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Documentation and Testing of the WEAP Model for the Rio Grande/Bravo Basin

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ABSTRACT

The Rio Grande/Bravo basin is located in North America between two riparian nations, the United States (U.S.) and Mexico. This river is currently considered a water scarce area with less then 500 m^3 per person per year of water available. Throughout the decades there has been a lot of population growth in the basin, with population expected to double over the next three decades.

The Physical Assessment Project promotes regional cooperation between the U.S. and Mexico to work towards more effectively managing the Rio Grande/Bravo's resources. This report falls under Task 3 of the project by documenting and testing the basin-wide model constructed Using WEAP software.

The documentation of the model addresses all of the inputs for demands and supplies for the river. The model is also set up to include operating polices of the different countries and how they each allocate water to their demands. The supplies in the model include tributary inflows, as well as reservoir and groundwater storage.

This report is the first of many testing phases. The two items that were evaluated here, by comparing them against historical records, were the reservoir storage volumes and the streamflow for six International Boundary Water Commission (IBWC) gages. This testing demonstrated that the model has the right logic and flow pattern, however adjustments need to be made to the reservoir releases in order to fully represent the existing system.

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1. INTRODUCTION

The Rio Grande/Bravo basin is located in North America along the boarder of the United States (U.S.) and Mexico. This region is considered one of the most water stressed areas in the world with less then 500 m^3 of water available per person per year as of 2001 (Figure 1). The water stress indexes are shown in Table 1.

Table 1: Water Stress Indexes (Giordono and Wolf 2002)

Term	Amount of Water	Results
Relative sufficiency	> 1700 m^3 /person/year	
Water stress	< 1700 m^3 /person/year	intermittent, localised shortages of freshwater
Water scarcity	< 1000 m^3 /person/year	chronic and widespread freshwater problems
Absolute scarcity	< 500 m^3 /person/year	

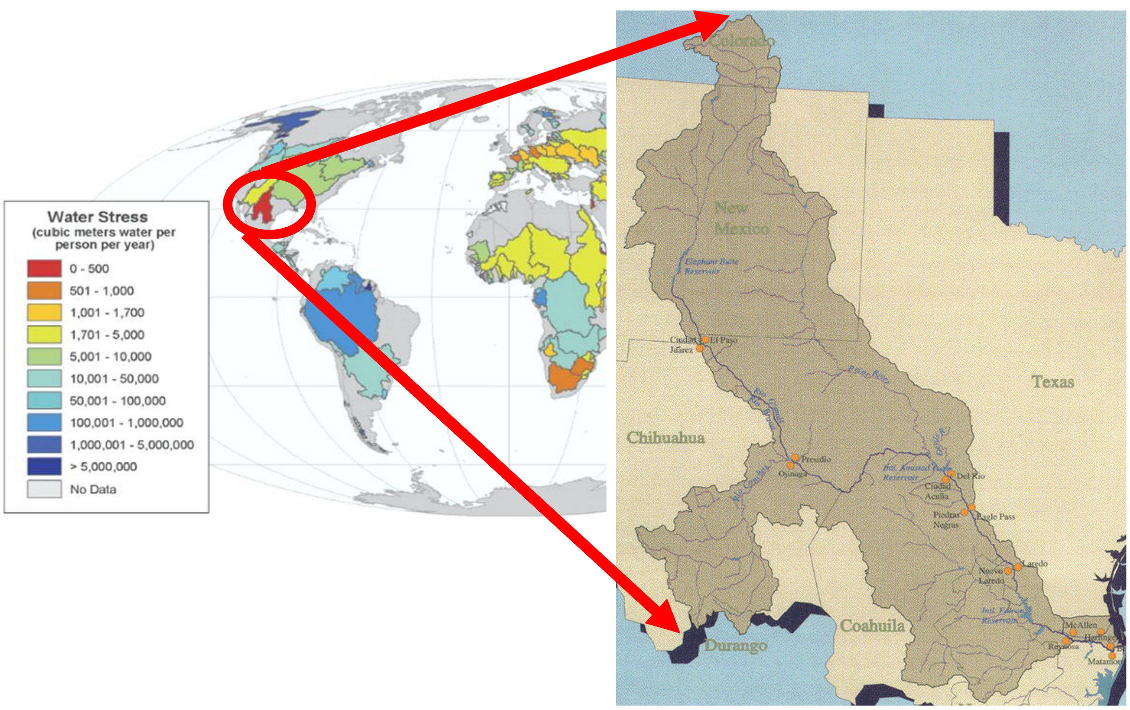


Figure 1: Global Water Stress and location of the Rio Grande basin
(Source: Stress - www.transboundarywaters.orst.edu; Rio Grande diagram - www.rioweb.org)

This river forms a binational border and international agreements have been in place since the formation of the International Boundary and Water Commission (IBWC) in 1889. The 1944 Water Treaty between the U.S. and Mexico established water allocations for both the Colorado River and the Rio Grande/Bravo. The treaty states, generally, that 432.7 million cubic meters

(MCM) (350,000 acre-feet) of water must be provided by Mexico as an annual average over a five year period below the confluence with the Rio Conchos (IBWC 1944).

The headwaters of the Rio Grande/Bravo are located in Colorado and the river flows southeast towards the Gulf of Mexico as shown in Figure 2 encompassing a total area of 555,000 km^2 with 228,000 km^2 in Mexico and 327,000 km^2 in the U.S.

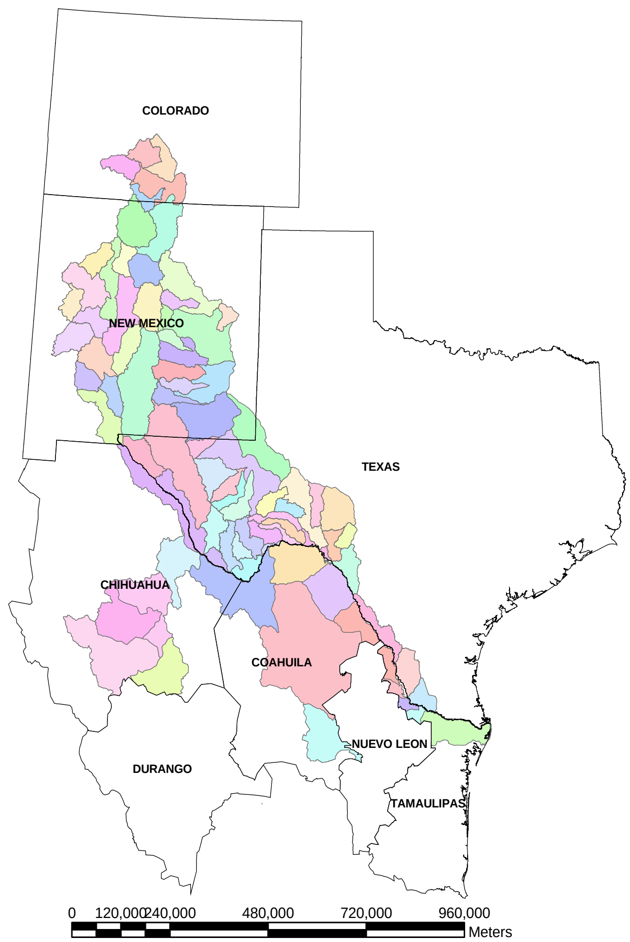


Figure 2: Rio Grande/Bravo Basin (McKinney et al. 2006)

This large river basin is highly stressed by the current population needs and will continue to be stressed because the population (9.73 million in December 2001) is expected to double by 2030 (CRWR 2006a).

This report describes the basin-wide Water Evaluation and Planning System (WEAP) model (SEI 2006) that was constructed to help evaluate stakeholder driven scenarios to more effectively manage these highly stressed water resources. This report also describes the background of the overall project, the WEAP software used for the basin-wide model, documenting the current model inputs, model testing, and then future work.

1.1. Physical Assessment Project Description

This work was conducted in conjunction with the Physical Assessment Project which is attempting to promote regional cooperation and policy development between and among the U.S. and Mexico. Technical assistance under the Physical Assessment Project is provided by both Mexican and U.S. experts and institutional counterparts; the project's steering committee, comprised of universities, non-governmental organizations, and government research institutes in the U.S. and Mexico, is shown in Figure 3.

The overall objective of the Physical Assessment Project is to "examine the hydro-physical opportunities for expanding the beneficial uses of the fixed water supply in the Rio Grande/Bravo to better satisfy an array of possible water management objectives, including meeting currently unmet needs in all sectors (agricultural, urban, and environmental), all segments, and both nations" (CRWR 2006a). The project website address is: www.riogrande-riobravo.org.

Task 3, Construct a Reconnaissance-Level Model at the Basin-Wide Scale, of the Physical Assessment Project is the main focus of this report. In particular, subtasks 3.1, Assembling the WEAP Tool, and 3.3, Refining the WEAP Model (CRWR 2006b). The purpose of this report is to document the current data inputs into the model and initial testing of the model.

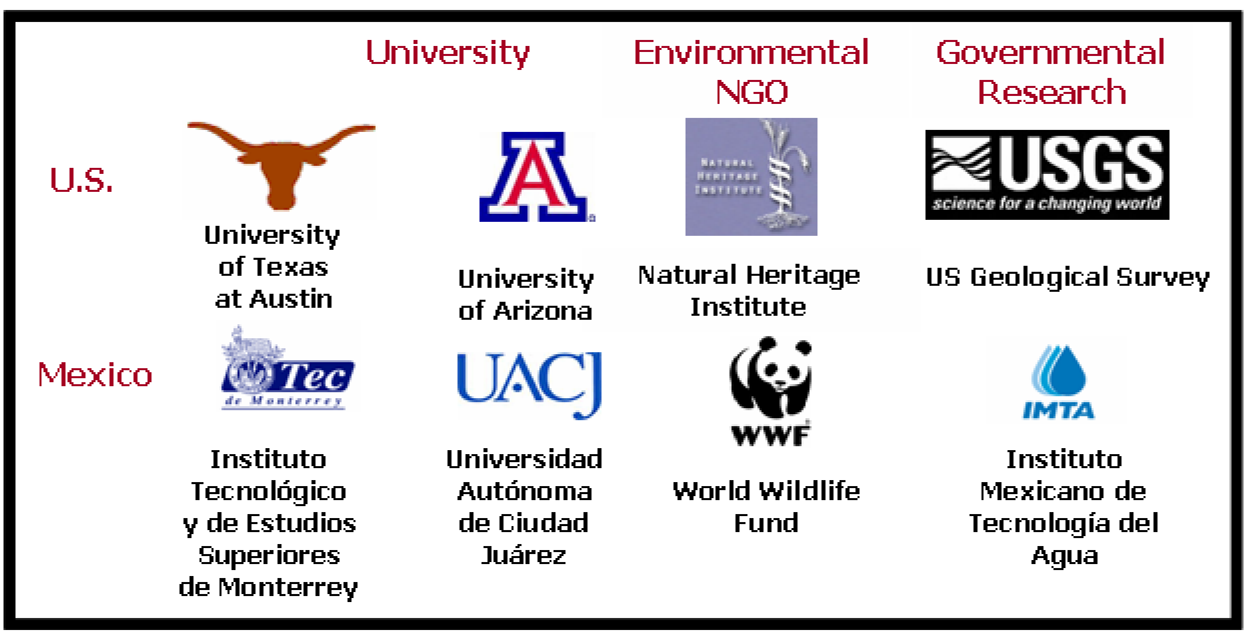


Figure 3: Physical Assessment Project Steering Committee (CRWR 2006a)

1.2. WEAP SOFTWARE

The software used for modeling the water management system of the Rio Grande/Bravo is Water Evaluation and Planning System (WEAP) developed by the Stockholm Environment Institute (SEI 2006). The license fee for this software is waived for academic, governmental, and other non-profit organizations in developing countries, including Mexico. Some of the highlights for using this software are that it has an integrated approach, easily involves stakeholders, Uses a priority-drive water balance methodology, and has ways to implement different scenarios in a friendly interface (Table 2). WEAP software also uses a graphic User interface that imports graphic files from other software systems to help create models, such as geographic information systems (GIS) Shapefiles. The WEAP model schematic generated for the Rio Grande/Bravo is shown in Figure 4. The Physical Assessment Project team has developed WEAP tutorials in Spanish and English for the Rio Conchos basin (Nicolau del Roure and McKinney 2005). These exercises are easy to use, step by step instructions addressing how to construct a WEAP model for this particular basin.

Table 2: WEAP Software Highlights (WEAP 2006)

Integrated Approach	Unique approach for conducting integrated water resources planning assessments
Stakeholder Process	Transparent structure facilitates engagement of diverse stakeholders in an open process
Water Balance	A database maintains water demand and supply information to drive mass balance model on a link-node architecture
Simulation Based	Calculates water demand, supply, runoff, infiltration, crop requirements, flows, and storage, and pollution generation, treatment, discharge and in stream water quality under varying hydrologic and policy scenarios
Policy Scenarios	Evaluates a full range of water development and management options, and takes account of multiple and competing uses of water systems
User-friendly Interface	Graphical drag-and-drop GIS-based interface with flexible model output as maps, charts and tables

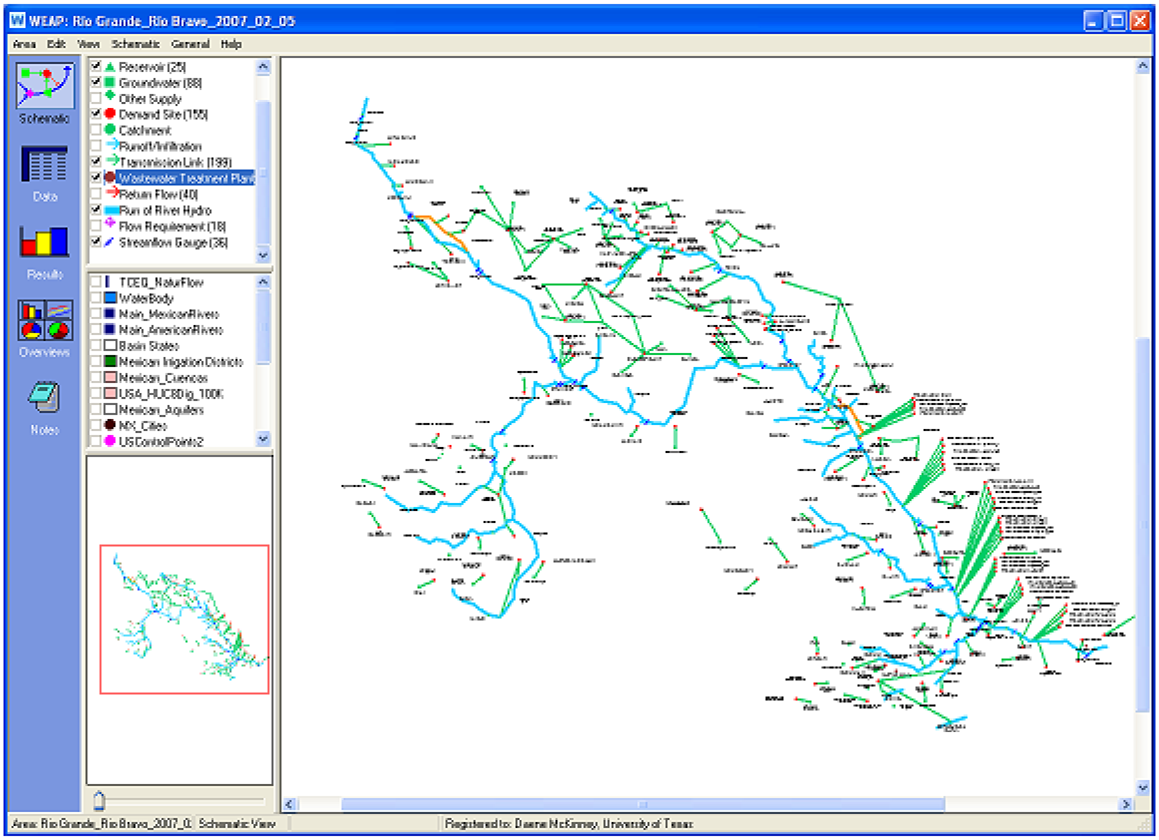


Figure 4: Schematic of the Rio Grande/Bravo WEAP Model

The Rio Grande/Bravo WEAP model utilizes three main screens. The first screen is the Schematic View as shown in Figure 4. This screen enables the User to add nodes, demand sites, transmission links, etc. The second screen is the Data View as shown in Figure 5. There are six main branches to the Data View including Key Assumptions, Demand Sites, Hydrology, Supply and Resources, Water Quality and Other Assumptions. The project is currently working with four of the six branches, Key Assumptions, Demand Sites, Supply and Resources and Water Quality. Each of these areas is further broken down into smaller branches. First, the branches for Key Assumptions are shown in Figure 6 and are currently being used for reservoir operating policies, demand priority levels, treaty requirements and the Texas Watermaster logic. Second, every Demand Site has its own branch as illustrated in Figure 7. Lastly, Supply and Resources is divided into five sub-branches; Linking Demands and Supply, River, Groundwater, Local Reservoirs, and Return Flows as shown in Figure 8. The last screen view used is for results. This screen is used after the model has been run and displays the results graphically or tabular. The model also has a feature where the user can export the results to a comma separated variable (.csv) file or a spreadsheet file.

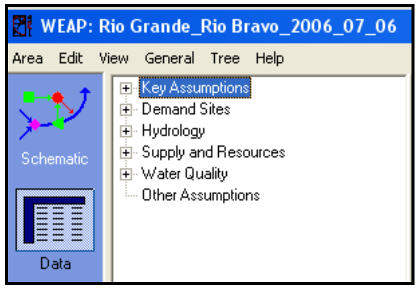


Figure 5: Data View for WEAP

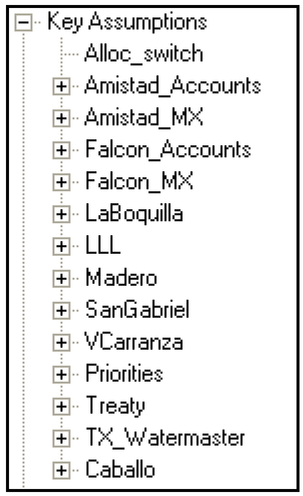


Figure 6: Key Assumptions Branches

Figure 7: Demand Site Branches

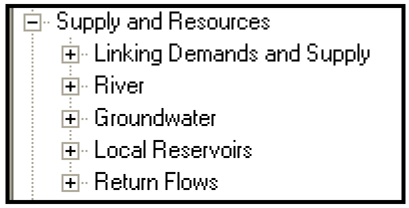


Figure 8: Supply and Resources Branches

2. RIO GRANDE/BRAVO WEAP MODEL

Data for the Rio Grande/Bravo WEAP model have been collected from numerous sources. The main source for data is the Rio Grande/Bravo geodatabase which was created through the cooperation of the Center for Research in Water Resources (CRWR) of the University of Texas at Austin, the Texas Commission on Environmental Quality (TCEQ), Instituto Mexicano de Tecnología del Agua (IMTA), and the Comisión Nacional de Agua (CNA) (Patiño-Gomez and McKinney, 2005). The Rio Grande/Bravo geodatabase is a relational Arc Hydro geodatabase containing geographic, hydrologic, hydraulic and related data for the entire basin. The Rio Grande/Bravo Geodatabase was also used to create the shapefiles for the WEAP model.

Other major sources of data include the Texas Commission on Environmental Quality (TCEQ) Water Availability Model (WAM) and a Rio Grande/Bravo model developed with the software Oasis by Tate (2002).

2.1. WEAP MODEL GEOGRAPHY

The Rio Grande/Bravo WEAP model includes the main stem of the Rio Grande/Bravo from the USGS gage at San Marcial, above Elephant Butte reservoir in New Mexico, to the Gulf of Mexico. The main tributaries on the U.S. side include the Pecos and Devils Rivers and Alamito, Terlingua, San Felipe and Pinto Creeks. The main tributaries on the Mexican side include the Rio Conchos and its tributaries, Rio San Diego, Rio San Rodrigo, Rio Escondido, Rio Salado, Rio San Juan, Rio Alamo and Arroyo Las Vacas (Figure 9). For analysis, this document divides the basin into five sections; Upper, Rio Conchos, Pecos, Middle and Lower subbasins.

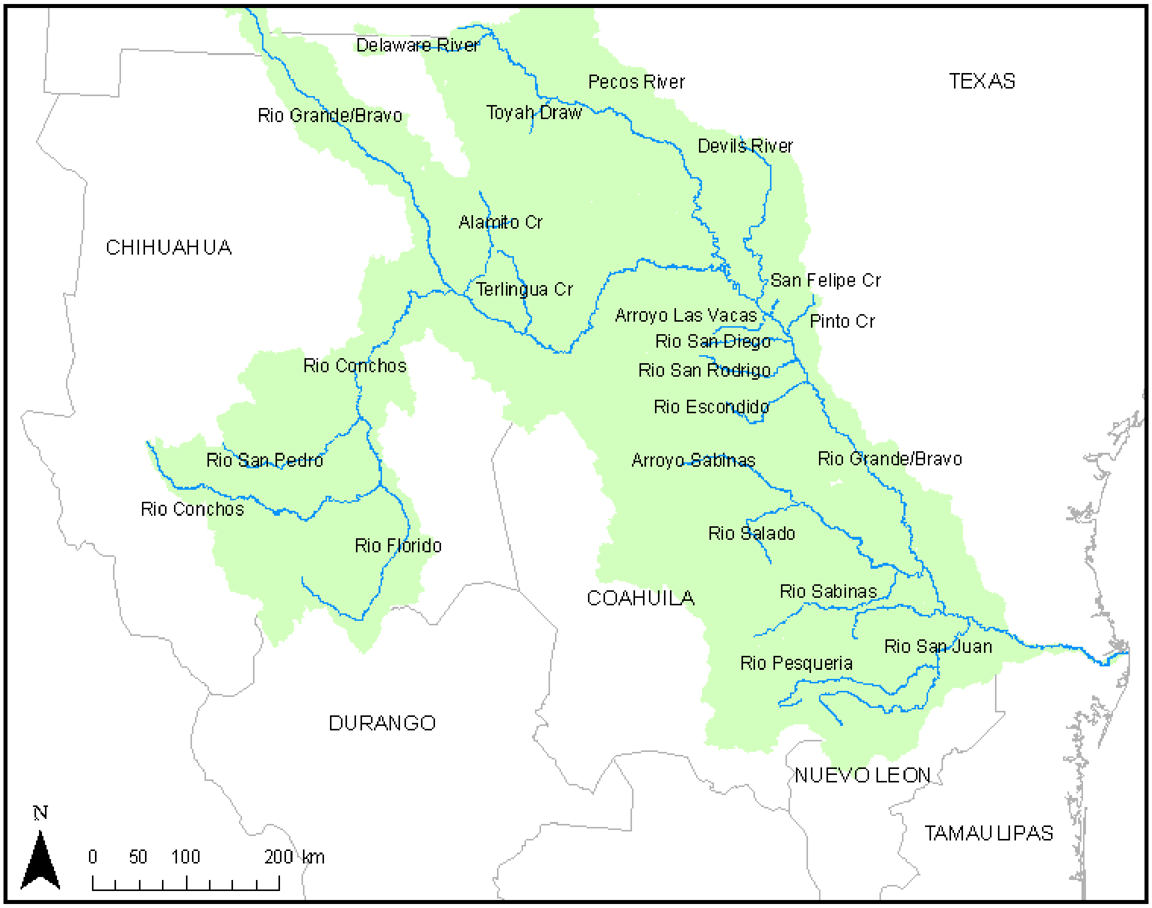


Figure 9: Main Tributaries of the Rio Grande/Bravo included in the WEAP Model

The Upper subbasin includes the main stem of the Rio Grande/Bravo from Elephant Butte Reservoir to above the confluence of the Rio Conchos (Appendix A). This section of the basin is located in the U.S. states of New Mexico and Texas and the Mexican state of Chihuahua. The two major reservoirs are Elephant Butte and Caballo.

The Rio Conchos subbasin contains the Rio Conchos and its main tributaries which lie in the Mexican state of Chihuahua and a small portion of Durango State (Appendix A). This section is the key for Mexico to meet its obligations under the 1944 Treaty. The two main tributaries for the Rio Conchos are the Rio Florido and the Rio San Pedro. The four main reservoirs in this subbasin are San Gabriel, La Boquillla, Francisco Madero and Luis L. Leon.

The Pecos River subbasin, in the U.S. states of New Mexico and Texas (Appendix A) encompasses the Pecos River beginning at the Texas – New Mexico border to the confluence with the Rio Grande/Bravo. This basin includes them main tributaries including The Delaware River and Toyah Creek. The main reservoir in this subbasin is Red Bluff.

The Middle Rio Grande/Bravo subbasin extends from the confluence of the Rio Conchos to the outflow of Amistad International Dam (Appendix A) and forms the border between the U.S. state of Texas and the Mexican states of Chihuahua and Coahuila.

The Lower Rio Grande/Bravo subbasin extends from the inflow of Amistad International Dam to the inflow into the Gulf of Mexico and also forms the border between Texas and the Mexican states of Coahuila, Nuevo Leon and Tamaulipas (Appendix A). There are four reservoirs of interest in this section including, Falcon International Dam, V. Carranza, and El Cuchillo. The V. Carranza reservoir is located on the Rio Salado tributary and El Cuchillo reservoir is located on the Rio San Juan.

