irrigation.

Shorn of the international, national and state ramifications of the situation, resolution of the dispute over the current U.S.-claimed deficit will determine whether irrigators in Texas or those in Mexico will be able to continue to irrigate, and which ones in each country will get water. These two groups should take the initiative, through their respective irrigation district officials, to begin meetings now to minimize friction, better understand each other’s needs, exchange information and perhaps, eventually, develop a framework for a solution that would be mutually beneficial.

- (5) Both countries, using international money sources to the maximum extent (e.g., NADBANK), should begin now to pay the costs to increase the efficiency of irrigation conveyance systems and on-farm water application. “In the three major Conchos irrigation districts (Bajo Rio Conchos, Delicias and Rio Florida, about 62% of the canals are lined, and 38% are unlined. Overall efficiency [including conveyance and on-farm distribution] of irrigation system deliveries is 40%” (Texas Center for Policy Studies, 2002b).

Irrigation water conveyance systems in the Texas portion of the lower Rio Grande/Rio Bravo Valley exhibit an efficiency of 64% (Texas Center for Policy Studies, 2002b). An increase to an efficiency of 90% could produce 223,000 acre-feet in water savings. Changes in on-farm irrigation equipments and practices could conserve the most water. The efficiencies of several methods are well developed, ranging from 40-60% with furrow irrigation, to 96-98% with drip irrigation and low energy precision application (LEPA).

Tillage practices determine soil moisture retention. Savings of 20-40% of all water currently applied to crops in the Rio Grande/Rio Bravo drainage basin could be realized with more efficient methods and equipment. Conservation of such water quantities would seem to make the necessary expenditure worthwhile.

Conflicts over the distribution of such conserved water, however, are likely. Environmental water requirements should have a high priority. Repayment of the Rio Conchos basin water deficits is obviously necessary. In anticipation of beneficial results of irrigation conservation, the two countries should decide as soon as possible how the water savings to be realized with such measures will be allocated.

- (6) Because Article 4 of the 1944 Treaty allows Mexico to suspend delivery of 350,000 acre-feet annually when there is an “extraordinary drought”, on the tributaries in Mexico, the two countries should agree on a definition of “extraordinary drought.” An accepted definition of that condition is essential to United States and Mexican agreement about such a water delivery suspension. Unfortunately, the Treaty itself contains no definition. After examining “water management

literature and laws in the 1980's", two authors "found about 150 definitions of drought." They broadly characterize them as follows:

- *Meteorological drought* -- in which rainfall is below a chosen benchmark level;
- *Hydrological drought* -- in which reservoir levels, water tables, river flow, or some other normally measurable aspect of the hydrological cycle drops far below a normal level;
- *Agricultural drought* -- in which water (from any source) is insufficient to meet the demands of the region's most important crops; and
- *Socioeconomic drought* -- in which available water supplies are insufficient to sustain current levels of municipal consumption, irrigation, and industrial output. (Wilhite and Glantz, 1985).

The Palmer Drought Severity Index (PDSI) developed in 1965 is used in the United States more than any other calculation method, to reflect five degrees of drought from "Incipient dry spell" to "Extreme drought" (Wilhite and Glantz, 1985).

According to the PDSI for Texas, as of June 22, 2002, the Trans-Texas region and the lower Rio Grande/Rio Bravo Valley were characterized as suffering "severe" or "extreme" drought. Mexico claims (1) justification for non delivery of 1 million acre feet for the 1992-1997 period because the area of the Mexican tributaries were undergoing "extraordinary drought;" and (2) that this deficiency was met in May 2000, and that the current 1.6 million acre-foot water deficit for the 1997-2002 period can be fulfilled during the 2002-2007 five-year cycle period (Texas Center for Policy Studies, 2002b).

- (7) The United States and Mexico could begin now to re-negotiate the 1944 Treaty, since its provisions, and the limitations of the IBWC, have proved inadequate to resolve unmet water deliveries during droughts. Such a course of action would probably also include a reexamination of the Treaty provisions governing the Colorado River, as well as the Rio Grande/Rio Bravo. The process would undoubtedly be long and tedious, with many pitfalls. Nevertheless, given the potential benefits of a more equitable and sustainable distribution and delivery of the water resources of this important international river system, this prospect of renegotiation of the 1944 Treaty deserves consideration by the governments of the two countries.

Conclusions

The present conflict involving the Rio Grande/Rio Bravo begs for speedy and amicable resolution. The longer the problem persists, the more difficult it will be to develop a mutually-beneficial solution to it. Although rainfall in the near future may temporarily alleviate the problems, the continuing, and unpredictable, drought situations that characterize this geographic area clearly point out that an agreeable, long-term solution to this problem is in the benefit of both countries. This situation also can negatively impact the estuarine system into which the Rio Grande/Rio Bravo ultimately drains. It is the hope that the analysis and guidance provided in this paper will be useful to those charged with addressing such difficult problems.

Disclaimer: *The conclusions and recommendations presented in this report are those of the authors alone, and do not necessarily represent the official opinions or policies of Southwest Texas State University or the Texas Parks and Wildlife Department.*

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