2.2. STREAMFLOW DATA

The Rio Grande/Bravo WEAP model utilizes naturalized streamflow flow and channel loss data from the Texas Commission on Environmental Quality (TCEQ) Water Availability Modeling (WAM) project (Appendix B and Brandes, 2003). Naturalized flows are calculated to represent historical streamflow in a river basin in the absence of human development and water use. A series of monthly naturalized flows were calculated for the Rio Grande/Bravo basin from El Paso to the Gulf of Mexico and along the major tributaries of the Pecos River and the Rio Conchos (Brandes, 2003).

Naturalized flows are used in the Rio Grande/Bravo WEAP model as input for both headflows and incremental flows. In the model, headflows are specified for 21 rivers and creeks (Figure 10). Incremental flows were calculated for 22 sites in the model to represent unaccounted gains along stream reaches (Figure 11). These incremental flows for various reaches in the model were calculated by taking the difference between the naturalized flows at an upstream gage and the naturalized flow at the corresponding downstream gage multiplied by the loss factor for the reach. A detailed description of the calculations for both naturalized flows and incremental flows are included in Appendix B.

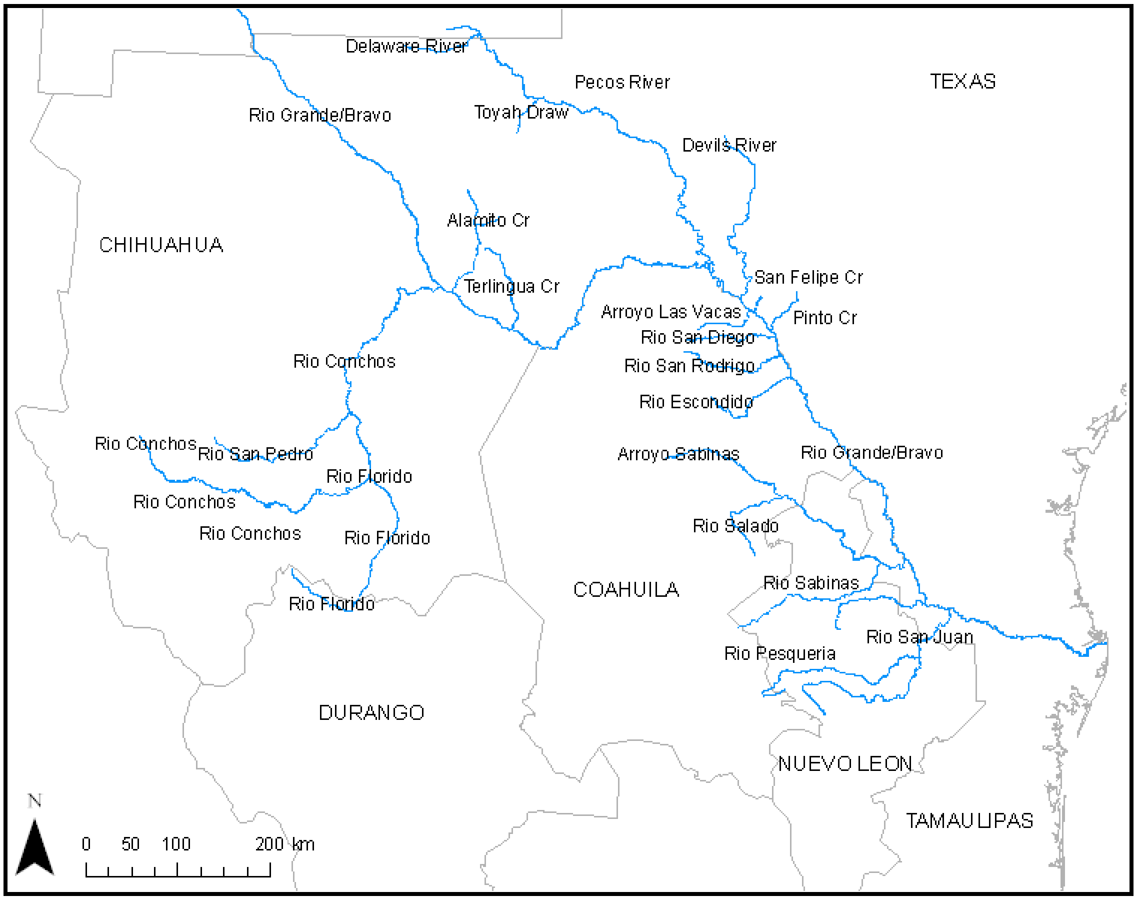
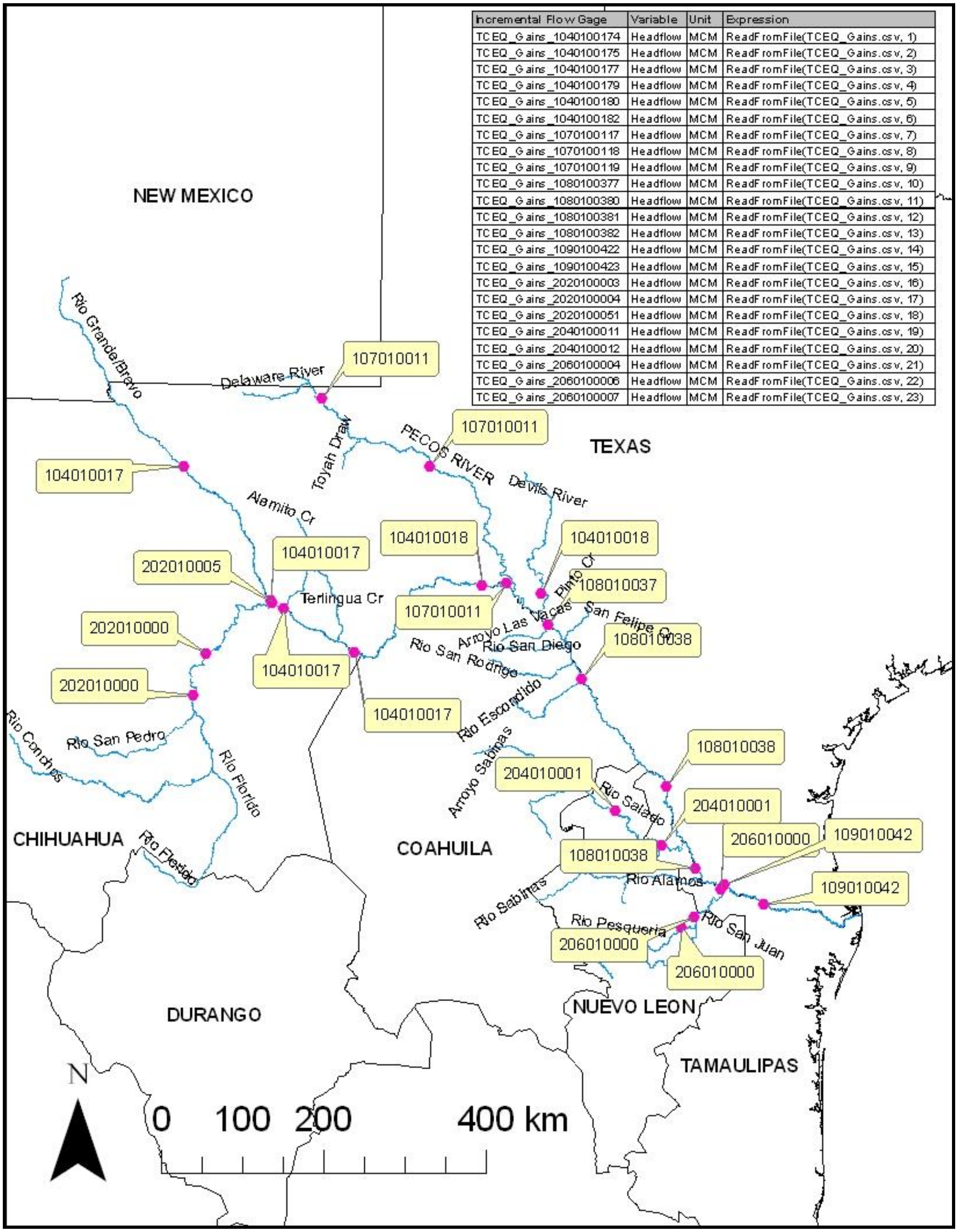


Figure 10: Rivers with TCEQ Naturalized Headflow for the WEAP Model



Incremental Flow Gage	Variable	Unit	Expression
TCEQ_Gains_1040100174	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 1)
TCEQ_Gains_1040100175	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 2)
TCEQ_Gains_1040100177	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 3)
TCEQ_Gains_1040100179	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 4)
TCEQ_Gains_1040100180	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 5)
TCEQ_Gains_1040100182	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 6)
TCEQ_Gains_1070100117	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 7)
TCEQ_Gains_1070100118	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 8)
TCEQ_Gains_1070100119	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 9)
TCEQ_Gains_1080100377	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 10)
TCEQ_Gains_1080100380	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 11)
TCEQ_Gains_1080100381	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 12)
TCEQ_Gains_1080100382	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 13)
TCEQ_Gains_1090100422	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 14)
TCEQ_Gains_1090100423	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 15)
TCEQ_Gains_2020100003	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 16)
TCEQ_Gains_2020100004	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 17)
TCEQ_Gains_2020100051	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 18)
TCEQ_Gains_2040100011	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 19)
TCEQ_Gains_2040100012	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 20)
TCEQ_Gains_2060100004	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 21)
TCEQ_Gains_2060100006	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 22)
TCEQ_Gains_2060100007	Headflow	MCM	ReadFromFile(TCEQ_Gains.csv, 23)

Figure 11: Incremental Inflows from TCEQ Naturalized Flows

2.2.1. *Special Streamflow Considerations*

Some areas of the model utilize streamflow which is not derived from the TCEQ naturalized flows. An inflow named Mesilla Inflow was created in New Mexico on the mainstem of the Rio Grande/Bravo. This inflow was created to represent the difference between return flows and diversions at the Mesilla Diversion. The Mesilla diversion is discussed further in Section 2.4. According to the IBWC DEIS Figure 3-3 (Appendix C), the return flows are greater than the diversions at the Mesilla Diversion for the months of November - February. To account for this inflow, a stream segment was created and this difference was specified as a headflow.

The municipal demand for Monterrey (demand - Metropolitan Monterrey) utilizes the reservoir La Boca (Rodriguez Gomez) as a surface water source. However, La Boca reservoir is located on a tributary of the Rio San Juan that does not have a calculated naturalized headflow. To include this reservoir in the system a river segment was created that is not connected to the Rio San Juan. This segment was created to provide inflow into La Boca so that the demand from Metropolitan Monterrey would not drain the reservoir. This segment was not connect to the Rio San Juan because the tributary flow is already accounted for in the incremental flows calculated from the naturalized flows and connecting this segment would double count this tributary and contribute too much water to the Rio San Juan. The historical inflows to La Boca were obtained from the Rio Grande/Bravo geodatabase (Patiño-Gomez and McKinney, 2005).

In addition to La Boca, Monterrey utilizes water from the reservoir Cerro Prieto. However, unlike La Boca, Cerro Prieto reservoir is located outside of the Rio Grande/Bravo basin. The rivers that provide the inflow to Cerro Prieto, Rios Pablillo and Camacho, do not contribute any flow to the Rio San Juan or any other tributary to the Rio Grande/Bravo. A stream segment was created to provide inflow into Cerro Prieto. Historical inflow values were obtained from CNA BANDAS database (IMTA 1999).

2.2.2. *Channel Loss Factors*

The last key factor considered for streamflow in the model is any losses that may occur along a reach. All of the losses have been grouped together as a percentage of flow in each reach and entered under the WEAP data branch: *Supply and Resources → River → Reach → Evaporation*. This percentage accounts for: channel losses, evaporative streamflow losses, evapotranspiration (plant uptake), and seepage (Teasley and McKinney 2005). Evaporation is entered for each reach and the loss percentages for each reach are shown Figure 12. Appendix D has a table with the evaporation losses for WEAP by reach.

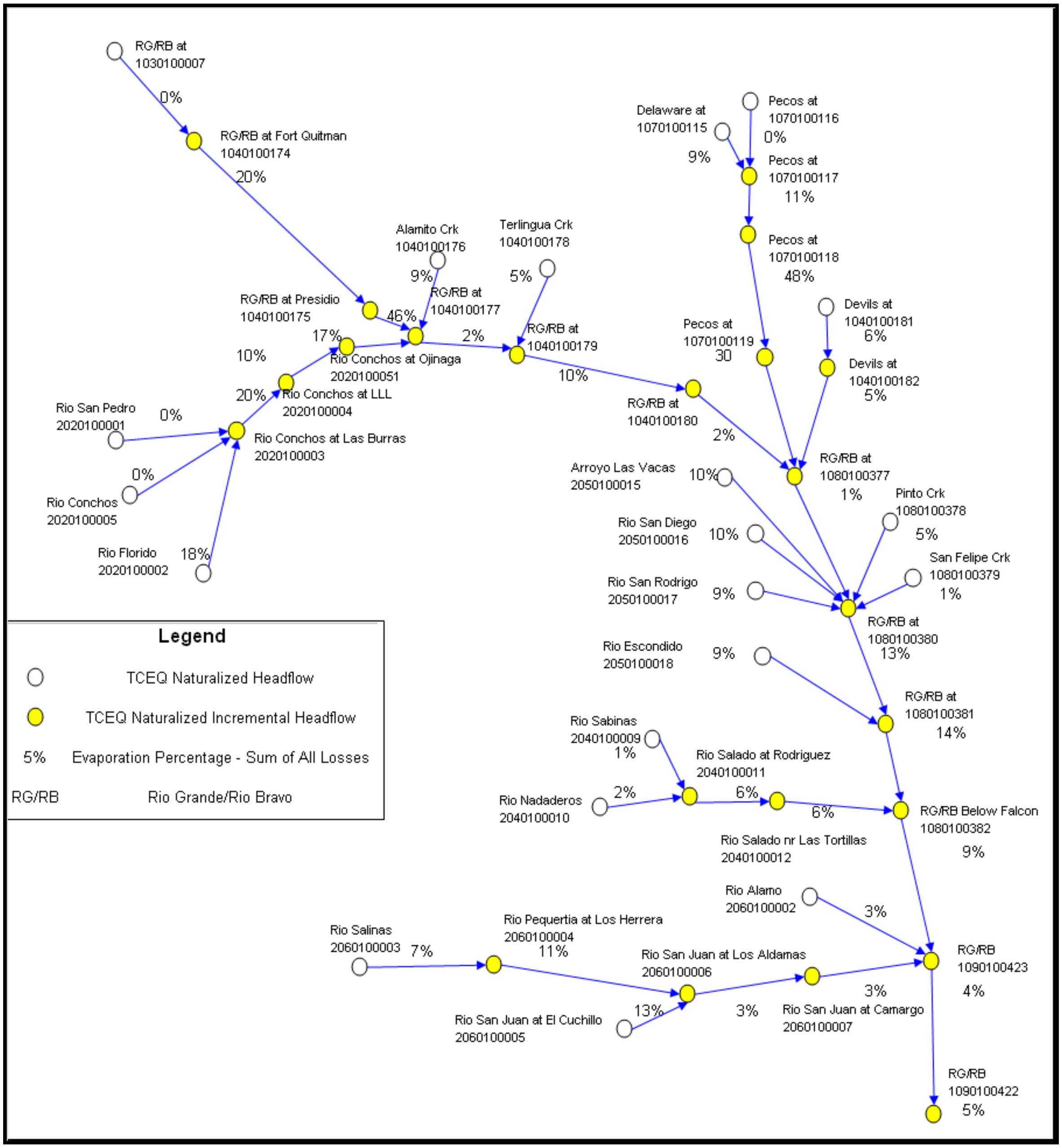


Figure 12: Reach Losses from the TCEQ Rio Grande/Bravo WAM model

2.3. DEMAND SITES

There are 155 demand sites included in the Rio Grande/ Bravo WEAP model. These demand sites include water use for municipalities, irrigation, mining, industrial and other uses. Table 3 is a summary of the number and type of demand nodes for each country. The large demand shown for groundwater in Mexico represents the demand from Uderales, which are irrigation districts in Mexico that rely solely on groundwater. These demands are discussed further in Section 2.3.2.

Table 3: Type and Number of Demand Nodes by Country in the Rio Grande/Bravo WEAP Model

Demand Type	Mexico		United States	
	Number of Demand Nodes	Annual Demand (million m^3)	Number of Demand Nodes	Annual Demand (million m^3)
Municipal	11	561	15	359
Irrigation	13	3,555	45	2,904
Groundwater	33	1,655	23	2,840*
Other	0	0	15	10
Total	**57**	**5,772**	**98**	**6,113**

*this value represents an upper bound on aquifer withdrawal by these demand nodes.

For each demand site, there are seven characteristic tabs in WEAP for entering information in the model: Water Use, Loss and Reuse, Demand Management, Water Quality, Cost, Priority, and Advanced, as shown in Figure 13. The current model uses data for the *Priority* and *Water Use* tabs.

The *Priority* tab assigns each demand site a priority level ranging from 1 to 99. Level 1 is the highest demand priority for water in the system and is assigned to all municipal users. This means that WEAP will try to satisfy all the demands at this level before any other level of priority demand. Mexican irrigation demands are assigned priority levels 2 through 4 and level 5 represents the 1944 Treaty requirements (Table 4). Priority levels 97 and 98 are used for reservoirs. U.S. irrigation demand priorities are ranked according to the breakdown shown in Table 5. The model uses these priority levels when allocating water for the demand sites. The model will deliver water to all the level one priority sites and, if there is any water remaining in the system, it will then deliver water to the remaining priority levels. An optional allocation rule is included in the Key Assumptions and was developed by IMTA for estimating allocations to the Mexican irrigation districts based on available reservoir storage (Wagner and Guitron, 2002). This rule is described in Section 2.5.4.

Table 4: Assigned Priority Levels for Mexican Demands

Demand Type	Priority Level
Municipal	1
Irrigation - For areas in the upper watershed	2
Irrigation - For areas in the middle watershed	3
Irrigation - For areas in the lower watershed	4
Treaty	5
Reservoir	97 -98

Table 5: Priority Levels for U.S. Demands

Demand Type	Priority Level
Municipal	1
Type A Irrigation	2
Type B Irrigation	3
Other	4
Treaty	5
Reservoir	99

The *Water Use* Tab has four Sub-tabs: Annual Activity Level, Annual Water Use Rate, Monthly Variation, and Consumption (Figure 13). Three of these fields, *Monthly Variation, Annual Water Use Rate*, and *Consumption* are used in the model. Monthly variation of water use as a percentage of the total annual water use rate is used in the model. Consumption data is entered as a percentage of the demand for some of the demand sites. Consumption is used to determine the percent of the water demand consumed by the demand site and the percent returned to the system. In the Lower Subbasin there is little or no return flow to the Rio Grande/Bravo due to the hydrological scheme that distributes the water to the Laguna Madre in both Texas and Tamaulipas rather then the Rio Grande/Bravo (Patiño 2006). Appendix E contains the Annual Water Use Rate, Consumption, Priority and Monthly Variation for all demand sites in the WEAP model.

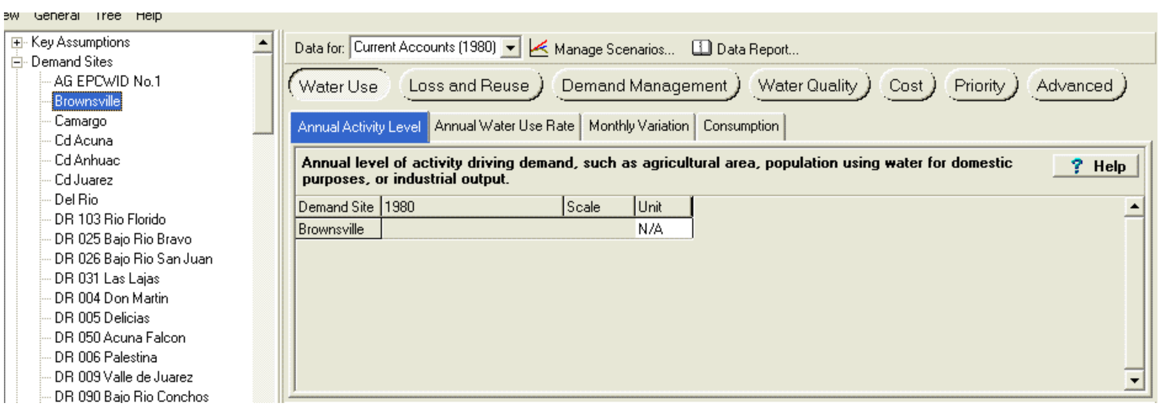


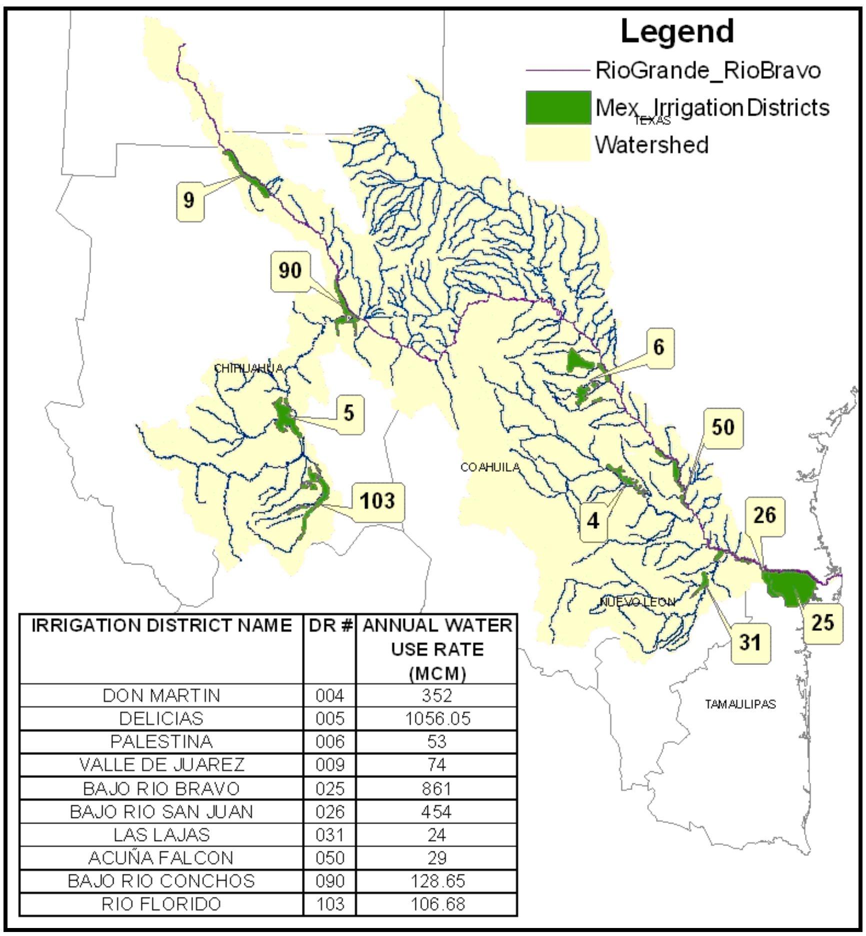
Figure 13: Water Use Tab Screen Capture for Brownsville Demand Site

2.3.1. MEXICAN MUNICIPALITIES

There are 11 Mexican municipalities represented in the model with a total annual water demand of 420.6 MCM. The eleven demand sites are: Camargo; Ciudad Acuna; Ciudad Anhuac; Ciudad Juarez; Matamoros; Metropolitan Monterrey; Nuevo Laredo; Reynosa; Piedras Negras; Ciudad Chihuahua; and Ciudad Miguel Aleman. The priority level of these demand sites are entered using a *key assumptions* expression "Key\Priorities\Municipal" which generates a priority level of one for them (Appendix E). Appendix E contains the Annual Water Use Rate, Consumption, Priority and Monthly Variation for all demand sites in the WEAP model.

2.3.2. *MEXICAN IRRIGATION DEMANDS*

There are two types of irrigation demands defined for the Mexican region of the basin. The first are the large Irrigation Districts (DR) supplied by surface water from the Rio Bravo. There are 10 DRs in the model with a total Annual Water Use rate of 3,032 MCM (Figure 14). An additional three smaller irrigation districts are included in the Rio San Juan basin with an annual demand of 523 MCM. In addition to the large DRs, there are smaller semi-formal districts called Uderales (URs) where groundwater is the source of water supply. There are 25 URs in the model with an annual water use rate of 1,655 MCM (Appendix E). The demand priorities for the DRs vary based on their location within the basin as shown in Appendix E. Since the source of water for the URs are aquifers unconnected to the Rio Bravo, the priority level for the URs are all set to one (Appendix E).



IRRIGATION DISTRICT NAME	DR #	ANNUAL WATER USE RATE (MCM)
DON MARTIN	004	352
DELICIAS	005	1056.05
PALESTINA	006	53
VALLE DE JUAREZ	009	74
BAJO RIO BRAVO	025	861
BAJO RIO SAN JUAN	026	454
LAS LAJAS	031	24
ACUÑA FALCON	050	29
BAJO RIO CONCHOS	090	128.65
RIO FLORIDO	103	106.68

Figure 14: Mexican Irrigation Districts

2.3.3. U.S. DEMAND SITE ASSUMPTIONS

The U.S. water demands include five water use types: irrigation, municipalities, mining, industrial and other. Water rights data for Texas users were obtained from the Texas Commission on Environmental Quality (TCEQ) Water Availability Model (WAM) *Current Allocation* version (TCEQ 2005a) and entered in the model. The *Current Allocation* water demands equal to the maximum annual use in the previous 10 years (1990-2000) (Brandes 2003). Water rights data for New Mexico were derived from the IBWC Draft Environmental Impact Statement (DEIS) as shown in Appendix C (IBWC DEIS 2003a).

Various assumptions have been made to accommodate the complicated regulations governing the deliveries to the U.S. water demands. Due the large number of individual water users in the U.S., many of the demands were combined into aggregated demands in the model. This aggregation was done based on type of demand, location in the basin, and legal jurisdiction. There are over 2,000 water users in the Middle and Lower subbasin in Texas. These demands were aggregated based on the type of water use (i.e. municipal, irrigation, etc) and location in the basin relative to the river reaches defined by the TCEQ Rio Grande Watermaster as shown in Appendix C.

Texas water users (i.e., irrigation, industrial, mining and other) below the international reservoirs, Amistad and Falcon, were aggregated into Type A and Type B water rights based on the Texas Watermaster allocation logic. The Texas Watermaster allocation logic is described in Section 2.5.2.

Monthly return flows have been specified on the U.S. side for municipal and industrial demands using a monthly consumption percentage at the demand nodes. The return flow factors were obtained from the TCEQ WAM model. The WAM model assumes no return flow from irrigation demands. Appendix E contains the Annual Water Use Rate, Consumption, Priority and Monthly Variation for all demand sites in the WEAP model.

2.3.4. U.S. MUNICIPALITIES

There are 15 U.S. municipal demand sites in the model with a total annual water demand of 359 MCM. These demand sites are classified into two groups: the major cities (Brownsville, Del Rio, Eagle Pass, Laredo, McAllen, Muni Maverick, and Balmorhea), and the smaller municipalities. The smaller municipalities have been aggregated into groups: Texas Watermaster section 2, Texas Watermaster sections 5 – 13, and Below the Rio Conchos. Water demand data for these demand sites were obtained from the TCEQ WAM current allocation version (TCEQ 2005a). The allocation priorities for the U.S. municipalities are set at level one (Appendix E). Monthly return flows have been specified for the municipal demands.

2.3.5. *U.S. Irrigation Demands*

There are two U.S. states with irrigation demands in the portion of the basin considered in this model, New Mexico and Texas. These are represented by 45 irrigation demand sites in the model requiring 2,902 MCM of water annually. There are many more than 45 irrigation water users on the U.S. side of the basin, but many of these have been aggregated in the model. There are three New Mexico irrigation diversions in the model requiring a total of 542 MCM annually. Texas has several different systems for allocating water to irrigation demands. The annual requirement for Texas irrigation is 2,360 MCM per year. The allocation priority for U.S. irrigation demands is level one (Appendix E).

Three New Mexico diversions are located in the Upper Subbasin: Percha, Leasburg, and Messilla. The data for these diversions were obtained from the IBWC DEIS for the River Management Alternatives for the Rio Grande Canalization Project (RGCP) (IBWC DEIS 2003a and 2003b).

Agricultural water users in the Pecos River are either water irrigation districts (WIDs) or individual permit holders. The Red Bluff WID has an agricultural demand of 140 MCM per year. The Red Bluff demands are Red Bluff Power Control, Red Bluff Ward WID 2, Red Bluff Water Pecos WID 3, Red Bluff Water Power Loving, Red Bluff Water Reeves WID 2, Red Bluff WID 1, Red Bluff WID 2, and Red Bluff 3. There are five additional individual water users located along the Pecos River in the model. Also, Comanche Creek Water Rights AG and Coyanosa Draw Water Rights AG are aggregated water uses on these two creeks. Joe B Chandler et al. Estate, John Edwards Robbins, and Mattie Banner Bell are individual water users requiring 42 MCM per year (TCEQ 2005a).

There are three agriculture demands for Texas that are not part of the Pecos or the Texas Rio Grande Watermaster Program: Below Conchos Agriculture, Forgotten River Agriculture, and AG EPC WID (El Paso County Irrigation District) No. 1. These require 540 MCM annually. The Forgotten River demand includes the portion of the Rio Grande/Bravo south of El Paso before the confluence with the Rio Conchos. The Below Conchos Agricultural demand site is the aggregated agricultural demand below the Rio Conchos and above Amistad Reservoir.

The Texas Rio Grande Watermaster Program (TCEQ 2005b) regulates U.S. water diversions in the Rio Grande/Bravo from Amistad Reservoir to the Gulf of Mexico. This program allocates water on an account basis. Municipal accounts have the highest priority and they are guaranteed an amount for each year. Irrigation accounts are not guaranteed an allocation of water and they rely on the water remaining in their account from the previous year (so called "balances forward"). Every month the Texas Watermaster determines the amount of unallocated water in the U.S. account of the international reservoirs (Amistad and Falcon) after the municipal allocation has been subtracted. If there is surplus water remaining, it is allocated to the irrigation accounts. The Texas Region M Regional Water Plan (TWDB 2006a) explains how the basin is divided into Watermaster sections according to the Texas Water Code (Subchapter G, Chapter 11). The Watermaster sections are divided between the Middle and Lower Rio Grande/Bravo regions. In the model, the Watermaster sections are represented as consecutive sections (numbers from 1 to 13, see

Appendix C) rather than split between the two regions. The model has eight Watermaster agriculture demand sites requiring 1,627 MCM annually.

2.3.6. U.S. Other Demands

Besides the categories described above, there are 15 other U.S. demands, including: mining, industrial, recreation and other withdrawals. These have an annual water demand of 10 MCM. Groundwater demands are entered for each of the Texas counties associated with the basin as a maximum annual diversion (See Section 2.4.3 for more details). All groundwater demand sites have a priority level of one (Appendix E). Groundwater demand information has been derived from the Regional Water Plans for this part of Texas (TWDB, 2006b). The water demand information is available on a county basis, so groundwater demand nodes were created in the model for each county.

2.4. Supply and Resources

Supply and Resources data are broken into five sections in WEAP: Linking Demands and Supply, River, Groundwater, Local Reservoirs, and Return Flows. The first branch, *Linking Demands and Supply*, has a branch for every demand site in the model and there are three tabs for this field: Linking Rules, Losses, and Cost (see Fig. 15). Data are available for the linking rules which in turn have three sub-tabs: Supply Preference, Maximum Flow Volume, and Maximum Flow Percent of Demand. Figure 15 shows the linking rules for the Camargo demand site as an example.

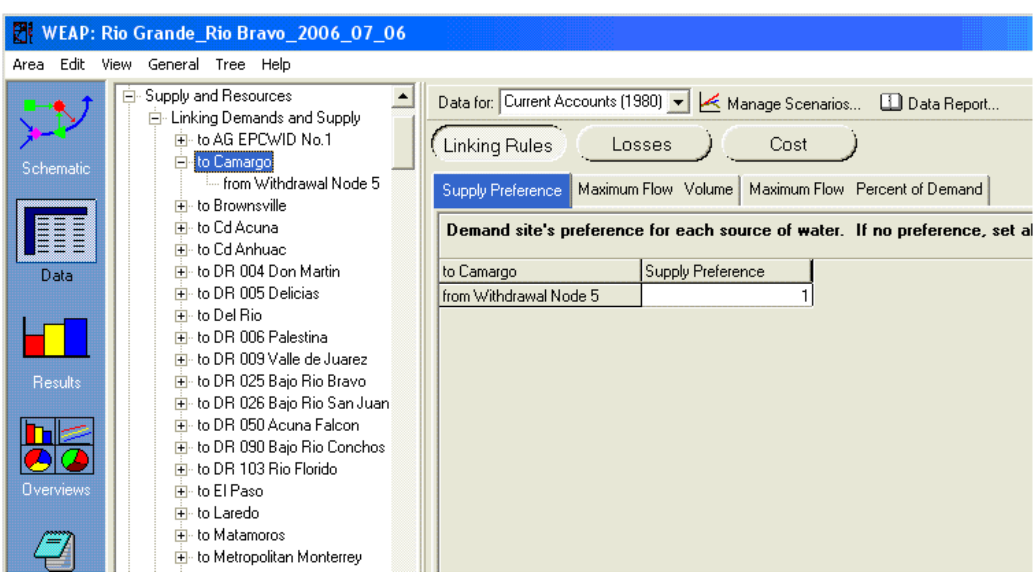


Figure 15: Camargo Example of Linking Rules

The second section of the Supply and Resources branch, *River*, has a branch for every tributary in the model and for all of the incremental flow sites (see Fig. 12). Each tributary has four branches: Reservoirs, Flow Requirements, Reaches and Streamflow Gages. Figure 12 shows the four sub-tabs for the Rio Grande/Bravo branch located in *Supply and Resources → River → RioGrande_RioBravo*.

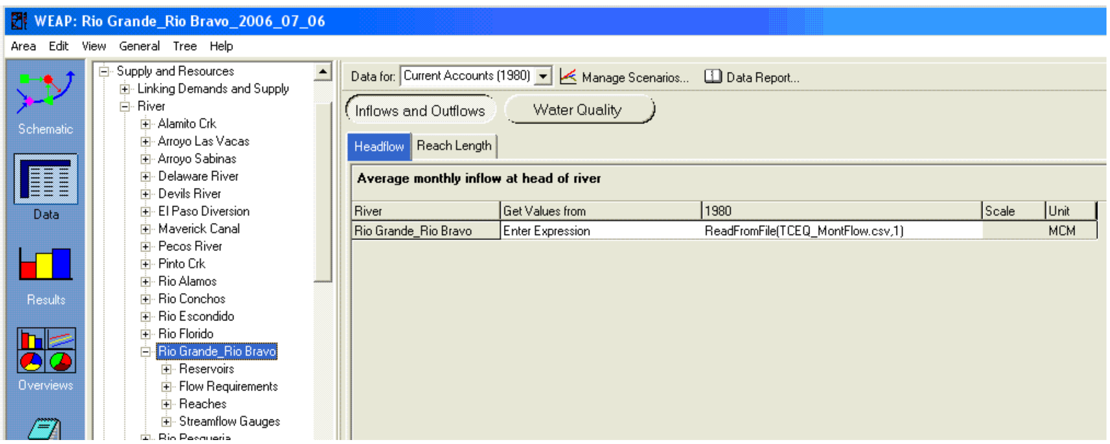


Figure 16: Rio Grande/Bravo River Example

The third section of the Supply and Resources branch, *Groundwater*, contains data for the groundwater nodes in the model and is discussed in detail later in this section. The fourth section, *Local Reservoirs*, contains information for six small reservoirs which are not located on the Rio Grande/Bravo or main tributaries included in the model. The last section, *Return Flows*, contains data for any gains returning from the demand sites after consumption.

2.4.1. RESERVOIRS

The reservoir information in the model is located in two areas in WEAP: (1) Supply and Resources; and (2) Key Assumptions. *Supply and Resources* contains the reservoir characteristics, such as: Storage Capacity, Initial Storage, Volume Elevation Curve, Net Evaporation, Top of Conservation, Top of Buffer, Top of Inactive, Buffer Coefficient, and Priority. These are located under the Physical, Operation, and Priority tabs (see Figure 13, Figure 14, and Figure 15). Every reservoir in the system was assigned a priority level of 99 initially. The reservoirs located under the river branch contain data shown in Appendix F.

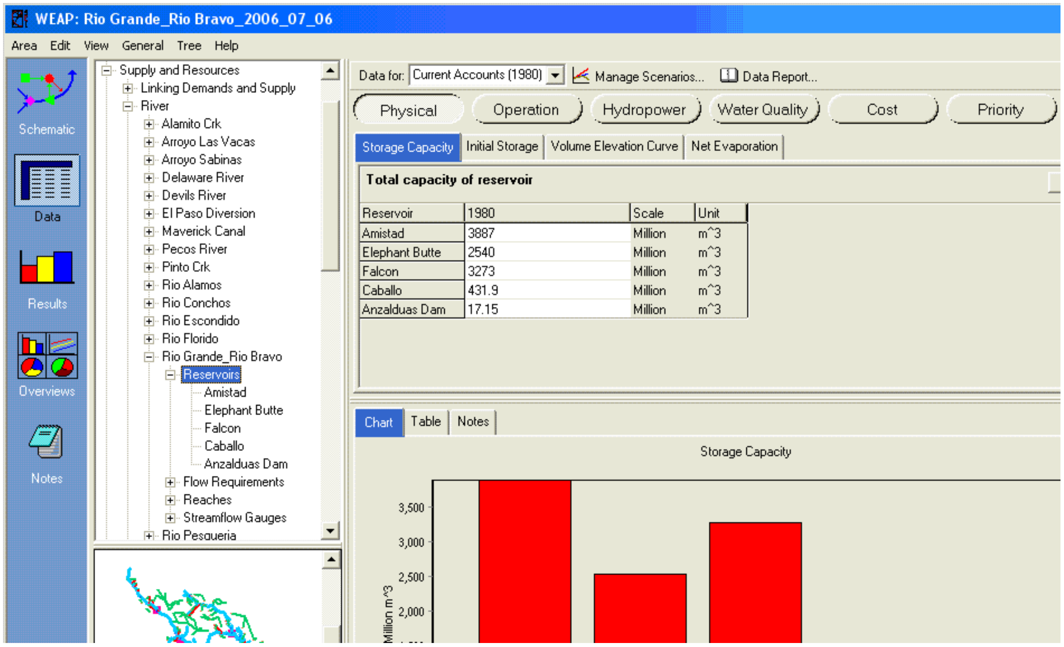


Figure 17: Example of the Physical Tab for Reservoirs

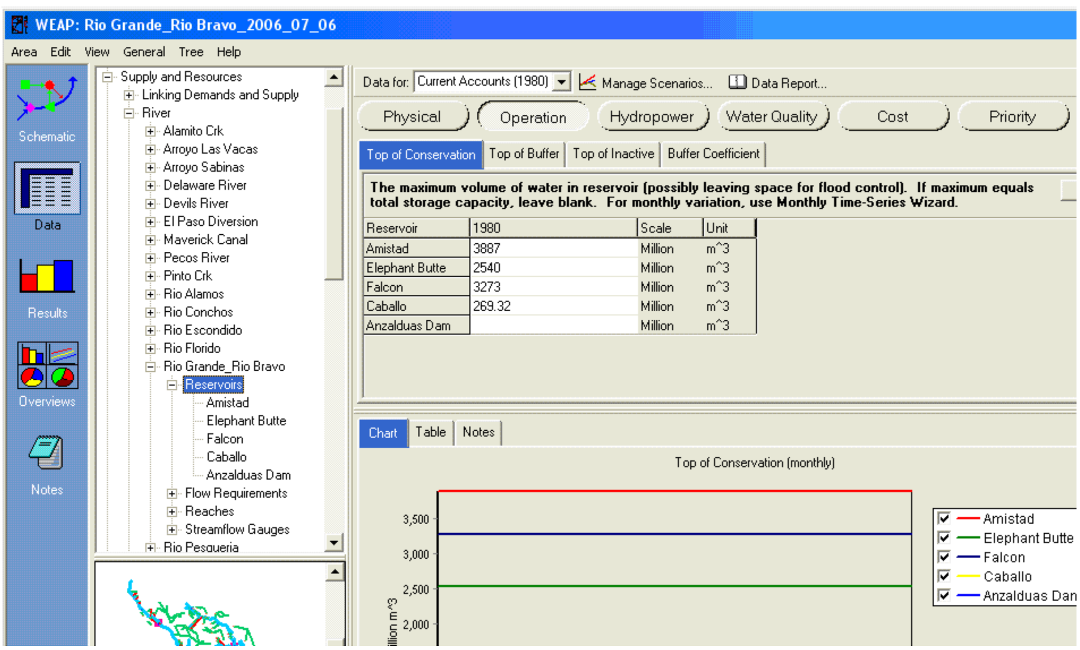


Figure 18: Example of the Operation Tab for Reservoirs

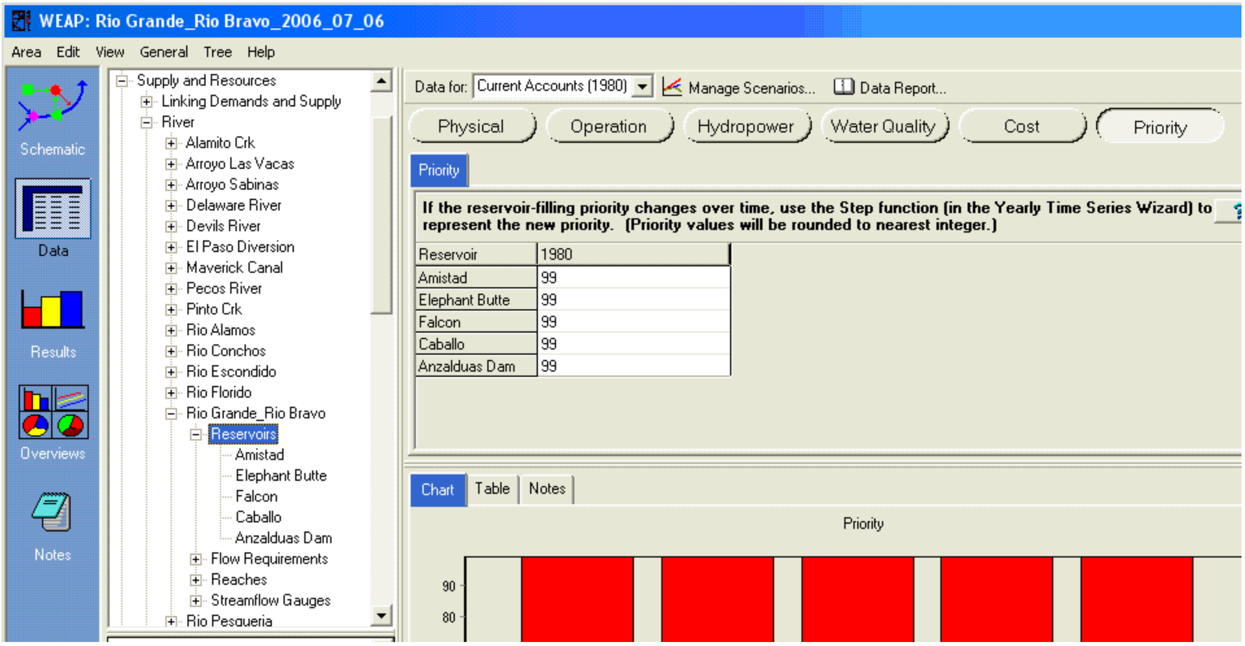


Figure 19: Example of the Priority Tab for Reservoirs

There are 25 reservoirs in the model with a total storage capacity of 22,034 MCM (Table 6). Eighteen of the reservoirs are located under their specific River Branch in the model and five are located under the Local Reservoirs branch. The two major international reservoirs are Amistad and Falcon (see Figure 16) which are jointly operated by the International Boundary Water Commission (IBWC) and Comisión Internacional de Límites y Aguas (CILA) with a total storage capacity of 7,177.2 MCM. Mexico owns and operates 14 reservoirs in the basin with a total storage capacity of 11,424.3 MCM (Figure 17) and the U.S. owns and operates five reservoirs in the system containing 3,432.7 MCM (Figure 18) of storage capacity. For each of the reservoirs, data are entered into the model for Storage Capacity, Top of Conservation and Top of Inactive as shown in Table 6. The Top of the Buffer has been set equal to the Top of Inactive for some reservoirs. The volume-elevation curves are referenced to the area-elevation-volume curves (see Appendix G). Net evaporation data are entered as monthly values from the historical evaporation in an external file.

Using a *Key Assumption*, the initial storage of each reservoir is set to the historical value in the month previous to the simulation water year from data in an external file. For example, if the simulation starts in 1983, then the initial value is set to the historical storage value of September 1982 (the model uses water years and the year corresponds to September). If a historical value is not available, then the median storage is taken as the initial storage for that reservoir.

The parameters *Top of Buffer* and *Buffer Coefficient* are used for some reservoirs to control releases. WEAP uses the Buffer Coefficient, the fraction of the water in the Buffer Zone which can be used each month for releases, to control releases from the buffer zone. The Buffer Coefficient is restricted to the range (0, 1.0) with a value near 1.0 allowing more water to be released to meet demands more fully, while a value near 0 leaves demands unmet while maintaining storage in the buffer zone.

Considerable time was spent in the Physical Assessment Project to gather information regarding the operating rules and procedures for the reservoirs of the Rio Grande/Bravo basin. A few reservoirs in the system have explicit operating rules, e.g., Elephant Butte and Red Bluff reservoirs. However, the majority of the reservoirs in the system have no formal, written operating rules of any kind, as far as the project participants were able to determine after about 2 years of searching data sources and conducting interviews of agency personnel in both the U.S. and Mexico. Project participants were told anecdotally of some flood control procedures that are applied by the IBWC to the Amistad and Falcon dams in case of extreme flood events (Ken Rakestraw, personal communication, June 2006). In terms of a water supply purpose, the procedures that are followed in operating any particular reservoir in the system seem to be oriented toward meeting downstream demands for water when water is available in the reservoir(s).

Table 6: WEAP Inputs for Reservoir Characteristics

No.	Location	Reservoir Name	Storage Capacity MCM	Top Of Conservation MCM	Top of Inactive MCM
1	IBWC/CILA[1]	Falcon	3897.0	4300.0	100.0
2	IBWC/CILA[1]	Amistad	6025.0	3887.0	23.0
3	IBWC/CILA[1]	Anzalduas	17.2	17.1	
1	Mexico[3]	Las Blancas	134.0	84.0	24.0
2	Mexico[2]	La Boquilla	3336.0	2903.3	129.7
3	Mexico[2]	Luis L. Leon	877.0	450.0	42.5
4	Mexico[3]	Pico del Aguila	86.8	50.0	4.4
5	Mexico[3]	San Gabriel	389.6	255.4	7.5
6	Mexico[2]	V Carranza	1385.0	1375.0	1.0
7	Mexico[2]	San Miguel	20.0	19.2	0.8
8	Mexico[3]	El Cuchillo	1784.0	1123.0	100.0
9	Mexico[3]	Marte R. Gomez	2303.9	1150.0	8.2
10	Mexico[2]	F. Madero	565.0	348.0	5.3
11	Mexico[2]	La Fragua	86.0	45.0	9.0
12	Mexico[2]	Centenario	26.6	25.5	0.9
13	Mexico[2]	Cerro Prieto	300.0	300.0	20.0
14	Mexico[3]	Chihuahua	26.0	24.9	2.0
15	Mexico[3]	El Rejon	6.6	6.6	0.4
16	Mexico[3]	La Boca	42.6	39.5	3.5
1	U.S.[1]	San Esteban Lake	3.8		
2	U.S.[1]	Red Bluff	425.7	413.4	3.7
3	U.S.[4]	Caballo	432.0	269.0	26.0
4	U.S.[5]	Elephant Butte	2540.0	2540.0	254.0
5	U.S.[1]	Lake Balmorhea	9.5	3.9	
6	U.S.[1]	Casa Blanca Lake	23.4		
		Total	24742.8	18171.7	766.0
	1. Source: TWDB 1971				
	2. Source: IMTA-BANDAS				
	3. Source: CNA				
	4. Source: USBR 2006a				
	5. Source: USBR 2006b				

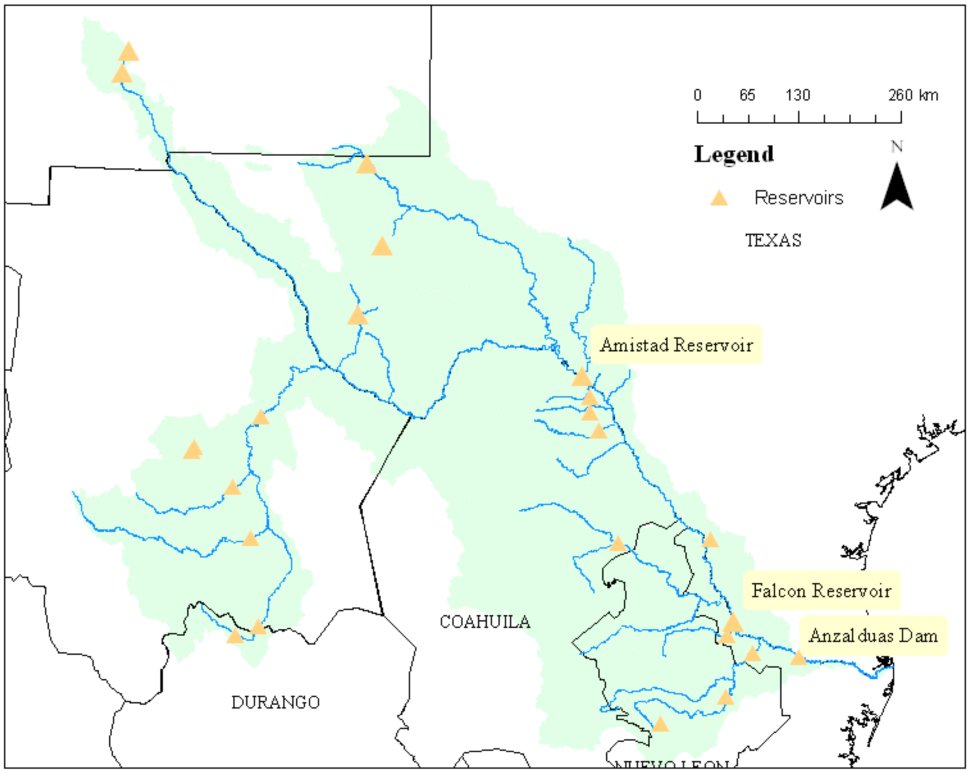


Figure 20: IBWC/CILA Reservoirs

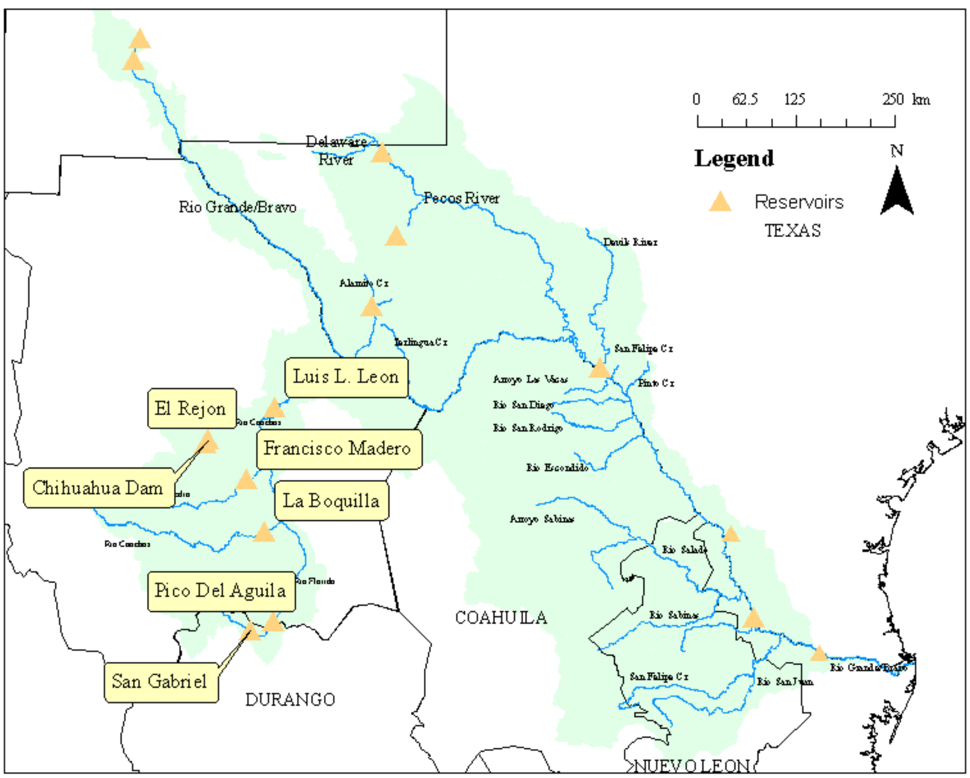


Figure 21: Rio Conchos Reservoirs

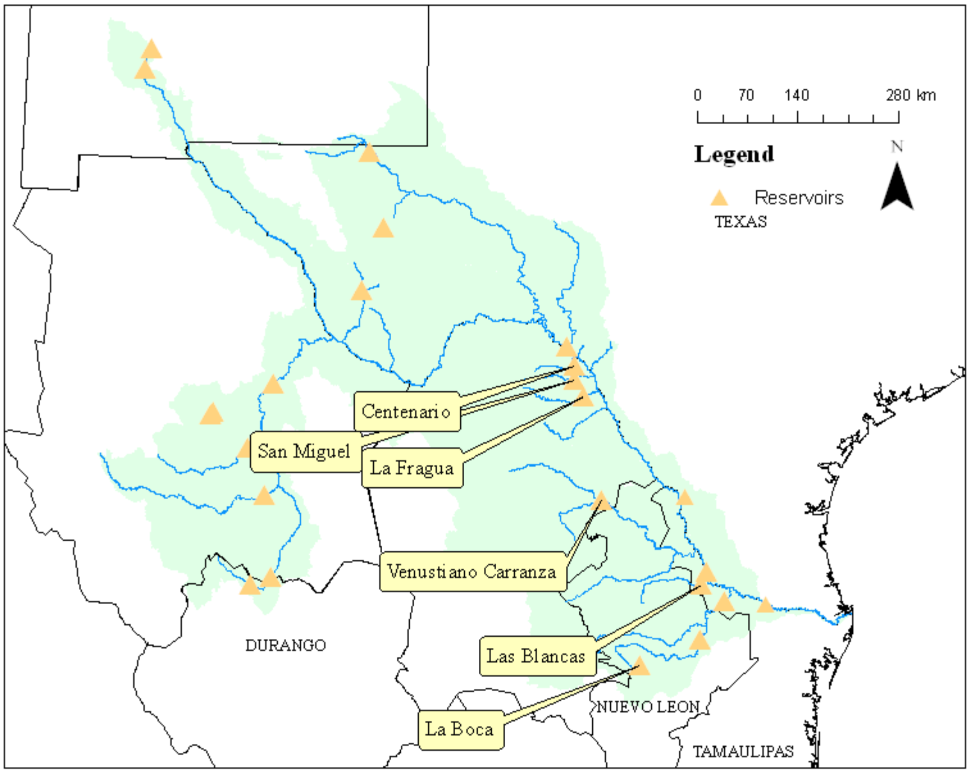


Figure 22: Mexican Lower Basin Reservoirs

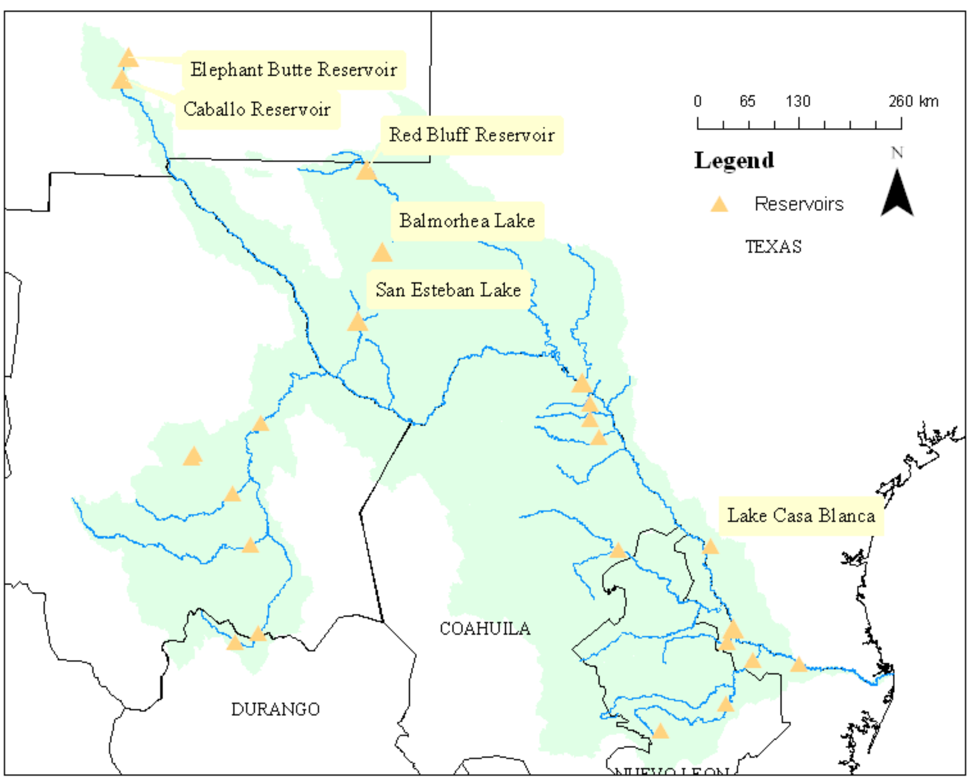


Figure 23: U.S. Reservoirs

2.4.2. *GROUNDWATER*

Groundwater is a key source of water supply for the Rio Grande/Bravo Basin. WEAP has three tabs for entering groundwater data or expressions within the Supply and Resources branch: Physical, Water Quality, and Cost. Data are entered under the *Physical* tab which has four sub-tabs: Storage Capacity, Initial Storage, Maximum Withdrawal, Natural Recharge and Method. Initial Storage, Maximum Withdrawal, and Natural Recharge data for the Mexican aquifers were obtained from CNA (Villalobos et al. 2001). Initial storage is used as the maximum annual withdrawal volume. Monthly natural recharge is defined as the annual recharge volume divided by 12 to distribute it throughout the year. Maximum monthly withdrawal is defined as the initial storage volume plus the monthly natural recharge. The total maximum withdrawal is 3,285.6 MCM (Table 7) for all the Mexican aquifer nodes.

Groundwater nodes are included for the U.S. Due to the large size of the aquifer formations in Texas, the aquifers were regionalized. For example, the Edwards Trinity Plateau aquifer has demands from 12 counties. To represent the portion of the aquifer which has demands from Pecos and Terrell Counties, a groundwater node named Edwards Trinity Plateau_PE TC Co was created. PE is the abbreviation for Pecos County and TC is the abbreviation for Terrell County.

Currently there is no demand information associated with each county groundwater demand for the U.S. However, each transmission link from the groundwater nodes to the county groundwater demand nodes has a Maximum Annual Delivery Volume (MCM/year) as specified in the Texas Regional Water Planning documents.

Table 7: Mexican Groundwater Node Characteristics (IMTA 2006)

Groundwater Node	Initial Storage (MCM)	Maximum Withdrawal (MCM)	Natural Recharge (MCM)
Agualeguas Ramones	5	6	1
Aldama San Diego	42.7	45.7	2.9
Allende Piedras Negras	142.3	153.2	10.8
Almo Chapo	0	1	1
Alto Rio San Pedro	39	43.7	4.7
Area Metropolitana de Monterrey	99.8	105.5	5.7
Bajo Rio Bravo	75.8	88	12.3
Bajo Rio Conchos	18.4	25.9	7.5
Bocoyna	0.2	1.6	1.4
Campo Buenos Aires	62	67.7	5.7
Campo Duranzo	5	5.4	0.4
Campo Mina	23	25.1	2.1
Campo Topo Chico	3	3.3	0.3
Canon del Derramadero	18.8	19.3	0.6
Canon del Huajuco	2	2.2	0.2
Carichi Nonoava	0.8	1.5	0.7
Cerro Colorado La Partida	6.2	7	0.8
Chihuahua Sacramento	124.8	129.4	4.6
China General Bravo	7	7.8	0.8
Citricola Norte	281.9	297.9	16
Cuatrocienegas	132.1	144	11.9
Cuatrocienegas Ocampo	34.9	39.4	4.4
Hidalgo	17	18.7	1.7
Jimenez Camargo	580.7	617.3	36.7
Laguna de Mexicanos	14.4	17.3	2.9
Lampazos Anahuac	63	68.4	5.4
Lampazos Villadama	13	14.5	1.5
Manuel Benavides	0.7	1	0.4
Meoqui Delicias	417	451.8	34.8
Monoclova	108	110.5	2.5
Paredon	23	24.6	1.6
Parral Valle Del Verano	22.9	25.2	2.2
Potrero del Llano	0	4.2	4.2
Region Carbonifera	177.2	190.6	13.4
Region Manzanera Zapaliname	48.3	52.9	4.6
Sabinas Paras	69.2	73	3.8
Saltillo Ramos Arizpe	50.7	53.2	2.5
San Felipe de Jesus	0	0.7	0.7
Santa Fe del Pino	4	4.9	0.9
Valle de Juarez	310	334.2	24.2
Valle de Zaragoza	0.5	1.6	1.1
Villalba	0	0.7	0.7

2.4.3. *Linking Supply and Demand*

Linking Rules under *Linking Demands and Supplies* are used to represent transmission losses or to constrain water deliveries to demand sites. In the model some Mexican demands have Linking Rules to represent transmission losses. These demand sites, their supply sources and their losses are summarized in Table 8.

Table 8: WEAP Mexican Transmission Losses

Demand	Supply Source	Loss from System (%)
to MX_IRR_DR 004 Don Martin	Rio Salado	20.15
to MX_IRR_DR 005 Delicias	Rio Conchos	19.76
to MX_IRR_DR 005 Delicias	Rio San Pedro	19.76
to MX_IRR_DR 025 Bajo Rio Bravo	Rio Grande/Bravo	27.30
to MX_IRR_DR 026 Bajo Rio San Juan	Rio San Pedro	9.14
to MX_IRR_DR 026 Bajo Rio San Juan	Rio Grande/Bravo	9.14
to MX_IRR_DR 050 Acuna Falcon	Rio Grande/Bravo	10.00
to MX_IRR_DR 090 Bajo Rio Conchos	Rio Conchos	21.00
to MX_IRR_DR 103 Rio Florido	Rio San Gabriel	5.00
to MX_IRR_DR 103 Rio Florido	Rio Florido	5.00
to MX_Muni_Camargo	Rio Conchos	33.00
to MX_Muni_Cd Acuna	Rio Grande/Bravo	33.33
to MX_Muni_Cd Anahuac	Rio Grande/Bravo	72.57
to MX_Muni_Cd. Miguel Aleman	Rio Grande/Bravo	33.33
to MX_Muni_Matamoros	Rio Grande/Bravo	33.33
to MX_Muni_Nuevo Laredo	Rio Grande/Bravo	33.33

Each Mexican Irrigation district (DR) has a Maximum Volume constraint for the IMTA Reservoir Operations Scenario discussed in the Key Assumptions section of this document. If the IMTA Reservoir Operations Scenario is enabled using the Allocation Switch (Alloc_switch = 1), then the deliveries to each DR are constrained based on the available amount of storage in the upstream reservoir.

If the IMTA Reservoir Operations Scenario is not enabled (Alloc_switch = 0) then the Mexican Demands below the international reservoirs (Amistad and Falcon), including both irrigation and municipal demands, are constrained by the amount of water available in the Mexican Accounts. The Mexican Storage Volume is tracked using a Key Assumption and this is described in the following Key Assumption Section under International Accounts.

The U.S. Demands below the international reservoirs are constrained based on the Texas Watermaster logic and the amount of water available in the US storage account in the international reservoirs. The US storage accounts are tracked using key assumptions. The links to Type A water rights are constrained by the amount of water available in the Type A Storage and Type B water rights are constrained by the amount of Type B Storage. See the key assumptions description in the following section under Texas Watermaster Storage Accounting.

Each transmission link from a groundwater node to a county groundwater demand node has a Maximum Annual Delivery Volume (MCM/year) as specified in the Texas Regional Water Planning documents (Appendix H).

2.5. Key Assumptions

This section describes the logic created for reservoir accounting and treaty tracking using the Key Assumptions. A brief description of an allocation scenario proposed by IMTA for managing the reservoirs is also included.

2.5.1. International Reservoir Accounting

Logic was created for tracking the reservoir storage accounts in the international reservoirs, Amistad and Falcon. This logic is written using Key Assumptions for each reservoir as follows: Key/Amistad_Accounts, and Key/Falcon_Accounts. For each of these accounts the following subdirectories were added: Inflows, Outflows, and Storage. The specific accounting for each reservoir is described in the following sections.

Amistad Accounts

Amistad accounts are tracked by first calculating total inflows to the reservoir and crediting those inflows to Mexico and the United States according to the 1944 Treaty. Mexican account in Amistad includes 2/3 of the Rio Conchos inflows plus half of the Rio Grande/Bravo flows at Presidio and half of the gains or losses between Ojinaga and Amistad reservoir. The remainder is included in the United States account. This is equivalent to 1/3 of the Rio Conchos flows plus half of the Rio Grande/Rio Bravo flows at Presidio, half of the gains or losses between Ojinaga and Amistad reservoir, plus all of the flows from the Pecos and Devils rivers.

Outflows from the reservoir are similarly deducted from the two storage accounts according to the release metrics of both countries. Because WEAP makes a single release from each reservoir in response to downstream demands, outflows are tracked in relation to each country's downstream diversions. That is, if the diversions to the U.S. and Mexico between Amistad and Falcon are equal in any given month, then each country is assumed to have released the same amount of water from Amistad to meet those diversions. If, on the other hand, the U.S. was diverting three times the volume of water that Mexico diverted, then 75 percent of the releases from Amistad would be charged to the U.S. account and 25 percent of the releases would be charged to the Mexican account. Any releases from Amistad in excess of the downstream diversions (i.e. spills) are shared equally by the two countries, unless there is insufficient usable storage in one account to share that release equally. In such a case, the account with greater storage releases the greatest share of water and the lesser account is reduced to zero storage.

Evaporation from Amistad is determined by subtracting the total change in Amistad storage for the previous month (i.e., last month's Amistad storage minus its previous month's storage) from the difference in inflows and outflows calculated above. The U.S. and Mexico share the evaporation losses equally. Thus, storage accounts for each country are updated by adding inflows and subtracting outflows (i.e., releases) and half of the evaporation from their previous month's accounts.

The storage accounts are updated in the model at the beginning of each month based on the results from the previous month (end of month flow, delivery, and storage values).

Falcon Accounts

Storage accounts in Falcon Reservoir for the U.S. and Mexico use a similar logic to those in Amistad. Inflows are calculated by apportioning tributary flows and gains/losses per the 1944 Treaty. Calculation of gains and losses is dependent upon Amistad accounting, because we must consider releases from Amistad and diversions above Falcon. We assume that return flows are accounted as gains and, thus, shared equally. As mentioned above, any releases from Amistad in excess of downstream diversion requirements, as a result of reservoir balancing or in response to demands downstream of Falcon, are shared equally between the two countries. These spills will arrive at Falcon and the amounts credited to storage accounts are equal to the amounts taken as spill from Amistad.

Water released from Falcon to meet downstream demands is charged to Mexican and U.S. storage accounts using the same procedure described for Amistad. That is, any releases for downstream diversions are charged to the storage accounts depending upon the volume of water diverted to U.S. and Mexican water contractors below Falcon. Water released from storage in excess of diversions is shared by the two countries, providing there is sufficient storage in both accounts. In the event that one account lacks storage to meet its share of the released water, then its account is reduced to zero and the other account is responsible for the remainder of the spilled water.

2.5.2. Texas Watermaster Storage Accounting

To track the accounting for Texas Watermaster storage in the international reservoirs the Key Assumption **Key/TX_Watermaster** was created. This logic allocates US storage in Amistad and Falcon to separate accounts based on the intended use of water and, in the case of agriculture, contractual arrangements. Allocations are based on combined Amistad and Falcon usable storage. This storage is assessed at the beginning of each month. To re-establish supplies for domestic, municipal, and industrial uses a reserve amount of 277.65 MCM (225 TAF) is deducted from the total usable storage. An operating reserve of 92.55 MCM (75 TAF) is also taken from usable storage. The last deduction subtracts the account balance for irrigation and mining (previous storage minus previous deliveries) from the total usable storage. The remaining unallocated water is distributed to irrigation and mining accounts based upon their current storage levels and status as either Class A or Class B.

Total storage for both contract types are capped at 1.41 times their total annual diversion rights. Where storage accounts have room to accommodate unallocated water, Class A storage receives 1.7 times the amount of water given to Class B. In the event that one account reaches its maximum storage and unallocated water remains, then the other account may claim that water.

The accounting also has provisions for penalizing the account balances of Class A and Class B irrigation and mining water rights holders when storages dip into the operating reserve. In this situation storage from account balances (which reflect previous gains from allocation of excess storage) are shifted back to the operating reserve in order to bring it back to full.

2.5.3. 1944 Treaty Logic

Logic was created to track the deliveries from Mexico under the 1944 Treaty. This tracking logic was created using a Key Assumption named **Key/Treaty.** Inflows are tracked for each of the Mexican tributaries referenced in the 1944 Treaty (i.e., Rio Conchos, Rio San Diego, Rio San Rodrigo, Rio Escondido, Rio Salado, and Arroyo Las Vacas). One-third of the total inflow from these rivers is deducted from a treaty deficit that is set at 431 MCM at the beginning of each water year. In addition to an annual deficit, a cumulative deficit is defined, which tracks the accumulation of deficits over multiple years. Any water received by the US in excess of 431 MCM in a single year is subtracted from this cumulative deficit, whereas shortfalls of the 431 MCM are added.

There are currently no rules to release water from storage to satisfy treaty obligations. The logic above is in place only to track inflows from Mexican tributaries. There are, however, place holders for flow requirements at the outflow points for each of these tributaries. These objects may be used later to specify flow requirements based on treaty deficits and current storage conditions.

2.5.4. IMTA Reservoir Operations Scenario

A Mexican reservoir operating policy scenario proposed by IMTA is modeled using the Key Assumptions. This scenario utilizes a switch (Alloc_switch) to turn the scenario on and off. These operating policies are included for Amistad, Falcon, La Boquilla, Luis L. Leon, F. Madero, El Cuchillo, San Gabriel and V. Carranza reservoirs. For the international reservoir Amistad and Falcon, the operating policies are applied to the Mexican storage only (Wagner and Guitron, 2002). The key assumptions for Amistad and Falcon are named as Amistad_MX and Falcon_MX. These operating policies allocate water to downstream demands based on available storage in the reservoirs. This switch is used to (de)activate allocation procedures for Mexican reservoirs: 0 = Off; 1 = On. This procedure defines permissible annual deliveries to irrigation districts based upon storage conditions at the beginning of the water year (October). The reservoirs considered, the downstream irrigation districts affected, and the locations of the model logic are:

Reservoir:	**Irrigation District:**	**Key Assumptions Directory:**
La Boquilla	DR005 - Delicias	LaBoquilla
Luis L. Leon	DR090 - Bajo Rio Conchos	LLL
San Gabriel	DR103 - Rio Florido	SanGabriel
Francisco Madero	DR005 – Delicias	Madero
V. Carranza	DR004 - Don Martin	VCarranza
Amistad	DR006 - Palestina AND	Amistad_MX
	DR050 - Acuna-Falcon	
Falcon	DR025 - Bajo Rio Bravo AND	Falcon_MX
	DR026 - Bajo Rio San Juan	

To limit deliveries to the downstream demands based on this scenario, constraints have been created on the links as discussed in the previous Section 2.4.3.

2.6. Wastewater Treatment

Wastewater Treatment is specified under the Water Quality tab. Five wastewater treatment plants are included in the WEAP model. These plants are located at the municipalities of Ciudad Juarez and Ciudad Monterrey in Mexico and Brownsville, Del Rio and Eagle Pass in the U.S. Daily Capacities for each plant are summarized in Table 9. The data for the Mexican municipalities were taken from the REPDA (CNA 2007) and the data for the U.S. municipalities were acquired from the TCEQ WAM model (Brandes 2003).

Table 9: Wastewater Treatment Plant Daily Capacities

Wastewater Treatment Plant	Daily Capacity (MCM)
MX_WTP Ciudad Juarez	0.267
MX_WTP_Cd Monterrey	0.691
US_WTP_Brownsville	0.048
US_WTP_Del Rio	0.024
US_WTP_Eagle Pass	0.022

3. Model Testing

Model testing is the next step in evaluating confidence in the model and the model data that have been discussed in the previous section. The model contains inflow data from 1941 to the present (1941 – 2000), demands for a recent period (2003), and operations for the present time as well as these could be determined from numerous interviews with technical personnel of the responsible agencies and studying what technical documents exist and are available. This is a long period to conduct testing since many conditions in the basin have changed over this period (e.g., demands and operations); therefore, a one year period of 1988 was selected for testing. The WEAP model uses a water year starting in October; therefore, the exact time frame used in testing was October 1987 to September 1988. This time period appeared most advantageous because there was no drought during this period and all of the reservoirs of interest were in operation.

For testing, model reservoir storage values and model streamflow values were compared to historical values. Additionally, the percent difference between total historical and total modeled storage and streamflow values were calculated.

3.1. Comparison of Reservoir Storage Values

Eleven reservoirs were selected for testing (see Table 10 and Figure 24). The historical data for these reservoirs was taken from four major agencies, IMTA (BANDAS database), CNA, CILA, and USBR.

Table 10: Reservoirs Used for Testing

Subbasin	Name	HydroID	Agency Used for Historical Data
Lower	V. Carranza	2040400041	IMTA/BANDAS
Lower	El Cuchillo	2060400104	CNA
Lower	Falcon	2040400003	CILA
Middle	Amistad	2030400002	CILA
Pecos	Red Bluff	1070400633	USBR
Rio Conchos	F. Madero	2020400058	IMTA/BANDAS
Rio Conchos	La Boquilla	2020400095	IMTA/BANDAS
Rio Conchos	Luis L. Leon	2020400030	IMTA/BANDAS
Rio Conchos	San Gabriel	2020400081	IMTA/BANDAS
Upper	Caballo	1030400017	USBR
Upper	Elephant Butte	1020400390	USBR

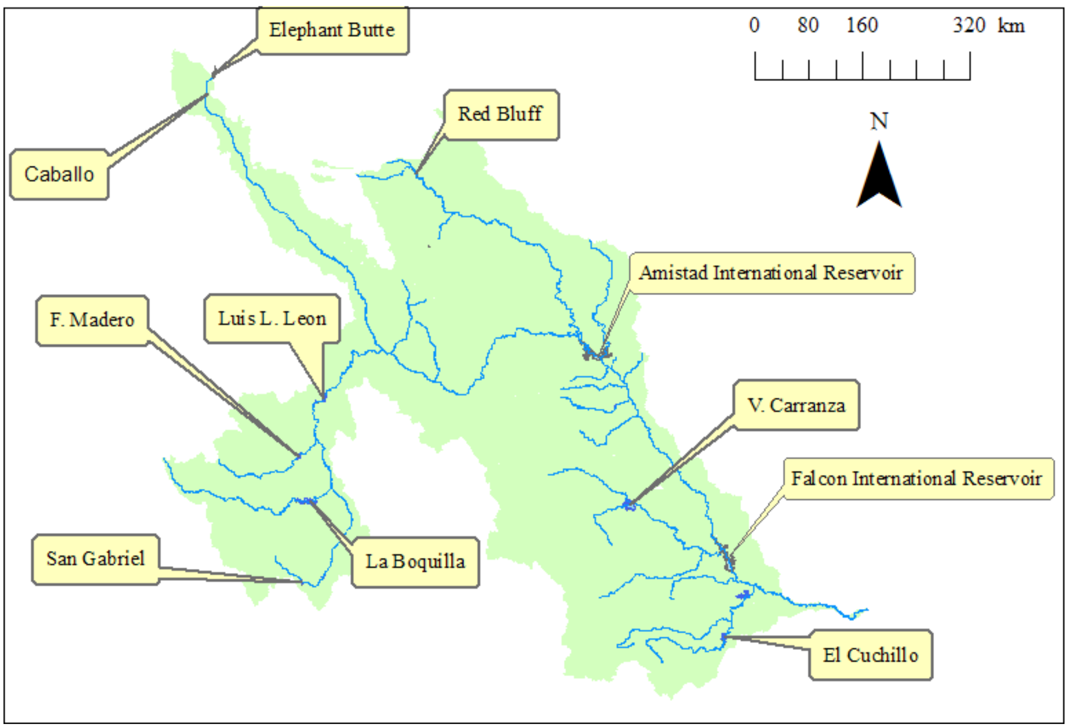


Figure 24: Eleven Reservoirs Used for Testing

The historical storage data were plotted against the modeled reservoir storage values. The comparisons for Luis L. Leon (Figure 25), San Gabriel (Figure 26), Amistad (Figure 27) and El Cuchillo (Figure 28) reservoirs are shown. The comparison graphs for the other seven reservoirs are contained in Appendix I. Comparing the historical values to the modeled storage values visually, Luis L. Leon, San Gabriel, Falcon and El Chuchillo reservoirs appear to capture the physical operating rules of the reservoirs. To quantify the difference between the historical and modeled storage volumes, the percent difference between the two values for the water year 1988 were calculated (Table 11).

All of the reservoirs tested had modeled storage volumes within a 12% difference of the historical storage volumes. The positive differences in Table 11 indicate reservoirs which are storing less water than historically measured while the negative differences indicate reservoirs which are storing more water.

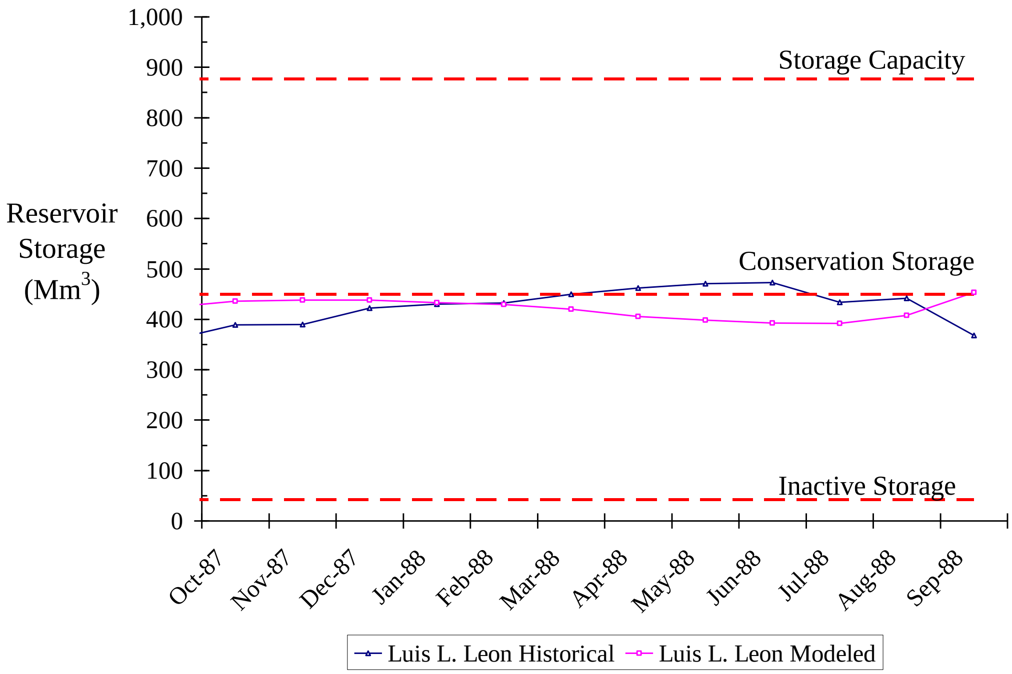


Figure 25 Historical and Modeled Reservoir Storage Volumes for Luis L. Leon Reservoir

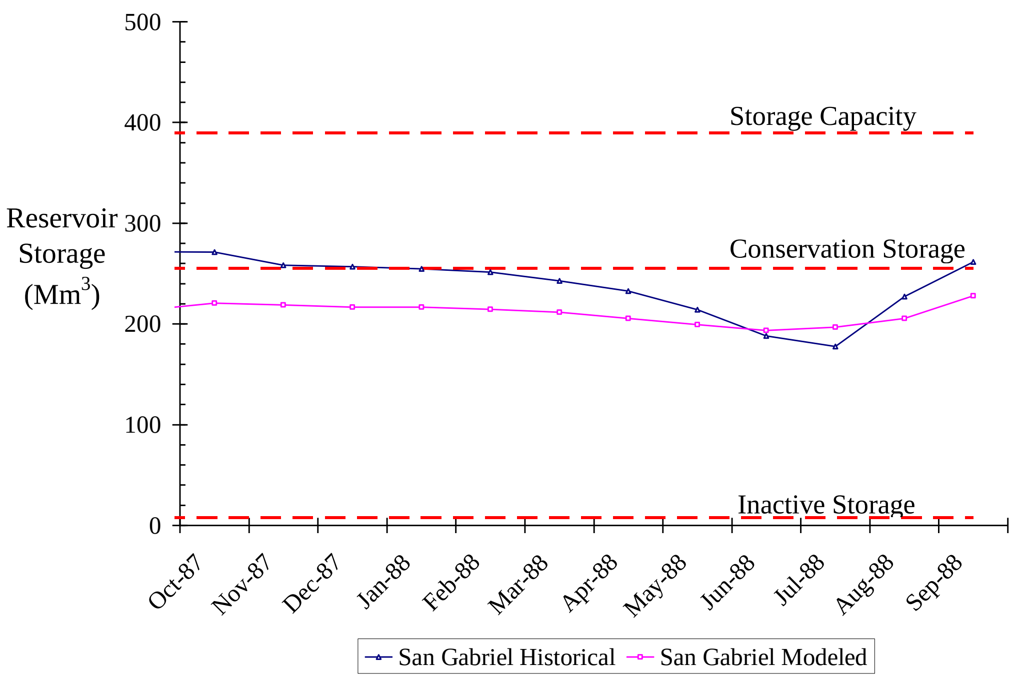


Figure 26 Historical and Modeled Reservoir Storage Volumes for San Gabriel Reservoir

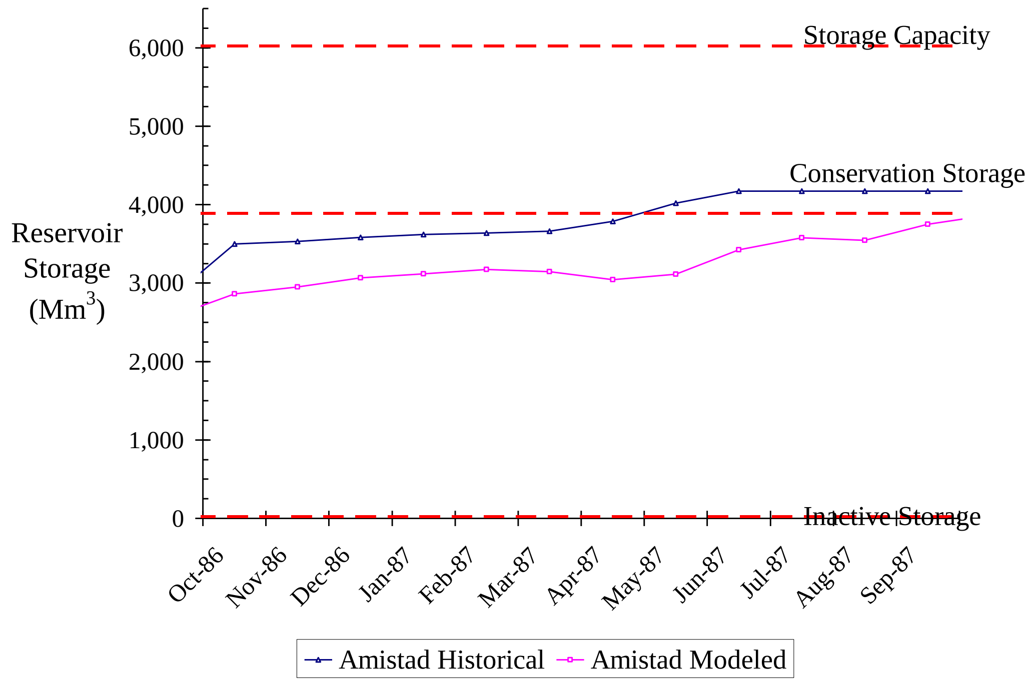


Figure 27 Historical and Modeled Reservoir Storage Volumes for Amistad Reservoir

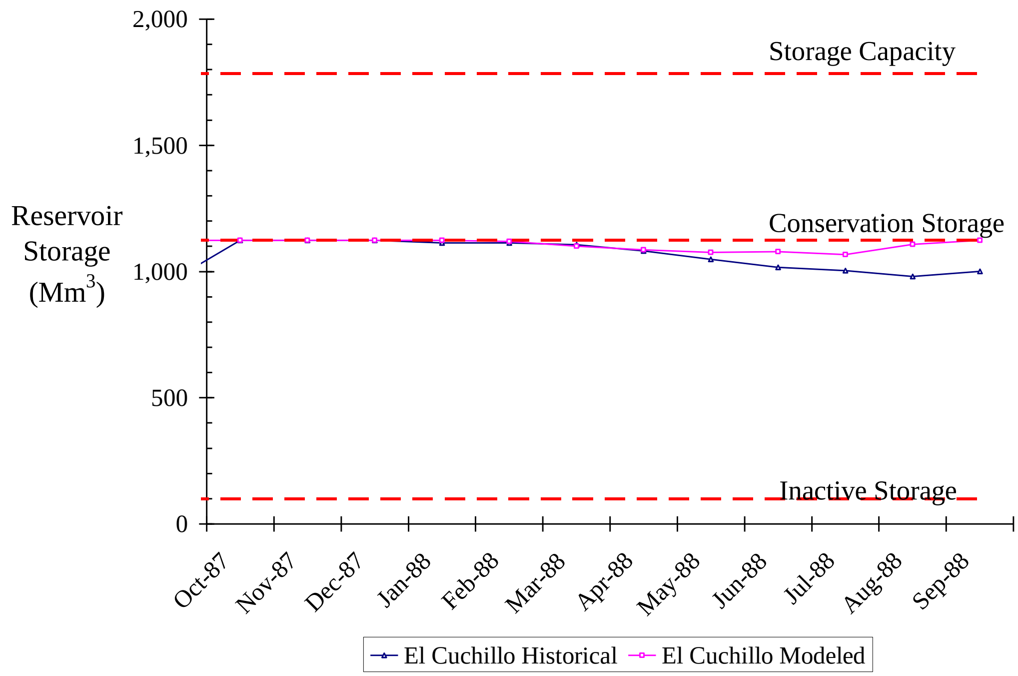


Figure 28 Historical and Modeled Reservoir Storage Volumes for El Cuchillo Reservoir

Table 11: Percent Difference between Historical and Modeled Storage Values for the Eleven Reservoirs for the 1988 Water Year

Subbasin	Name	HydroID	Percent Difference
Lower	V. Carranza	2040400041	9.6%
Lower	El Cuchillo	2060400104	-3.3%
Lower	Falcon	2040400003	4.4%
Middle	Amistad	2030400002	12%
Pecos	Red Bluff	1070400633	-4.1%
Rio Conchos	F. Madero	2020400058	-10%
Rio Conchos	La Boquilla	2020400095	-12%
Rio Conchos	Luis L. Leon	2020400030	2.3%
Rio Conchos	San Gabriel	2020400081	11%
Upper	Caballo	1030400017	5.0%
Upper	Elephant Butte	1020400390	-1.1%

3.2. Comparison of Gaged Flows

Historical streamflow data from six IBWC gages were examined and compared to modeled streamflow values for the same locations (see Table 12 and Figure 29). The comparison plots for historical and modeled streamflow are shown in Appendix J.

Table 12: IBWC Gages Compared to Model Reaches

River	IBWC Gage Name	Gage HydroID	Closest Upstream Node in WEAP
Rio Grande/Bravo	Ft Quitman	1040700004	TCEQ_Gains_1040100174_inflow
Rio Grande/Bravo	Ojinaga/Presidio	1040700009	Rio Conchos Inflow
Pecos River	Pecos	1070700001	TCEQ_Gains_1070100119_Inflow
Rio Salado	Rio Salado	1080700029	TCEQ_Gains_2040100012_Inflow
Rio Grande/Bravo	Rio Grande City	1090700003	TCEQ_Gains_1090100423_Inflow
Rio Grande/Bravo	Brownsville	1090700007	Return Flow Node 24

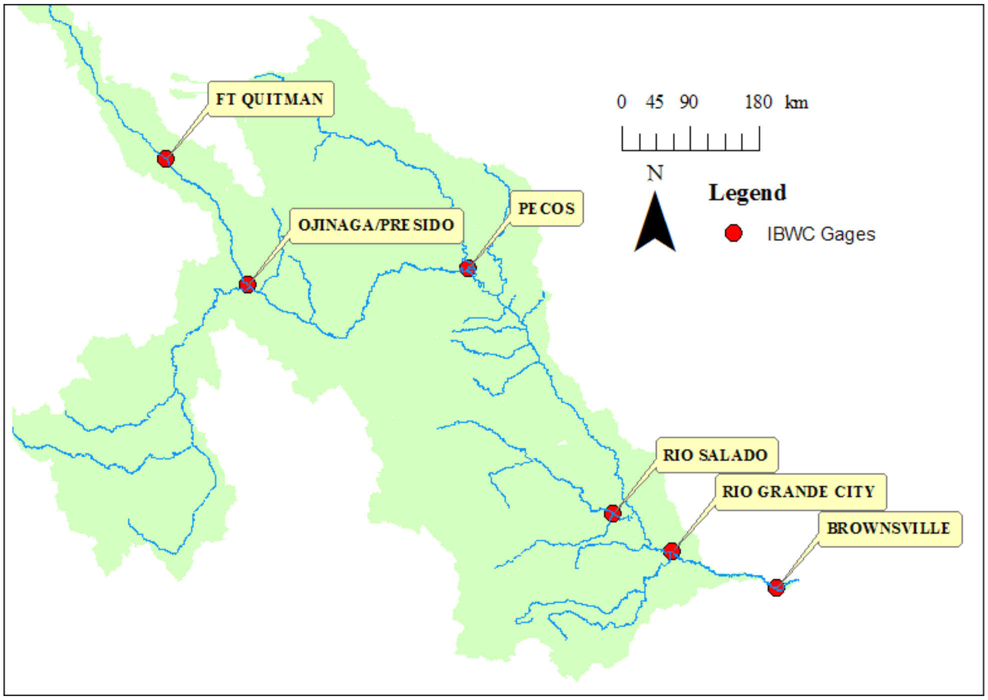


Figure 29: Six IBWC Gages Used for Testing

The percent difference between historical and modeled streamflow for 1988 water year are shown in Table 13. Comparison of the streamflow data and the reservoir data show that under the current representation of reservoir operation too much water is being released and this causes the modeled streamflow values to be higher than the historical values. For example, Rio Grande City is below Falcon reservoir. The modeled streamflow is greater than the historical streamflow and Table 13 shows that Falcon is releasing too much water. In addition to adjusting the reservoir operations to more accurately represent the historical streamflow, the channel losses might need to be increased in some sections to either account for additional channel losses or lowered in sections where estimates may be too high. Note that no model calibration has been performed to modify these loss values.

Table 13: Percent Difference between Historical and Modeled Streamflow for 1988 Water Year

River	IBWC Gage Name	Gage HydroID	Percent Difference
Rio Grande/Bravo	Ft Quitman	1040700004	-5%
Rio Grande/Bravo	Ojinaga/Presidio	1040700009	-14%
Pecos River	Pecos	1070700001	23%
Rio Salado	Rio Salado	1080700029	-5.6%
Rio Grande/Bravo	Rio Grande City	1090700003	-5%
Rio Grande/Bravo	Brownsville	1090700007	-9%

4. CONCLUSION

This report documents the data inputs and key parameters for the WEAP model of the Rio Grande/Bravo river system to be used by the United States and Mexico. The model incorporates both natural and man-made impacts on the basin system.

The model has three main screen views: Schematic, Data, and Results. This report looks at the Data screen view in detail, including the three main branches: Key Assumptions, Demand Sites and Supply and Resources. There are 155 demand sites in the model, representing withdrawals for municipalities, irrigation, and other, with a total annual water requirement of 11,885 MCM. These demand sites are constrained by the Key Assumptions and the Supply and Resources that have been entered into the model. The main sources of water for these demand sites are reservoirs and headflows for each tributary. The other source of water is groundwater which provides additional water for this semi-arid region. The data entered for all of these fields have been provided from multiple sources and some data still need to be entered for the model to be complete; however, the current model demonstrates the current strain on the system and the need to manage these resources for optimal conservation.

The model testing phase reported here for the reservoirs and the IBWC gages demonstrates that for the water year of 1988 modeled storage values are within 12% of the historical storage value. Additionally, parts of the model have more water in the system than shown in the historical records because some of the reservoirs are releasing too much water. The main reason for this difference is that the modeled reservoir operation policies do not directly reflect the actual actions of the operators.

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Appendix A. GRANDE/BRAVO SUBBASIN MAPS

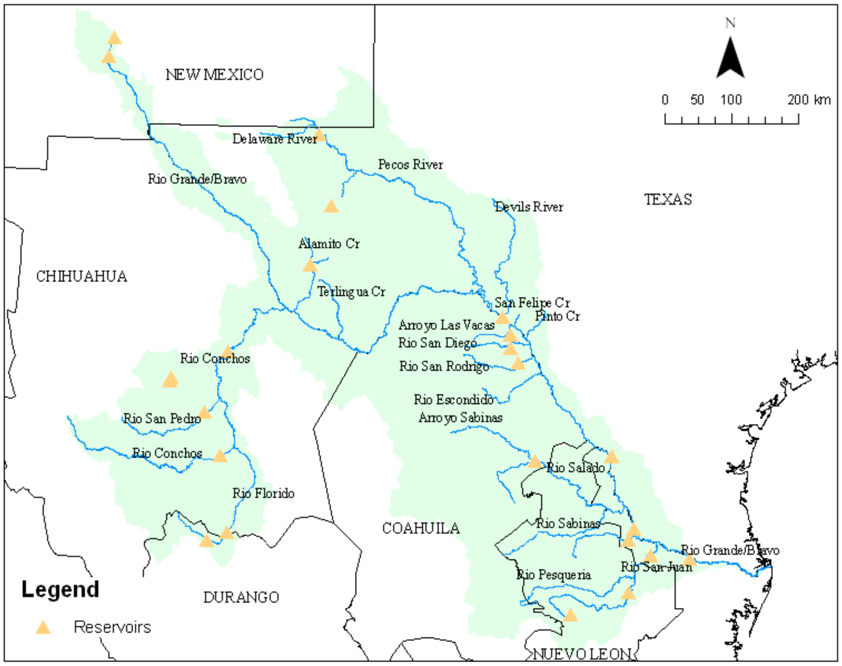

Figure 30: GIS Map of the Rio Grande/Bravo Basin

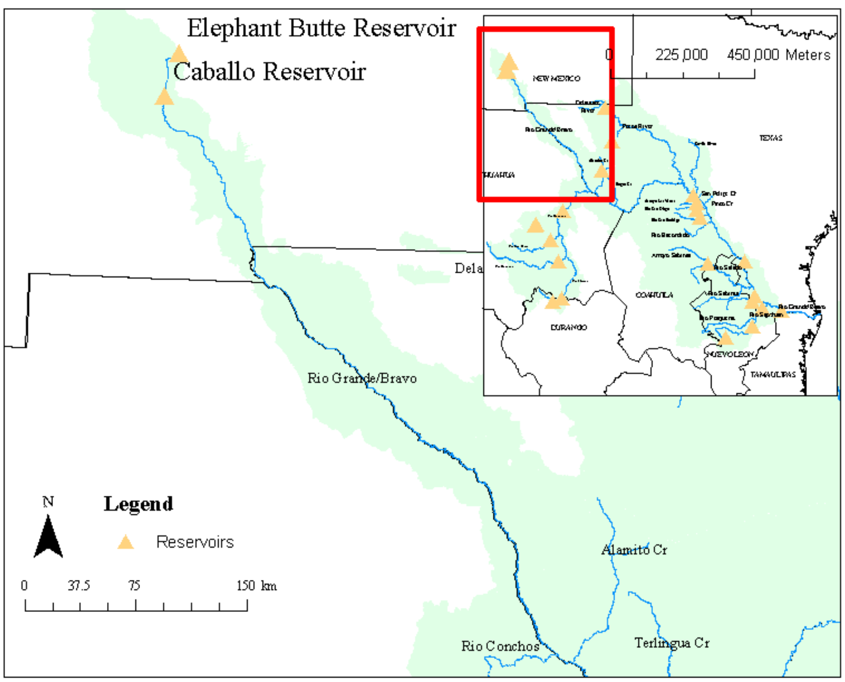

Figure 31: GIS Map of the Upper Rio Grande/Bravo Subbasin

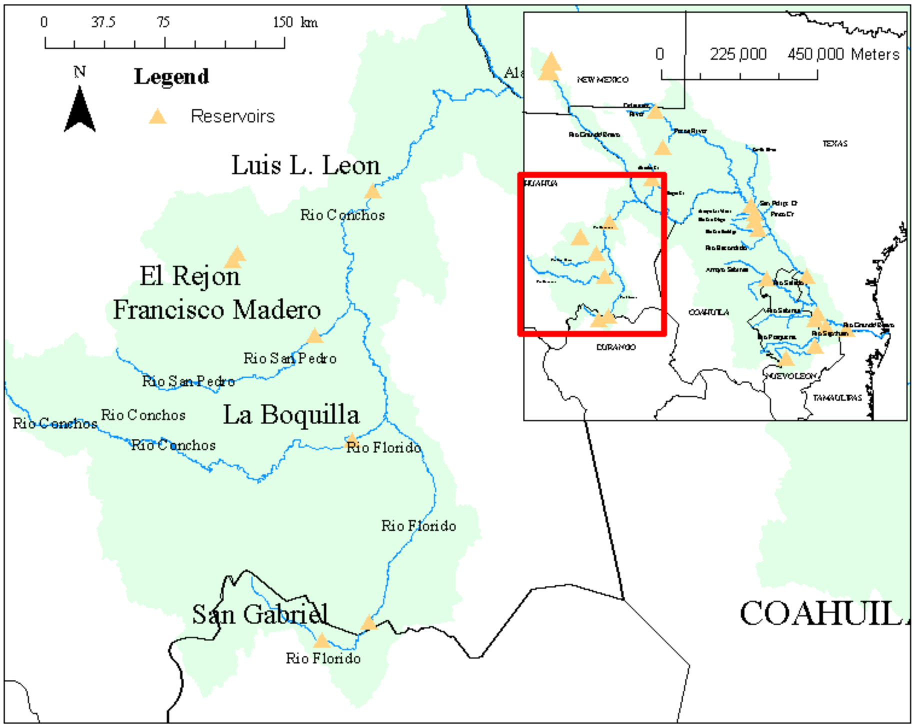

Figure 32: GIS Map of the Rio Conchos Subbasin

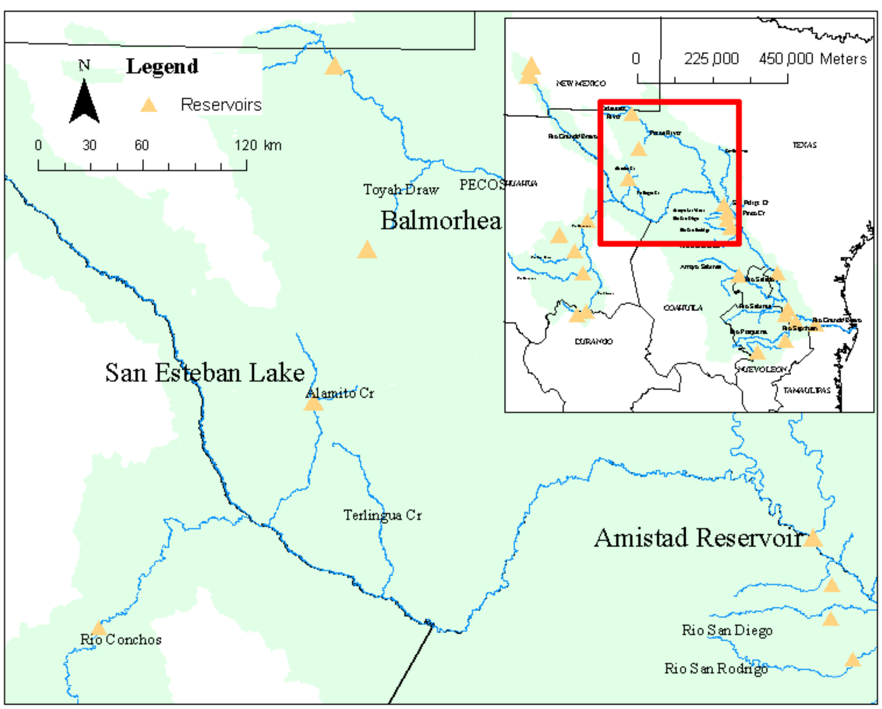

Figure 33: GIS Map of the Middle Rio Grande/Bravo Subbasin

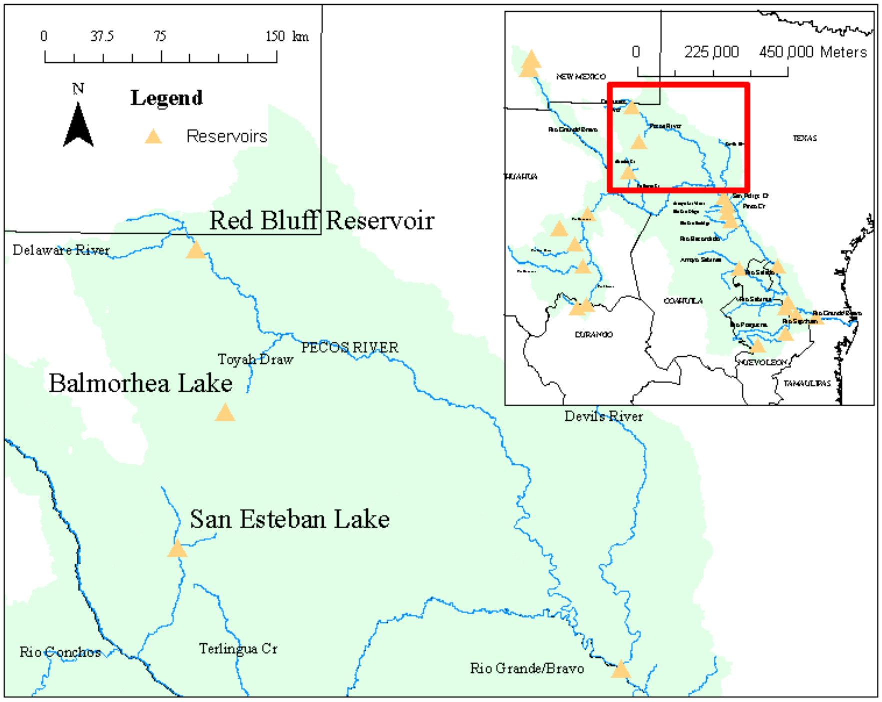

Figure 34: GIS Map of the Pecos River Subbasin

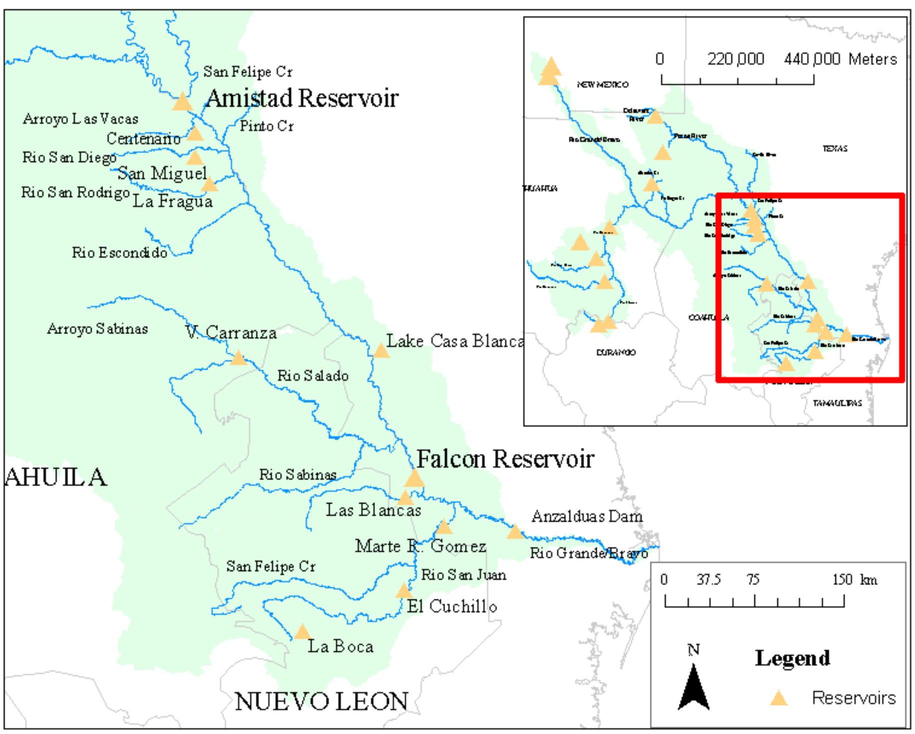

Figure 35: GIS Map of the Lower Rio Grande/Bravo Subbasin

Appendix B. TCEQ Naturalized Flows for the Rio Grande/Bravo Basin

Naturalized Flow Equation

Naturalized flows are calculated to represent historical streamflow in a river basin in the absence of human development and water use. A series of monthly naturalized flows were calculated for the Rio Grande - Rio Bravo basin from El Paso to the Gulf of Mexico and along the major tributaries of the Pecos River and the Rio Conchos as part of the Texas Commission on Environmental Quality (TCEQ) Water Availability Modeling (WAM) project (Brandes 2003). The WAM project utilizes naturalized streamflow in its simulations of water availability for water rights permits. The process of data collection and the methodology used to calculate the naturalized flow are detailed in the report by Brandes (2003). Naturalized flows were calculated for 43 points in the basin (Figure 1). These naturalized flows were calculated monthly for 61 years, over the period of January 1940 to December 2000.

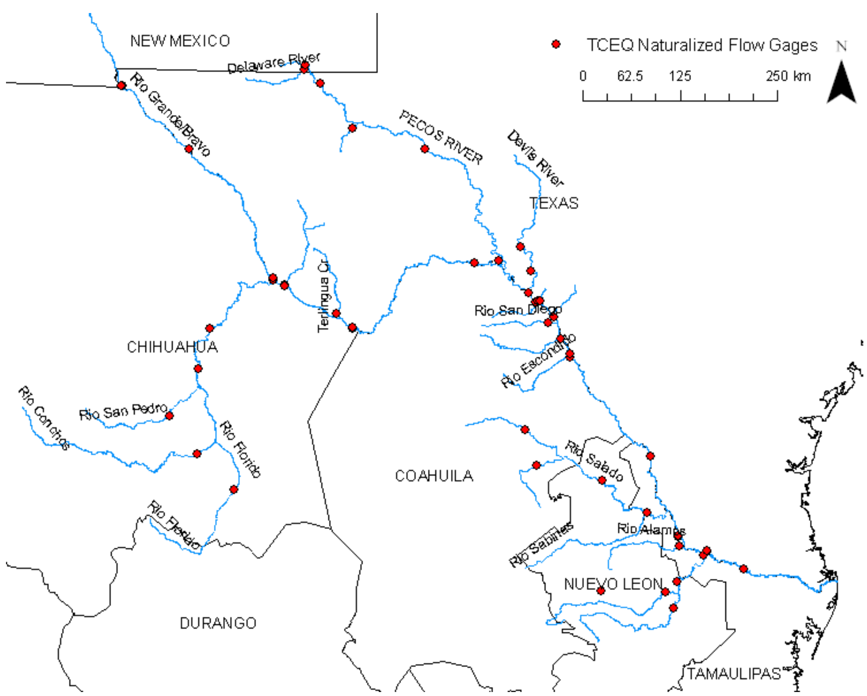

Figure 36 Locations of the TCEQ naturalized flow gages

The TCEQ naturalized flow for various locations j=1,..,43 in the basin, over period t = 1,…,732, with a variable number of upstream locations i, are calculated using the following equation (adapted from Wurbs, 2006):

$$NF_j^t = GF_j^t + \sum_{i=1\cdots ?} D_{ij}^t - \sum_{i=1\cdots ?} RF_{ij}^t + \sum_{i=1\cdots ?} EP_{ij}^t + \sum_{i=1\cdots ?} \Delta S_{ij}^t - \sum_{i=1\cdots ?} Misc_{ij}^t;$$
$$j = 1, \cdots, 43, \; t = 1, \cdots, 732 \qquad (Eq.1)$$

where:

NF_j^t = Naturalized Flow in month *t* at station *j*

GF_j^t = Historical gaged Flow in month *t* at station *j*

D_{ij}^t = Historical water diversions at site *i* upstream of station *j* and downstream of station *j-1* in month *t*

RF_{ij}^t = Historical return flows at site *i* upstream of station *j* and downstream of station *j-1* in month *t*

EP_{ij}^t = Historical reservoir evaporation at site *i* upstream of station *j* and downstream of station *j-1* in month *t*

ΔS_{ij}^t = Historical changes in reservoir storage at site *i* upstream of station *j* and downstream of station *j-1* in month *t*

$Misc_{ij}^t$ = Historical miscellaneous adjustments at site *i* upstream of station *j* and downstream of station *j-1* in month *t*

When available, historical data were collected from both Texas and Mexician agencies for the calculation of naturalized flows. Historical streamflows were collected from multiple U.S. and Mexican agencies including the U.S. Geologic Survey (USGS), International Boundary Water Commission (IBWC) and Comisión Nacional de Agua (CNA). Daily average historical streamflow were summed to create total monthly streamflows. Data on historical diversions include diversions for municipal, industrial, and irrigation uses, as well as the historical return flows, including returns from irrigation, industrial wastewater and municipal wastewater sources. Detailed descriptions of the data sources for these historical flows are contained in Sections 2.1, 2.6, 2.7, and 2.8 of Brandes (2003). Sections 3.3 and 3.4 contain information about data use and assumptions for the naturalized flow calculations.

Changes in reservoir storage were calculated only for major reservoirs defined as having a storage capacity of 5,000 acre-ft (6.2 million m^3) or greater. The changes in storage were calculated from historical records of reservoir storage volumes. The historical reservoir evaporation losses in the above equation are defined as the difference between evaporation and precipitation and they are adjusted to include the runoff that would have occurred in the absence of the reservoir.

Evaporation and precipitation rates in Texas were derived from the Texas Water Development Board (TWDB) one-degree quadrangle maps which were developed using data available for precipitation and evaporation from the National Weather Service and the TWDB. Evaporation rates in Mexico were derived from historical pan evaporation rates and precipitation rates were collected from historical gaged rates. Runoff in the absence of the reservoir was estimated from a regression of historical streamflow and historical precipitation to create a runoff coefficient. Section 1.2 of Brandes (2003) details the methodology for calculating the reservoir evaporative losses, Section 2.5 describes the evaporation data, and Section 2.3 describes the reservoir storage data.

The miscellaneous adjustment term shown in the above naturalized flow equation refers to streamflow additions such as spring flow. Spring flows with significant contributions to streamflow were removed from the naturalized flows and are accounted for separately in the WAM process. Spring flow adjustments are discussed in Sections 2.2 and 3.1 (Brandes 2003).

Loss Factors

Channel loss factors were calculated to represent losses from channel seepage, evaporation, evapotranspiration and other unaccounted losses. Channel loss factors were used to translate upstream flow adjustments, such as diversions or return flows, to the downstream end of a reach during the calculation of naturalized flows. These channel loss factors are also included in the Rio Grande/Bravo WEAP model created by the Physical Assessment Project.

Channel seepage was determined by the analysis of previous studies of the geology and hydrogeology for the Rio Grande/Bravo basin (Brandes 2003). However, when previous studies on channel losses were not available, channel losses were calculated. An analysis of the historical gaged streamflows, taking into account the streamflow losses due to evaporation and plant uptake (evapotranspiration), was completed by subtracting upstream gaged streamflow values from downstream gaged streamflow values for a reach. This analysis was completed with streamflows that occurred during the non-irrigation season (October through March). This time period was selected because it minimized diversions and return flow related to irrigation, minimized evapotranspiration and also minimized evaporation. During the non-irrigation seasons, the temperatures are lower leading to lower evaporation and evapotranspiration rates than at other times of the year when temperatures are higher. With these three factors at a minimum, the loss calculated between gages can be assumed to more closely reflect the channel losses due to seepage.

The total streamflow losses were adjusted to include evaporation and evapotranspiration. Evaporation rates in Texas were derived from the Texas Water Development Board (TWDB) one-degree quadrangle maps. Evaporation rates in Mexico were derived from historical pan evaporation rates. Evapotranspiration rates were calculated from estimates of salt cedar coverage and an annual consumption. The consumption rate was applied to either known acreage of salt cedar or an estimated acreage based on an assumed width of salt cedar growth along a specific reach. Section 3.6 of Brandes (2003) contains a detailed description of the channel loss calculations and data.

Incremental Flow Calculations

The Rio Grande/Bravo WEAP model utilizes the TCEQ naturalized flows for both headflows and incremental flows. In WEAP the upstream streamflow inputs for each river are known as "headflows". In the Rio Grande/Bravo WEAP model, headflows are specified for the mainstem and each main tributary of the Rio Grande/Bravo basin.

Incremental flows were calculated for the Rio Grande/Bravo WEAP model to represent unaccounted gains along stream reaches. These incremental flows for various reaches in the model were calculated by taking the difference between the naturalized flows at an upstream gage and the naturalized flow at the corresponding downstream gage multiplied by the loss factor for the reach.

$$IF_i^t = NF_{down,i}^t - NF_{up,i}^t \left(1 - loss\ factor_i\right) \qquad (Eq.\ 2)$$

where:

IF_i^t	=	Incremental Flow for site *i* in month *t*
$NF_{up,i}^t$	=	Upstream Naturalized Flow for site *i* in month *t*
$NF_{down,i}^t$	=	Downstream Naturalized Flow for site *i* in month *t*

If the results of Equation 2 are negative, then the incremental flow value is set to zero.

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Appendix C. NEW MEXICO AND TEXAS SECTIONS

Table 14: Texas Watermaster Sections (Brandes 2003)

Region M Regional Water Plan		**WEAP Model**	
River Reaches Used by the Texas Watermaster		**Texas Watermaster Sections**	**Description**
Middle Rio Grande	Reach 1	1	Amistad Dam to IBWC Streamflow Gage at Del Rio, Texas
	Reach 2	2	IBWC Streamflow Gage at Del Rio, Texas to IBWC Streamflow Gage at Eagle Pass, Texas
	Reach 3	3	IBWC Streamflow Gage at Eagle Pass, Texas to IBWC Streamflow Gage at El Indio, Texas
	Reach 4	4	IBWC Streamflow Gage at El Indio, Texas to IBWC Streamflow Gage at Laredo, Texas
	Reach 5	5	IBWC Streamflow Gage at Laredo, Texas to San Ygnacio, Texas (at the headwaters of Falcon Reservoir)
	Reach 6	6	San Ygnacio, Texas (at the headwaters of Falcon Reservoir) to Falcon Dam
Lower Rio Grande	Reach 1	7	Falcon Dam to the IBWC Streamflow Gage at Rio Grande City, Texas
	Reach 2	8	IBWC Streamflow Gage at Rio Grande City, Texas to Anzalduas Dam
	Reach 3	9	Anzalduas Dam to Retamal Dam
	Reach 4	10	Retamal Dam to the IBWC Streamflow Gage at San Benito, Texas
	Reach 5	11	IBWC Streamflow Gage at San Benito, Texas to Cameron County WCID No. 6 River Diversion Point
	Reach 6	12	Cameron County WCID No. 6 River Diversion Point to IBWC Streamflow Gage near Brownsville, Texas
	Reach 7	13	IBWC Streamflow Gage near Brownsville, Texas to the Gulf of Mexico

Figure 3-3 Flow Distribution Along the RGCP

Inflow / Outflow	Location	Average Flow (cfs) Mar-Oct	Nov-Feb	Annual
	Caballo Dam Release[b]	1,301	167	923
Percha Lateral/Arrey Canals (350 cfs)[a]	Water Diversion at Percha Dam	*(160)*	*(20)*	*(114)*
	Downstream Release[c]	1,141	147	809
Garfield, Hatch, Angostura and Rincon Drains	Return Flows[d]	78	16	58
	Seldon Canyon Flow[b]	1,219	163	867
Leasburg Canal (625 cfs)[a]	Water Diversion at Leasburg Dam[b]	*(265)*	*(13)*	*(181)*
	Downstream Release[c]	954	150	686
Seldon & Picacho Drains	Return Flows[e]	80	4	54
East and West Canals (950 cfs)[a]	Water Diversion at Mesilla Dam[b]	*(455)*	*(27)*	*(312)*
	Downstream Release[c]	579	127	428
Del Rio, La Mesa, Anthony, East, Montoya Drains, other	Return Flows[d]	196	97	163
	Upstream of Amer. Dam[b]	774	224	591
American Canal (1,200 cfs)[a]	Water Diversion at American Dam[b]	*(595)*	*0*	*(397)*
	Downstream Release[c]	179	224	194
Acequia Madre	Water Diversion at International Dam[b]	*(102)*	*0*	*(68)*

a. Maximum diversion capacities, in parenthesis, from U.S. Bureau of Reclamation (www.usbr.gov)

b. Highlighted values indicate stream flows. Values as reported in the Draft EIS, El Paso-Las Cruces Regional Sustainable Water Project (USIBWC & EPWU/PSB, 2000: Table 3.3-17).

c. Releases from dams were calculated as the difference between upstream flow and diverted flow.

d. Return flows were calculated as the difference between upstream and downstream flows.

e. Mesilla Valley return flows represent 30% of the diverted flow (USIBWC & EPWU/PSB, 2000, p. 3-10)

Figure 37: New Mexico Diversions Data (IBWC DEIS 2003a)

Table 15: Texas County Abbreviations for Groundwater Nodes and Demands in Texas

Texas County Name	Abbreviation
Anderson	AN
Brewster	BS
Cameron	CF
Crane	CR
Crockett	CX
Culberson	CU
Dimmitt	DM
Ector	EC
Edwards	ED
El Paso	EP
Hidalgo	HG
Hudspeth	HZ
Jeff Davis	JD
Jim Hogg	JH
Jim Wells	JW
Kinney	KY
Loving	LV
Maverick	MV
Pecos	PC
Presidio	PS
Reagan	RG
Schleicher	SL
Starr	SR
Sutton	SU
Terrell	TE
Upton	UT
Val Verde	VV
Ward	WR
Webb	WB
Winkler	WK
Zapata	ZP

Appendix D. LOSSES IN WEAP MODEL REACHES

Table 16: WEAP Inputs for Combined Losses per Reach (TCEQ 2005a)

Stream Name	WEAP Reach	Losses (%)
Alamito Crk	Reaches\Below Alamito Crk Headflow	9
Arroyo Las Vacas	Reaches\Below Arroyo Las Vacas Headflow	10
Arroyo Sabinas	Reaches\Below Arroyo Sabinas Headflow	1
Delaware River	Reaches\Below Delaware River Headflow	9
Devils River	Reaches\Below TCEQ_Gains_1040100182 Inflow	5
Devils River	Reaches\Below Devils River Headflow	6
Pecos River	Reaches\Below TCEQ_Gains_1070100117 Inflow	5.5
Pecos River	Reaches\Below TCEQ_Gains_1070100119 Inflow	15
Pecos River	Reaches\Below TCEQ_Gains_1070100118 Inflow	24
Pinto Crk	Reaches\Below Pinto Crk Headflow	5
Rio Alamos	Reaches\Below Las Blancas	3
Rio Conchos	Reaches\Below Withdrawal Node 2	17
Rio Conchos	Reaches\Below Rio San Pedro Inflow	20
Rio Escondido	Reaches\Below Rio Escondido Headflow	9
Rio Florido	Reaches\Below Withdrawal Node 6	18
Rio Grande_Rio Bravo	Reaches\Below Withdrawal Node 11	0
Rio Grande_Rio Bravo	Reaches\Below TCEQ_Gains_1080100377 Inflow	1
Rio Grande_Rio Bravo	Reaches\Below TCEQ_Gains_1040100177 Inflow	2
Rio Grande_Rio Bravo	Reaches\Below TCEQ_Gains_1040100180 Inflow	2
Rio Grande_Rio Bravo	Reaches\Below TCEQ_Gains_1090100423 Inflow	4
Rio Grande_Rio Bravo	Reaches\Below TCEQ_Gains_1090100422 Inflow	5
Rio Grande_Rio Bravo	Reaches\Below TCEQ_Gains_1080100382 Inflow	9
Rio Grande_Rio Bravo	Reaches\Below TCEQ_Gains_1040100179 Inflow	10
Rio Grande_Rio Bravo	Reaches\Below TCEQ_Gains_1080100380 Inflow	13
Rio Grande_Rio Bravo	Reaches\Below TCEQ_Gains_1080100381 Inflow	14
Rio Grande_Rio Bravo	Reaches\Below Return Flow Node 9	20
Rio Grande_Rio Bravo	Reaches\Below TCEQ_Gains_1040100175 Inflow	46
Rio Pesqueria	Reaches\Below TCEQ_Gains_2060100004 Inflow	11
Rio Salado	Reaches\Below Rio Salado Headflow	2
Rio Salado	Reaches\Below TCEQ_Gains_2040100011 Inflow	6
Rio Salado	Reaches\Below TCEQ_Gains_2040100012 Inflow	6
Rio Salinas	Reaches\Below Rio Salinas Headflow	7
Rio San Diego	Reaches\Below Rio San Diego Headflow	10
Rio San Juan	Reaches\Below TCEQ_Gains_2060100006 Inflow	3
Rio San Juan	Reaches\Below Marte R. Gomez	3
Rio San Juan	Reaches\Below El Cuchillo	13
Rio San Rodrigo	Reaches\Below Rio San Rodrigo Headflow	9
San Felipe Crk	Reaches\Below San Felipe Crk Headflow	1
Terlingua Crk	Reaches\Below Terlingua Crk Headflow	5

Appendix E. WEAP Demand Site Annual Water Use Rates, Priorities, Monthly Variation and Consumption

Mexican Demand Sites

Table 17: Mexican Municipality Annual Water Use Rate, Percent Consumption and Priority

WEAP Mexican Municipal Demand Site	Annual Water Use Rate (MCM)	Consumption %	Demand Priority	Monthly Variation % Share											
				Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
MX_Muni_Camargo	20	78.00	Key\Priorities\Municipal	8.1	8.4	8.7	7.7	7.3	8.2	7.6	8.4	8.5	9.3	9.0	8.6
MX_Muni_Cd Acuna	3	50.00	Key\Priorities\Municipal	8.1	8.4	8.7	7.7	7.3	8.2	7.6	8.4	8.5	9.3	9.0	8.6
MX_Muni_Cd Anhuac	8		Key\Priorities\Municipal	8.1	8.4	8.7	7.7	7.3	8.2	7.6	8.4	8.5	9.3	9.0	8.6
MX_Muni_Cd Juarez	132	26.11	Key\Priorities\Municipal	8.1	8.4	8.7	7.7	7.3	8.2	7.6	8.4	8.5	9.3	9.0	8.6
MX_Muni_Cd. Chihuahua	15.6		Key\Priorities\Municipal	8.1	8.4	8.7	7.7	7.3	8.2	7.6	8.4	8.5	9.3	9.0	8.6
MX_Muni_Cd. Miguel Aleman	9	78.93	Key\Priorities\Municipal	8.1	8.4	8.7	7.7	7.3	8.2	7.6	8.4	8.5	9.3	9.0	8.6
MX_Muni_Matamoros	48	98	Key\Priorities\Municipal	8.1	8.4	8.7	7.7	7.3	8.2	7.6	8.4	8.5	9.3	9.0	8.6
MX_Muni_Metropolitan Monterrey	187	29.03	Key\Priorities\Municipal	8.1	8.4	8.7	7.7	7.3	8.2	7.6	8.4	8.5	9.3	9.0	8.6
MX_Muni_Nuevo Laredo	36.1	30.06	Key\Priorities\Municipal	8.1	8.4	8.7	7.7	7.3	8.2	7.6	8.4	8.5	9.3	9.0	8.6
MX_Muni_Piedras Negras	36	81	Key\Priorities\Municipal	8.1	8.4	8.7	7.7	7.3	8.2	7.6	8.4	8.5	9.3	9.0	8.6
MX_Muni_Reynosa	67	67	Key\Priorities\Municipal	8.1	8.4	8.7	7.7	7.3	8.2	7.6	8.4	8.5	9.3	9.0	8.6

Table 18: Mexican Irrigation District Annual Water Use Rate, Priority and Monthly Variation

Irrigation Demand Site	Annual Water Use Rate (MCM)	Consumption %	Demand Priority	Monthly Variation % Share											
				Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
MX_IRR_DR 004 Don Martin	352		Key\Priorities\Irrigation1	0.8	1.7	5.7	5.0	14.5	16.5	8.6	16.5	18.5	5.9	3.4	2.9
MX_IRR_DR 005 Delicias	1131	75	Key\Priorities\Irrigation1	6.5	0.7	0.4	7.4	7.5	12.7	13.2	10.3	12.9	12.7	9.7	6.2
MX_IRR_DR 006 Palestina	53		Key\Priorities\Irrigation1	9.6	5.7	5.0	5.5	7.3	8.8	9.2	12.3	9.4	7.8	8.7	10.7
MX_IRR_DR 009 Valle de Juarez	74		Key\Priorities\Irrigation3	1.8	0.9	0.0	0.0	1.8	9.1	20.0	20.0	20.0	13.6	7.3	5.5
MX_IRR_DR 025 Bajo Rio Bravo	861	70	Key\Priorities\Irrigation1	7.3	3.7	3.6	9.4	5.8	5.6	14.6	16.9	10.2	6.7	10.0	6.2
MX_IRR_DR 026 Bajo Rio San Juan	464		Key\Priorities\Irrigation1	7.3	3.7	3.6	9.4	5.8	5.6	14.6	16.9	10.2	6.7	10.0	6.2
MX_IRR_DR 031 Las Lajas*	24		Key\Priorities\Irrigation1	3.0	0.5	1.3	14.5	11.0	3.1	19.4	23.9	12.2	2.7	5.5	2.8
MX_IRR_DR 050 Acuna Falcon	29		Key\Priorities\Irrigation1	9.6	5.7	5.0	5.5	7.3	8.8	9.2	12.3	9.4	7.8	8.7	10.7
MX_IRR_DR 090 Bajo Rio Conchos	85	75	Key\Priorities\Irrigation3	4.1	4.5	6.0	8.8	9.5	10.2	11.1	9.3	11.3	11.0	9.0	5.3
MX_IRR_DR 103 Rio Florido	107	75	Key\Priorities\Irrigation1	2.4	2.8	2.0	3.0	5.5	5.5	10.7	17.7	17.8	14.1	13.7	4.9
MX_IRR_Pesqueria y Ayancual Ag	124		Key\Priorities\Irrigation1												
MX_IRR_ Rio Pesqueria Ag	33		Key\Priorities\Irrigation1												
MX_IRR_Sn Juan Ramos Pilon	229		Key\Priorities\Irrigation1												

Table 19: Uderales Demand, Annual Water Use Rate, Priority and Monthly Variation (Villalobos 2001)

WEAP Uderales Demand Site	Annual Water Use Rate (MCM)	Demand Priority	Monthly Variation % Share											
			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
MX_GW_URs Agualeguas Ramones	2.00	Key\Priorities\Groundwater_MX	7.30	3.70	3.60	9.40	5.80	5.60	14.60	16.90	10.20	6.70	10.00	6.20
MX_GW_URs Aldama San Diego	20.70	Key\Priorities\Groundwater_MX	6.47	0.65	0.40	7.42	7.47	12.65	13.22	10.31	12.90	12.66	9.69	6.16
MX_GW_URs Allende Piedras Negras	126.00	Key\Priorities\Groundwater_MX	9.60	5.70	5.00	5.50	7.30	8.80	9.20	12.30	9.40	7.80	8.70	10.70
MX_GW_URs Alto Río San Pedro	11.00	Key\Priorities\Groundwater_MX	6.47	0.65	0.40	7.42	7.47	12.65	13.22	10.31	12.90	12.66	9.69	6.16
MX_GW_URs Área Metropolitana de Monterrey	0.80	Key\Priorities\Groundwater_MX	7.30	3.70	3.60	9.40	5.80	5.60	14.60	16.90	10.20	6.70	10.00	6.20
MX_GW_URs Bajo Río Bravo	68.39	Key\Priorities\Groundwater_MX	7.30	3.70	3.60	9.40	5.80	5.60	14.60	16.90	10.20	6.70	10.00	6.20
MX_GW_URs Bajo Río Conchos	10.93	Key\Priorities\Groundwater_MX	4.07	4.47	6.02	8.78	9.47	10.19	11.07	9.33	11.32	11.00	8.95	5.33
MX_GW_URs Bocoyna	0.15	Key\Priorities\Groundwater_MX	2.37	2.76	1.97	2.96	5.49	5.45	10.72	17.74	17.84	14.09	13.72	4.89
MX_GW_URs Cañón del Derramadero	15.00	Key\Priorities\Groundwater_MX	7.30	3.70	3.60	9.40	5.80	5.60	14.60	16.90	10.20	6.70	10.00	6.20
MX_GW_URs Carichi Nonoava	0.82	Key\Priorities\Groundwater_MX	2.37	2.76	1.97	2.96	5.49	5.45	10.72	17.74	17.84	14.09	13.72	4.89
MX_GW_URs Cerro Colorado la Partida	5.50	Key\Priorities\Groundwater_MX	9.60	5.70	5.00	5.50	7.30	8.80	9.20	12.30	9.40	7.80	8.70	10.70
MX_GW_URs Chihuahua Sacramento	44.49	Key\Priorities\Groundwater_MX	6.47	0.65	0.40	7.42	7.47	12.65	13.22	10.31	12.90	12.66	9.69	6.16
MX_GW_URs China General Bravo	1.00	Key\Priorities\Groundwater_MX	7.30	3.70	3.60	9.40	5.80	5.60	14.60	16.90	10.20	6.70	10.00	6.20
MX_GW_URs Citricola Norte	106.00	Key\Priorities\Groundwater_MX	7.30	3.70	3.60	9.40	5.80	5.60	14.60	16.90	10.20	6.70	10.00	6.20
MX_GW_URs Cuatrocienegas	7.05	Key\Priorities\Groundwater_MX	0.84	1.74	5.72	4.98	14.50	16.50	8.57	16.50	18.50	5.88	3.40	2.87
MX_GW_URs Cuatrocienegas Ocampo	48.63	Key\Priorities\Groundwater_MX	0.84	1.74	5.72	4.98	14.50	16.50	8.57	16.50	18.50	5.88	3.40	2.87
MX_GW_URs Hidalgo	3.80	Key\Priorities\Groundwater_MX	9.60	5.70	5.00	5.50	7.30	8.80	9.20	12.30	9.40	7.80	8.70	10.70
MX_GW_URs Jimenez Camargo	559.00	Key\Priorities\Groundwater_MX	2.37	2.76	1.97	2.96	5.49	5.45	10.72	17.74	17.84	14.09	13.72	4.89
MX_GW_URs Laguna de Mexicanos	21.40	Key\Priorities\Groundwater_MX	6.47	0.65	0.40	7.42	7.47	12.65	13.22	10.31	12.90	12.66	9.69	6.16
MX_GW_URs Lampazos Anáhuac	63.00	Key\Priorities\Groundwater_MX	0.84	1.74	5.72	4.98	14.50	16.50	8.57	16.50	18.50	5.88	3.40	2.87
MX_GW_URs Lampazos Villaldama	6.00	Key\Priorities\Groundwater_MX	0.84	1.74	5.72	4.98	14.50	16.50	8.57	16.50	18.50	5.88	3.40	2.87
MX_GW_URs Manuel Benavides	0.66	Key\Priorities\Groundwater_MX	4.07	4.47	6.02	8.78	9.47	10.19	11.07	9.33	11.32	11.00	8.95	5.33
MX_GW_URs Meoqui Delicias	220.86	Key\Priorities\Groundwater_MX	6.47	0.65	0.40	7.42	7.47	12.65	13.22	10.31	12.90	12.66	9.69	6.16
MX_GW_URs Monclova	27.00	Key\Priorities\Groundwater_MX	0.84	1.74	5.72	4.98	14.50	16.50	8.57	16.50	18.50	5.88	3.40	2.87
MX_GW_URs Paredón	22.36	Key\Priorities\Groundwater_MX	7.30	3.70	3.60	9.40	5.80	5.60	14.60	16.90	10.20	6.70	10.00	6.20
MX_GW_URs Parral Valle del Verano	8.76	Key\Priorities\Groundwater_MX	2.37	2.76	1.97	2.96	5.49	5.45	10.72	17.74	17.84	14.09	13.72	4.89
MX_GW_URs Región Carbonífera	4.91	Key\Priorities\Groundwater_MX	9.60	5.70	5.00	5.50	7.30	8.80	9.20	12.30	9.40	7.80	8.70	10.70
MX_GW_URs Región Manzanera Zapaliname	68.45	Key\Priorities\Groundwater_MX	7.30	3.70	3.60	9.40	5.80	5.60	14.60	16.90	10.20	6.70	10.00	6.20
MX_GW_URs Sabinas Paras	15.00	Key\Priorities\Groundwater_MX	0.84	1.74	5.72	4.98	14.50	16.50	8.57	16.50	18.50	5.88	3.40	2.87
MX_GW_URs Saltillo Ramos Arizpe	21.27	Key\Priorities\Groundwater_MX	7.30	3.70	3.60	9.40	5.80	5.60	14.60	16.90	10.20	6.70	10.00	6.20
MX_GW_URs Santa Fe del Pino	0.80	Key\Priorities\Groundwater_MX	4.07	4.47	6.02	8.78	9.47	10.19	11.07	9.33	11.32	11.00	8.95	5.33
MX_GW_URs Valle de Juárez	143.44	Key\Priorities\Groundwater_MX												
MX_GW_URs Valle de Zaragoza	0.08	Key\Priorities\Groundwater_MX	2.37	2.76	1.97	2.96	5.49	5.45	10.72	17.74	17.84	14.09	13.72	4.89

Table 20: U.S. Municipality Demand Annual Water Use Rate, Percent Consumption, Priority and Monthly Variation

WEAP Municpal Demand Site	Annual Water Use Rate (MCM)	Demand Priority	Monthly Variation % Share											
			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
US_Muni_Below Conchos Municipal	0.83	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_Brownsville	51.5	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_City of Balmorhea	0.79	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_Del Rio	14.1	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_Eagle Pass	9.51	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_El Paso	13.6	Key\Priorities\Municipal	1.50	0.00	0.00	0.20	1.50	9.90	13.80	13.70	15.20	15.30	15.20	13.70
US_Muni_Laredo	52.7	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_McAllen	0.84	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_Muni Maverick	1.85	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_Water Master Section 2 Municipal	0.00	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_Water Master Section 5 Municipal	2.52	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_Water Master Section 6 Municipal	2.18	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_Water Master Section 7 Municipal	6.16	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_Water Master Section 8 Municipal	41.9	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70
US_Muni_Water Master Section 9 to 13 Municipal	161	Key\Priorities\Municipal	8.10	7.00	6.80	6.80	6.50	7.70	8.30	9.10	9.40	11.00	10.60	8.70

U.S. Demand Sites

Table 21: U.S. Municipality Demand Monthly Consumption Percentage

WEAP Municpal Demand Site	Annual Water Use Rate (MCM)	Monthly Consumption %											
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
US_Muni_Below Conchos Municipal	0.83	8.08	7.62	7.14	7.52	7.77	8.43	8.23	8.83	9.24	9.86	9.00	8.28
US_Muni_Brownsville	51.5	64.70	71.13	67.93	67.19	69.48	67.18	71.47	75.61	75.55	75.98	72.85	72.87
US_Muni_City of Balmorhea	0.79	58.06	54.75	51.32	54.01	55.78	60.59	59.12	63.43	66.35	70.81	64.67	59.47
US_Muni_Del Rio	14.1	49.75	26.16	26.73	5.20	18.07	55.67	61.69	55.70	61.87	45.65	61.57	49.80
US_Muni_Eagle Pass	9.51	47.42	42.01	33.30	44.97	49.33	54.55	69.10	72.05	73.29	77.34	58.91	60.92
US_Muni_El Paso	13.6	58.06	54.75	51.32	54.01	55.78	60.59	59.12	63.43	66.35	70.81	64.67	59.47
US_Muni_Laredo	52.7	60.83	60.13	57.24	60.77	61.59	60.99	56.68	62.49	64.88	73.40	65.46	60.66
US_Muni_McAllen	0.84	58.06	54.75	51.32	54.01	55.78	60.59	59.12	63.43	66.35	70.81	64.67	59.47
US_Muni_Muni Maverick	1.85	58.06	54.75	51.32	54.01	55.78	60.59	59.12	63.43	66.35	70.81	64.67	59.47
US_Muni_Water Master Section 2 Municipal	0.00	58.06	54.75	51.32	54.01	55.78	60.59	59.12	63.43	66.35	70.81	64.67	59.47
US_Muni_Water Master Section 5 Municipal	2.52	58.06	54.75	51.32	54.01	55.78	60.59	59.12	63.43	66.35	70.81	64.67	59.47
US_Muni_Water Master Section 6 Municipal	2.18	58.06	54.75	51.32	54.01	55.78	60.59	59.12	63.43	66.35	70.81	64.67	59.47
US_Muni_Water Master Section 7 Municipal	6.16	8.08	7.62	7.14	7.52	7.77	8.43	8.23	8.83	9.24	9.86	9.00	8.28
US_Muni_Water Master Section 8 Municipal	41.9	58.06	54.75	51.32	54.01	55.78	60.59	59.12	63.43	66.35	70.81	64.67	59.47
US_Muni_Water Master Section 9 to 13 Municipal	161	58.06	54.75	51.32	54.01	55.78	60.59	59.12	63.43	66.35	70.81	64.67	59.47

Table 22a: U.S. Irrigation Demand Annual Water Use Rate, Percent Consumption, Priority and Monthly Variation

WEAP US Irrigation Demand Site	Annual Water Use Rate (MCM)	Demand Priority	Monthly Variation % Share											
			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
US_IRR_AG EPCWID No.1	464	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Below Conchos Agriculture	31.5	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Comanche Creek Water Rights AG	18.9	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Coyanosa Draw Water Rights AG	23.1	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Forgotten River Agriculture	44.6	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Joe B Chandler et al Estate	0.173	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_John Edwards Robbins	0.010	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Mattie Banner Bell	0.000	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Red Bluff Power Control	82.2	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Red Bluff Ward WID 2	32.0	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Red Bluff Water Pecos WID 3	0.00	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Red Bluff Water Power Loving	0.38	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Red Bluff Water Reeves WID2	2.96	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Red Bluff WID 1	0.00	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Red Bluff WID 2	5.97	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Red Bluff WID 2	12.1	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Red Bluff WID 3	4.67	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Sandia Creek Water Rights AG	53.0	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Six Shooter Draw Water Rights	8.73	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_The Nature Conservancy	0.65	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Wilson Harden Cy Banner	0.19	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11
US_IRR_Wilson Hardin Cy Banner	0.06	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11

Table 23b: U.S. Irrigation Demand Annual Water Use Rate, Percent Consumption, Priority and Monthly Variation

WEAP US Irrigation Demand Site	Annual Water Use Rate (MCM)	Demand Priority	Monthly Variation % Share											
			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
US_IRR_Water Master Section 2 Agriculture	17.2	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11.0
US_IRR_Water Master Section 2 Agriculture_A	117	Key\Priorities\Type_A_Irrigation	7.9	7.8	7.7	7.4	7.9	9.1	9.3	9.5	8.8	8.5	8.3	7.6
US_IRR_Water Master Section 2 Agriculture_B	0.021	Key\Priorities\Type_B_Irrigation	7.9	7.8	7.7	7.4	7.9	9.1	9.3	9.5	8.8	8.5	8.3	7.6
US_IRR_Water Master Section 3 4 Agriculture_A	9.68	Key\Priorities\Type_A_Irrigation	7.9	7.8	7.7	7.4	7.9	9.1	9.3	9.5	8.8	8.5	8.3	7.6
US_IRR_Water Master Section 3 4 Agriculture	3.15	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11.0
US_IRR_Water Master Section 3 4 Agriculture_B	1.20	Key\Priorities\Type_B_Irrigation	7.9	7.8	7.7	7.4	7.9	9.1	9.3	9.5	8.8	8.5	8.3	7.6
US_IRR_Water Master Section 3 4 Mining_A	0.854	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_IRR_Water Master Section 5 Agriculture	2.15	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11.0
US_IRR_Water Master Section 5 Agriculture_A	4.47	Key\Priorities\Type_A_Irrigation	7.9	7.8	7.7	7.4	7.9	9.1	9.3	9.5	8.8	8.5	8.3	7.6
US_IRR_Water Master Section 5 Agriculture_B	8.97	Key\Priorities\Type_B_Irrigation	7.9	7.8	7.7	7.4	7.9	9.1	9.3	9.5	8.8	8.5	8.3	7.6
US_IRR_Water Master Section 6 Agriculture_B	2.04	Key\Priorities\Type_B_Irrigation	7.5	7.0	5.3	5.9	7.7	10.1	10.2	10.0	8.7	10.4	10.6	6.5
US_IRR_Water Master Section 6 Agriculture_A	2.26	Key\Priorities\Type_A_Irrigation	7.5	7.0	5.3	5.9	7.7	10.1	10.2	10.0	8.7	10.4	10.6	6.5
US_IRR_Water Master Section 7 Agriculture_A	0.459	Key\Priorities\Type_A_Irrigation	7.5	7.0	5.3	5.9	7.7	10.1	10.2	10.0	8.7	10.4	10.6	6.5
US_IRR_Water Master Section 7 Agriculture_B	5.508	Key\Priorities\Type_B_Irrigation	7.5	7.0	5.3	5.9	7.7	10.1	10.2	10.0	8.7	10.4	10.6	6.5
US_IRR_Water Master Section 8 Agriculture	0.485	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11.0
US_IRR_Water Master Section 8 Agriculture_A	259	Key\Priorities\Type_A_Irrigation	7.5	7.0	5.3	5.9	7.7	10.1	10.2	10.0	8.7	10.4	10.6	6.5
US_IRR_Water Master Section 8 Agriculture_B	69.6	Key\Priorities\Type_B_Irrigation	7.5	7.0	5.3	5.9	7.7	10.1	10.2	10.0	8.7	10.4	10.6	6.5
US_IRR_Water Master Section 9 to 13 Agriculture_A	1001	Key\Priorities\Type_A_Irrigation	7.5	7.0	5.3	5.9	7.7	10.1	10.2	10.0	8.7	10.4	10.6	6.5
US_IRR_Water Master Section 9 to 13 Agriculture_B	70.0	Key\Priorities\Type_B_Irrigation	7.5	7.0	5.3	5.9	7.7	10.1	10.2	10.0	8.7	10.4	10.6	6.5
US_IRR_Water Master Section1 Agriculture	1.43	Key\Priorities\Type_A_Irrigation	6.8	2.5	1.6	2.2	3.5	11.8	8.8	10.2	13.4	14.6	13.6	11.0

Table 24: U.S. Other Demand Annual Water Use Rate, Percent Consumption, Priority and Monthly Variation

WEAP US Other Demand Site	Annual Water Use Rate (MCM)	Demand Priority	Monthly Variation % Share											
			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
US_Other_Below Conchos Other	0.0247	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Forgotten River Industrial	0.2200	Key\Priorities\Other	8.1	7.0	6.8	6.8	6.5	7.7	8.3	9.1	9.4	11.0	10.6	8.7
US_Other_Forgotten River Other	0.0641	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Water Master Section 2 Other	0.0002	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Water Master Section 3 4 Other	0.0617	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Water Master Section 3 4 Mining_B	2.0794	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Water Master Section 5 Mining_A	1.9845	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Water Master Section 5 Mining_B	4.9022	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Water Master Section 6 Mining	0.1357	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Water Master Section 6 Mining_A	0.0052	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Water Master Section 6 Mining_B	0.0389	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Water Master Section 7 Mining	0.0496	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Water Master Section 9 to 13 Mining_A	0.0004	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3
US_Other_Water Master Section 9 to 13 Mining_B	0.0108	Key\Priorities\Other	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3

Table 25: U.S. Other Demand Monthly Consumption Percentage

WEAP US Other Demand Site	Annual Water Use Rate (MCM)	Demand Priority	Monthly Consumption %											
			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
US_Other_Below Conchos Other	0.0247	Key\Priorities\Other												
US_Other_Forgotten River Industrial	0.2200	Key\Priorities\Other	81.7	76.9	90.3	78.4	75.9	72.2	85.2	89.8	84.0	88.0	88.2	86.9
US_Other_Forgotten River Other	0.0641	Key\Priorities\Other												
US_Other_Water Master Section 2 Other	0.0002	Key\Priorities\Other												
US_Other_Water Master Section 3 4 Other	0.0617	Key\Priorities\Other												
US_Other_Water Master Section 3 4 Mining_B	2.0794	Key\Priorities\Other												
US_Other_Water Master Section 5 Mining_A	1.9845	Key\Priorities\Other												
US_Other_Water Master Section 5 Mining_B	4.9022	Key\Priorities\Other												
US_Other_Water Master Section 6 Mining	0.1357	Key\Priorities\Other												
US_Other_Water Master Section 6 Mining_A	0.0052	Key\Priorities\Other												
US_Other_Water Master Section 6 Mining_B	0.0389	Key\Priorities\Other												
US_Other_Water Master Section 7 Mining	0.0496	Key\Priorities\Other												
US_Other_Water Master Section 9 to 13 Mining_A	0.0004	Key\Priorities\Other												
US_Other_Water Master Section 9 to 13 Mining_B	0.0108	Key\Priorities\Other												

Appendix F. WEAP Reservoir Inputs

Table 26: Parameters Entered into WEAP for the Reservoirs

Owner	River	Reservoir	Storage Capacity	Initial Storage	Volume Elevation Curve	Net Evap.	Top of Cons.	Top of Buffer	Top of Inactive	Buffer Coefficient	Priority
IBWC/CILA	Rio Grande/Bravo	Amistad	X	X	X	X	X		X		98
IBWC/CILA	Rio Grande/Bravo	Falcon	X	X	X	X	X		X		98
IBWC/CILA	Rio Grande/Bravo	Anzalduas Dam	X	X	X						98
Mexico	Rio San Juan	El Cuchillo	X	X	X	X	X		X		97
Mexico	Rio San Pedro	F. Madero	X	X	X	X	X	X	X	X	98
Mexico	Rio Conchos	La Boquilla	X	X	X	X	X	X	X	X	98
Mexico	Rio San Rodrigo	La Fragua	X		X		X		X		98
Mexico	Rio Alamos	Las Blancas	X				X		X		98
Mexico	Rio Conchos	Luis L. Leon	X	X	X	X	X	X	X	X	98
Mexico	Rio San Juan	Marte R. Gomez	X	X	X	X	X		X		98
Mexico	Rio Florido	Pico del Aguila	X	X	X	X	X	X	X		98
Mexico	Rio Florido	San Gabriel	X	X	X	X	X	X	X	X	98
Mexico	Rio Salado	V. Carranza	X	X	X	X	X		X		98
U.S.	Rio Grande/Bravo	Caballo	X	X	X	X	X		X		98
U.S.	Rio Grande/Bravo	Elephant Butte	X	X	X	X	X		X		97
U.S.	Toyah Creek	Lake Balmorhea	X								98
U.S.	Pecos River	Red Bluff	X				X		X		98
U.S.	Alamito Creek	San Esteban Lake	X								98
X = Data has been entered into this field in WEAP. If the field is blank then no value or expression as been entered to date.											

Appendix G. RESERVOIR PHYSICAL DATA

International Reservoirs

Table 27: Amistad International Reservoir Physical Data (TWDB 1971)

River	Reservoir Name	Variable	Unit	Expression
Rio Grande_Rio Bravo	Reservoirs\Amistad	Storage Capacity	MCM	6025
Rio Grande_Rio Bravo	Reservoirs\Amistad	Initial Storage	MCM	See key assumption
Rio Grande_Rio Bravo	Reservoirs\Amistad	Volume Elevation Curve		See Table
Rio Grande_Rio Bravo	Reservoirs\Amistad	Net Evaporation	mm	If(And(Y>=1955,TS>3), ReadFromFile(DamEvap.csv,1), MonthlyValues(Oct, 62, Nov, 96.8, Dec, 43.7, Jan, 54.8, Feb, 65, Mar, 161.7, Apr, 158.9, May, 190.1, Jun, 149.6, Jul, 248.9, Aug, 161.2, Sep, 116))
Rio Grande_Rio Bravo	Reservoirs\Amistad	Top of Conservation	MCM	4300
Rio Grande_Rio Bravo	Reservoirs\Amistad	Top of Buffer	MCM	
Rio Grande_Rio Bravo	Reservoirs\Amistad	Top of Inactive	MCM	23
Rio Grande_Rio Bravo	Reservoirs\Amistad	Buffer Coefficient		
Rio Grande_Rio Bravo	Reservoirs\Amistad	Priority		98

Table 28: Amistad Area-Elevation Capacity Curve Data (TWDB 1971)

Elevation (m)	Storage (MCM)
291.1	74.0
298.7	148.0
303.3	222.0
307.8	370.0
312.4	518.1
315.5	666.1
320.0	962.1
323.1	1258.2
329.2	1924.2
330.7	2220.3
333.8	2738.3
336.8	3330.4
338.3	3700.4
341.4	4588.6
344.4	5402.7
345.9	5846.7
347.5	6290.8
349.0	6956.8

Table 29: Falcon International Reservoir Physical Data (TWDB 1971)

River	Reservoir Name	Variable	Unit	Expression
Rio Grande_Rio Bravo	Reservoirs\Falcon	Storage Capacity	MCM	3897
Rio Grande_Rio Bravo	Reservoirs\Falcon	Initial Storage	MCM	See key assumption
Rio Grande_Rio Bravo	Reservoirs\Falcon	Volume Elevation Curve		See Table
Rio Grande_Rio Bravo	Reservoirs\Falcon	Net Evaporation	mm	If(And(Y>=1969,TS>3), ReadFromFile(DamEvap.csv,10), MonthlyValues(Oct, 92, Nov, 106.9, Dec, 62.2, Jan, 36.5, Feb, 64.59, Mar, 103.6, Apr, 88.9, May, 10.8, Jun, 209.9, Jul, 182.9, Aug, 164.7, Sep, 136.6))
Rio Grande_Rio Bravo	Reservoirs\Falcon	Top of Conservation	MCM	3500
Rio Grande_Rio Bravo	Reservoirs\Falcon	Top of Buffer	MCM	
Rio Grande_Rio Bravo	Reservoirs\Falcon	Top of Inactive	MCM	100
Rio Grande_Rio Bravo	Reservoirs\Falcon	Buffer Coefficient		
Rio Grande_Rio Bravo	Reservoirs\Falcon	Priority		98

Table 30: Falcon Area-Elevation Capacity Curve Data (TWDB 1971)

Elevation (m)	Storage (MCM)
65.23	61.67
69.49	123.35
73.15	246.70
74.68	308.37
77.42	493.39
78.64	616.74
79.86	740.09
81.69	789.43
85.34	1665.20
86.56	1911.90
87.78	2220.27
90.83	3083.71
92.66	3700.45
94.18	4317.19
96.93	5550.67
98.15	6167.41
99.37	6907.50
100.58	7647.59

Table 31: Anzalduas Dam Physical Data (TWDB 1971)

River	Reservoir Name	Variable	Unit	Expression
Rio Grande_Rio Bravo	Reservoirs\Anzalduas Dam	Storage Capacity	MCM	17.15
Rio Grande_Rio Bravo	Reservoirs\Anzalduas Dam	Initial Storage	MCM	See key assumption
Rio Grande_Rio Bravo	Reservoirs\Anzalduas Dam	Volume Elevation Curve		See Table
Rio Grande_Rio Bravo	Reservoirs\Anzalduas Dam	Net Evaporation	mm	
Rio Grande_Rio Bravo	Reservoirs\Anzalduas Dam	Top of Conservation	MCM	17.1
Rio Grande_Rio Bravo	Reservoirs\Anzalduas Dam	Top of Buffer	MCM	17.1
Rio Grande_Rio Bravo	Reservoirs\Anzalduas Dam	Top of Inactive	MCM	
Rio Grande_Rio Bravo	Reservoirs\Anzalduas Dam	Buffer Coefficient		0
Rio Grande_Rio Bravo	Reservoirs\Anzalduas Dam	Priority		98

Table 32: Anzalduas Dam Area-Elevation Capacity Curve Data (TWDB 1971)

Elevation (m)	Volume (MCM)
275.591	0.108
278.871	0.308
282.152	0.617
285.433	0.863
288.714	0.987
291.995	1.419
295.276	1.85
298.556	2.344
301.837	2.837
305.118	3.392
308.399	4.194
311.68	4.811
314.961	5.797
318.241	6.661
321.522	8.215
323.163	8.696

Rio Conchos Reservoirs

Table 33: San Gabriel Reservoir Physical Data (CNA)

River	Reservoir Name	Variable	Unit	Expression
Rio Florido	Reservoirs\San Gabriel	Storage Capacity	MCM	389.6
Rio Florido	Reservoirs\San Gabriel	Initial Storage	MCM	See key assumption
Rio Florido	Reservoirs\San Gabriel	Volume Elevation Curve		See Table
Rio Florido	Reservoirs\San Gabriel	Net Evaporation	mm	If(And(Y>=1943, TS>3), ReadFromFile(DamEvap.csv, 8), MonthlyValues(Oct, 78.7, Nov, 75.8, Dec, 60.3, Jan, 68.4, Feb, 100.6, Mar, 159.4, Apr, 177.5, May, 195.4, Jun, 135.7, Jul, 39.3, Aug, 15.1, Sep, 17.4))
Rio Florido	Reservoirs\San Gabriel	Top of Conservation	MCM	255.43
Rio Florido	Reservoirs\San Gabriel	Top of Buffer	MCM	250
Rio Florido	Reservoirs\San Gabriel	Top of Inactive	MCM	7.5
Rio Florido	Reservoirs\San Gabriel	Buffer Coefficient		0.03
Rio Florido	Reservoirs\San Gabriel	Priority		98

Table 34: San Gabriel Reservoir Elevation Capacity Curve Data (CNA)

Elevation (m)	Storage (MCM)
1742	0
1757	19.04
1760	32.37
1763	50.74
1766	70.26
1769	106.67
1775	195.42
1785	432.58

Table 35: Pico del Aguila Reservoir Physical Data (CNA)

River	Reservoir Name	Variable	Unit	Expression
Rio Florido	Reservoirs\Pico del Aguila	Storage Capacity	MCM	86.8
Rio Florido	Reservoirs\Pico del Aguila	Initial Storage	MCM	See key assumption
Rio Florido	Reservoirs\Pico del Aguila	Volume Elevation Curve		See Table
Rio Florido	Reservoirs\Pico del Aguila	Net Evaporation	mm	If(And(Y>=1942, TS>3), ReadFromFile(DamEvap.csv, 11), MonthlyValues(Oct, 61.0, Nov, 59.6, Dec, 50.0, Jan, 56.1, Feb, 80.9, Mar, 128.5, Apr, 140.2, May, 149.0, Jun, 99.7, Jul, 27.2, Aug, 10.0, Sep, 5.1))
Rio Florido	Reservoirs\Pico del Aguila	Top of Conservation	MCM	50
Rio Florido	Reservoirs\Pico del Aguila	Top of Buffer	MCM	Top of Inactive[MCM]
Rio Florido	Reservoirs\Pico del Aguila	Top of Inactive	MCM	4.41
Rio Florido	Reservoirs\Pico del Aguila	Buffer Coefficient		0.3
Rio Florido	Reservoirs\Pico del Aguila	Priority		98

Table 36: Pico del Aguila Reservoir Elevation Capacity Curve Data (CNA)

Elevation (m)	Storage (MCM)
1590	0
1595	0.58
1600	3.46
1605	10.23
1610	22.19
1615	40.61
1620	65.95
1625	98.57

Table 37: La Boquilla Reservoir Physical Data (IMTA – BANDAS)

River	Reservoir Name	Variable	Unit	Expression
Rio Conchos	Reservoirs\La Boquilla	Storage Capacity	MCM	3336
Rio Conchos	Reservoirs\La Boquilla	Initial Storage	MCM	See key assumption
Rio Conchos	Reservoirs\La Boquilla	Volume Elevation Curve		See Table
Rio Conchos	Reservoirs\La Boquilla	Net Evaporation	mm	ReadFromFile(DamEvap.csv,5)
Rio Conchos	Reservoirs\La Boquilla	Top of Conservation	MCM	2903.3
Rio Conchos	Reservoirs\La Boquilla	Top of Buffer	MCM	Top of Inactive[MCM]
Rio Conchos	Reservoirs\La Boquilla	Top of Inactive	MCM	129.7
Rio Conchos	Reservoirs\La Boquilla	Buffer Coefficient		0.3
Rio Conchos	Reservoirs\La Boquilla	Priority		98

Table 38: La Boquilla Reservoir Elevation Capacity Curve Data (IMTA-BANDAS)

Elevation (m)	Storage (MCM)
1252	0
1264	0.2
1270	10.8
1276	66.8
1282	174.9
1294	586.7
1300	944.4
1306	1760.5
1312	2134.6
1324	4308.6
1325	4544.5

Table 39: F. Madero Reservoir Physical Data (IMTA – BANDAS)

River	Reservoir Name	Variable	Unit	Expression
Rio San Pedro	Reservoirs\F. Madero	Storage Capacity	MCM	565
Rio San Pedro	Reservoirs\F. Madero	Initial Storage	MCM	See key assumption
Rio San Pedro	Reservoirs\F. Madero	Volume Elevation Curve		See Table
Rio San Pedro	Reservoirs\F. Madero	Net Evaporation	mm	If(And(Y>=1949, TS>3), ReadFromFile(DamEvap.csv, 4), MonthlyValues(Oct, 79.8, Nov, 84.2, Dec, 73.0, Jan, 78.8, Feb, 110.5, Mar, 164.7, Apr, 180.8, May, 193.7, Jun, 130.5, Jul, 82.1, Aug, 65.7, Sep, 45.3))
Rio San Pedro	Reservoirs\F. Madero	Top of Conservation	MCM	348
Rio San Pedro	Reservoirs\F. Madero	Top of Buffer	MCM	Top of Inactive[MCM]
Rio San Pedro	Reservoirs\F. Madero	Top of Inactive	MCM	5.3
Rio San Pedro	Reservoirs\F. Madero	Buffer Coefficient		0.3
Rio San Pedro	Reservoirs\F. Madero	Priority		98

Table 40: F. Madero Reservoir Elevation Capacity Curve Data (IMTA-BANDAS)

Elevation (m)	Storage (MCM)
1204	0
1210	4.17
1213	9.18
1216	16.41
1217	19.59
1221	39.81
1223	56.58
1226	90.56
1231	173.66
1234	245.92
1237	331.9
1242	514.9
1245	651.2

Table 41: Luis L. Leon Reservoir Physical Data (IMTA – BANDAS)

River	Reservoir Name	Variable	Unit	Expression
Rio Conchos	Reservoirs\Luis L. Leon	Storage Capacity	MCM	877
Rio Conchos	Reservoirs\Luis L. Leon	Initial Storage	MCM	See key assumption
Rio Conchos	Reservoirs\Luis L. Leon	Volume Elevation Curve		See Table
Rio Conchos	Reservoirs\Luis L. Leon	Net Evaporation	mm	If(Y>=1949, ReadFromFile(DamEvap.csv, 6), MonthlyValues(Oct, 106.6, Nov, 81.6, Dec, 63.6, Jan, 67.7, Feb, 87.3, Mar, 142.6, Apr, 170.8, May, 205.2, Jun, 195.2, Jul, 127.1, Aug, 107.1, Sep, 92))
Rio Conchos	Reservoirs\Luis L. Leon	Top of Conservation	MCM	450
Rio Conchos	Reservoirs\Luis L. Leon	Top of Buffer	MCM	450
Rio Conchos	Reservoirs\Luis L. Leon	Top of Inactive	MCM	42.5
Rio Conchos	Reservoirs\Luis L. Leon	Buffer Coefficient		1
Rio Conchos	Reservoirs\Luis L. Leon	Priority		98

Table 42: Luis L. Leon Reservoir Elevation Capacity Curve Data (IMTA-BANDAS)

Elevation (m)	Storage (MCM)
1002	0
1014	16
1019	40
1021	57
1024	90.5
1028	157
1028	164
1029	171
1030	186
1032	246
1035	332
1040	515
1050	877

Local Mexican Reservoirs

Table 43: El Rejon Reservoir Physical Data (CNA)

River	Reservoir Name	Variable	Unit	Expression
Local Reservoirs	El Rejon	Storage Capacity	MCM	6.6
Local Reservoirs	El Rejon	Initial Storage	MCM	See key assumption
Local Reservoirs	El Rejon	Volume Elevation Curve		
Local Reservoirs	El Rejon	Net Evaporation	mm	
Local Reservoirs	El Rejon	Top of Conservation	MCM	6.6
Local Reservoirs	El Rejon	Top of Buffer	MCM	
Local Reservoirs	El Rejon	Top of Inactive	MCM	0.4
Local Reservoirs	El Rejon	Buffer Coefficient		
Local Reservoirs	El Rejon	Priority		98

Table 44: Chihuahua Reservoir Physical Data (CNA)

River	Reservoir Name	Variable	Unit	Expression
Local Reservoirs	Chihuahua	Storage Capacity	MCM	26
Local Reservoirs	Chihuahua	Initial Storage	MCM	See key assumption
Local Reservoirs	Chihuahua	Volume Elevation Curve		
Local Reservoirs	Chihuahua	Net Evaporation	mm	
Local Reservoirs	Chihuahua	Top of Conservation	MCM	24.85
Local Reservoirs	Chihuahua	Top of Buffer	MCM	
Local Reservoirs	Chihuahua	Top of Inactive	MCM	1.6
Local Reservoirs	Chihuahua	Buffer Coefficient		
Local Reservoirs	Chihuahua	Priority		959

Table 45: La Fragua Reservoir Physical Data (IMTA-BANDAS)

River	Reservoir Name	Variable	Unit	Expression
Rio San Rodrigo	Reservoirs\La Fragua	Storage Capacity	MCM	86
Rio San Rodrigo	Reservoirs\La Fragua	Initial Storage	MCM	See key assumption
Rio San Rodrigo	Reservoirs\La Fragua	Volume Elevation Curve		See Table
Rio San Rodrigo	Reservoirs\La Fragua	Net Evaporation	mm	
Rio San Rodrigo	Reservoirs\La Fragua	Top of Conservation	MCM	45
Rio San Rodrigo	Reservoirs\La Fragua	Top of Buffer	MCM	
Rio San Rodrigo	Reservoirs\La Fragua	Top of Inactive	MCM	9
Rio San Rodrigo	Reservoirs\La Fragua	Buffer Coefficient		
Rio San Rodrigo	Reservoirs\La Fragua	Priority		98

Table 46: La Fragua Reservoir Elevation Capacity Curve Data (IMTA-BANDAS)

Elevation (m)	Storage (MCM)
283	0
284	0.01
285	0.07
286	0.33
287	0.78
288	1.44
289	2.6
290	3.77
291	4.94
292	6.72
293	8.91
294	11.62
295	14.98
296	19.05
297	23.83
298	29.37
299	35.77
300	43.14
300.3	45.53

Table 47: Centenario Reservoir Physical Data (IMTA-BANDAS)

River	Reservoir Name	Variable	Unit	Expression
Local Reservoirs	Centenario	Storage Capacity	MCM	26.9
Local Reservoirs	Centenario	Initial Storage	MCM	See key assumption
Local Reservoirs	Centenario	Volume Elevation Curve		See Table
Local Reservoirs	Centenario	Net Evaporation	mm	If(And(Y>=1985,TS>3), ReadFromFile(DamEvap.csv,2), MonthlyValues(Oct, 109.7, Nov, 83.4, Dec, 48.3, Jan, 55.1, Feb, 56.5, Mar, 81.3, Apr, 93.9, May, 93.1, Jun, 140, Jul, 154, Aug, 138.6, Sep, 81.8))
Local Reservoirs	Centenario	Top of Conservation	MCM	25.3
Local Reservoirs	Centenario	Top of Buffer	MCM	
Local Reservoirs	Centenario	Top of Inactive	MCM	0.9
Local Reservoirs	Centenario	Buffer Coefficient		
Local Reservoirs	Centenario	Priority		95

Table 48: Centenario Reservoir Elevation Capacity Curve Data (IMTA-BANDAS)

Elevation (m)	Storage (MCM)
325.5	0.00
326.0	1.46
327.0	2.25
328.0	3.30
329.0	4.65
330.0	6.25
331.0	8.20
332.0	10.50
333.0	13.43
333.5	15.00
337.0	27.00

Table 49: San Miguel Reservoir Physical Data (IMTA-BANDAS)

River	Reservoir Name	Variable	Unit	Expression
Local Reservoirs	San Miguel	Storage Capacity	MCM	21.7
Local Reservoirs	San Miguel	Initial Storage	MCM	See key assumption
Local Reservoirs	San Miguel	Volume Elevation Curve		See Table
Local Reservoirs	San Miguel	Net Evaporation	mm	If(And(Y>=1985,TS>3), ReadFromFile(DamEvap.csv,12), MonthlyValues(Oct, 109.7, Nov, 83.4, Dec, 48.3, Jan, 55.1, Feb, 56.5, Mar, 81.3, Apr, 93.9, May, 93.1, Jun, 140, Jul, 154, Aug, 138.6, Sep, 81.8))
Local Reservoirs	San Miguel	Top of Conservation	MCM	20.2
Local Reservoirs	San Miguel	Top of Buffer	MCM	
Local Reservoirs	San Miguel	Top of Inactive	MCM	0.5
Local Reservoirs	San Miguel	Buffer Coefficient		
Local Reservoirs	San Miguel	Priority		98

Table 50: San Miguel Reservoir Elevation Capacity Curve Data (IMTA-BANDAS)

Elevation (m)	Storage (MCM)
330.5	0.0
330.8	0.1
331.0	0.1
331.5	0.3
332.0	0.5
332.5	0.7
333.0	1.1
333.5	1.5
334.0	2.0
334.5	2.5
335.0	3.2
335.5	3.9
336.0	4.7
336.5	5.6
337.0	6.6
337.5	7.6
338.0	8.7
338.5	9.9
339.0	11.3
342.0	20.2
342.5	22.0

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Table 51: V. Carranza Reservoir Physical Data (IMTA-BANDAS)

River	Reservoir Name	Variable	Unit	Expression
Rio Salado	Reservoirs\V Carranza	Storage Capacity	MCM	1385
Rio Salado	Reservoirs\V Carranza	Initial Storage	MCM	See key assumption
Rio Salado	Reservoirs\V Carranza	Volume Elevation Curve		See Table
Rio Salado	Reservoirs\V Carranza	Net Evaporation	mm	ReadFromFile(DamEvap.csv,9)
Rio Salado	Reservoirs\V Carranza	Top of Conservation	MCM	1375
Rio Salado	Reservoirs\V Carranza	Top of Buffer	MCM	Top of Inactive[Million m^3]
Rio Salado	Reservoirs\V Carranza	Top of Inactive	MCM	1
Rio Salado	Reservoirs\V Carranza	Buffer Coefficient		0.3
Rio Salado	Reservoirs\V Carranza	Priority		98

Table 52: V. Carranza Reservoir Elevation Capacity Curve Data (IMTA-BANDAS)

Elevation (m)	Storage (MCM)
241	0
242	4.0
243	7.5
244	12.5
245	20.0
246	30.0
247	43.0
248	61.0
249	82.5
250	110.0
251	146.0
252	195.0
253	253.0
254	325.0
255	410.0
256	508.0
257	618.0
258	747.7
259	891.4
260	1052.9
261	1240.0
262	1424.3

Table 53: Las Blancas Reservoir Physical Data (CNA)

River	Reservoir Name	Variable	Unit	Expression
Rio Alamos	Reservoirs\Las Blancas	Storage Capacity	MCM	134
Rio Alamos	Reservoirs\Las Blancas	Initial Storage	MCM	See key assumption
Rio Alamos	Reservoirs\Las Blancas	Volume Elevation Curve		
Rio Alamos	Reservoirs\Las Blancas	Net Evaporation	mm	
Rio Alamos	Reservoirs\Las Blancas	Top of Conservation	MCM	84
Rio Alamos	Reservoirs\Las Blancas	Top of Buffer	MCM	83
Rio Alamos	Reservoirs\Las Blancas	Top of Inactive	MCM	24
Rio Alamos	Reservoirs\Las Blancas	Buffer Coefficient		0
Rio Alamos	Reservoirs\Las Blancas	Priority		98

Table 54: El Cuchillo Reservoir Physical Data (CNA)

River	Reservoir Name	Variable	Unit	Expression
Rio San Juan	Reservoirs\El Cuchillo	Storage Capacity	MCM	1784
Rio San Juan	Reservoirs\El Cuchillo	Initial Storage	MCM	See key assumption
Rio San Juan	Reservoirs\El Cuchillo	Volume Elevation Curve		See Table
Rio San Juan	Reservoirs\El Cuchillo	Net Evaporation	mm	ReadFromFile(DamEvap.csv,3)
Rio San Juan	Reservoirs\El Cuchillo	Top of Conservation	MCM	1123
Rio San Juan	Reservoirs\El Cuchillo	Top of Buffer	MCM	Top of Inactive[MCM]
Rio San Juan	Reservoirs\El Cuchillo	Top of Inactive	MCM	100
Rio San Juan	Reservoirs\El Cuchillo	Buffer Coefficient		0.3
Rio San Juan	Reservoirs\El Cuchillo	Priority		97

Table 55: El Cuchillo Reservoir Elevation Capacity Curve Data (CNA)

Elevation (m)	Storage (MCM)
128	0
148	108.2
150	171.4
152	252.7
154	355.7
156	486.1
158	648.4
160	844.8
162	1076.0
164	1345.5
166	1661.4
168	2033.9
170	2465.6

Table 56: Marte R. Gomez Reservoir Physical Data (CNA)

River	Reservoir Name	Variable	Unit	Expression
Rio San Juan	Reservoirs\Marte R. Gomez	Storage Capacity	MCM	2303.9
Rio San Juan	Reservoirs\Marte R. Gomez	Initial Storage	MCM	See key assumption
Rio San Juan	Reservoirs\Marte R. Gomez	Volume Elevation Curve		See Table
Rio San Juan	Reservoirs\Marte R. Gomez	Net Evaporation	mm	ReadFromFile(DamEvap.csv,7)
Rio San Juan	Reservoirs\Marte R. Gomez	Top of Conservation	MCM	1150
Rio San Juan	Reservoirs\Marte R. Gomez	Top of Buffer	MCM	Top of Inactive[MCM]
Rio San Juan	Reservoirs\Marte R. Gomez	Top of Inactive	MCM	8.2
Rio San Juan	Reservoirs\Marte R. Gomez	Buffer Coefficient		0.3
Rio San Juan	Reservoirs\Marte R. Gomez	Priority		98

Table 57: Marte R. Gomez Reservoir Elevation Capacity Curve Data (CNA)

Elevation (m)	Storage (MCM)
58.0	0.0
67.5	91.3
69.5	196.5
70.0	228.8
71.0	302.7
72.0	390.7
73.0	492.8
73.5	550.7
74.0	608.6
75.0	736.5
75.5	807.5
76.0	878.4
76.5	957.6
77.5	1125.2
78.0	1230.6
78.5	1311.9
79.0	1410.2
79.5	1517.7
80.0	1625.1
80.5	1743.5
81.0	1861.9
81.5	1992.4
82.0	2123.0
82.5	2264.6
83.0	2406.1
83.5	2558.8
84.0	2711.4
84.5	2875.5
85.0	3039.6

Table 58: La Boca Reservoir Physical Data (CNA)

River	Reservoir Name	Variable	Unit	Expression
La Boca Inflow	Reservoirs\La Boca	Storage Capacity	MCM	42.6
La Boca Inflow	Reservoirs\La Boca	Initial Storage	MCM	See key assumption
La Boca Inflow	Reservoirs\La Boca	Volume Elevation Curve		See Table
La Boca Inflow	Reservoirs\La Boca	Net Evaporation	mm	ReadFromFile(DamEvap.csv,15)
La Boca Inflow	Reservoirs\La Boca	Top of Conservation	MCM	39.5
La Boca Inflow	Reservoirs\La Boca	Top of Buffer	MCM	
La Boca Inflow	Reservoirs\La Boca	Top of Inactive	MCM	0.83
La Boca Inflow	Reservoirs\La Boca	Buffer Coefficient		
La Boca Inflow	Reservoirs\La Boca	Priority		98

Table 59: La Boca Reservoir Elevation Capacity Curve Data (CNA)

Elevation (m)	Storage (MCM)
422	0
435.02	5.7
436.06	6.8
437.18	8.2
438.14	9.6
439.18	11.4
440.22	13.3
441.26	15.4
443.34	20.4
444.38	23.4
445.42	26.8
446.46	30.9
447.53	35.8
448.55	41.4
448.6	41.5
448.65	42.6

Table 60: Cerro Prieto Reservoir Physical Data (IMTA-BANDAS)

River	Reservoir Name	Variable	Unit	Expression
Rios Pablillo y Camacho	Reservoirs\Cerro Prieto	Storage Capacity	MCM	392
Rios Pablillo y Camacho	Reservoirs\Cerro Prieto	Initial Storage	MCM	See key assumption
Rios Pablillo y Camacho	Reservoirs\Cerro Prieto	Volume Elevation Curve		See Table
Rios Pablillo y Camacho	Reservoirs\Cerro Prieto	Net Evaporation	mm	ReadFromFile(DamEvap.csv,3)
Rios Pablillo y Camacho	Reservoirs\Cerro Prieto	Top of Conservation	MCM	300
Rios Pablillo y Camacho	Reservoirs\Cerro Prieto	Top of Buffer	MCM	
Rios Pablillo y Camacho	Reservoirs\Cerro Prieto	Top of Inactive	MCM	24.8
Rios Pablillo y Camacho	Reservoirs\Cerro Prieto	Buffer Coefficient		
Rios Pablillo y Camacho	Reservoirs\Cerro Prieto	Priority		98

Table 61: Cerro Prieto Reservoir Elevation Capacity Curve Data (IMTA-BANDAS)

Elevation (m)	Storage (MCM)
0	256.5
0.308	256.7
0.61	256.9
0.77	257
1.08	257.2
1.39	257.4
1.7	257.6
2	257.8
2.33	258
2.67	258.2
3	258.4
3.4	258.6
3.8	258.8
4.22	259
4.67	259.2
5.13	259.4
5.63	259.6
51.67	268.5
103.57	273
150.7	276
199.7	278.5
246.32	280.5
299.44	282.5
360.67	284.5
377	285
392	285.4

U.S. Reservoirs

Table 62: Elephant Butte Reservoir Physical Data (USBRb)

River	Reservoir Name	Variable	Unit	Expression
Rio Grande_Rio Bravo	Reservoirs\Elephant Butte	Storage Capacity	MCM	2540
Rio Grande_Rio Bravo	Reservoirs\Elephant Butte	Initial Storage	MCM	See key assumption
Rio Grande_Rio Bravo	Reservoirs\Elephant Butte	Volume Elevation Curve		See Table
Rio Grande_Rio Bravo	Reservoirs\Elephant Butte	Net Evaporation	mm	ReadFromFile(DamEvap.csv,13)
Rio Grande_Rio Bravo	Reservoirs\Elephant Butte	Top of Conservation	MCM	2540
Rio Grande_Rio Bravo	Reservoirs\Elephant Butte	Top of Buffer	MCM	2496
Rio Grande_Rio Bravo	Reservoirs\Elephant Butte	Top of Inactive	MCM	Storage Capacity[MCM]/10
Rio Grande_Rio Bravo	Reservoirs\Elephant Butte	Buffer Coefficient		0
Rio Grande_Rio Bravo	Reservoirs\Elephant Butte	Priority		97

Table 63: Elephant Butte Area-Elevation Capacity Curve Data (USBR 2006b)

Elevation (m)	Capacity (MCM)
1293.88	0
1294.79	0.070
1296.62	1.252
1297.84	3.808
1298.45	5.648
1299.67	10.970
1301.50	23.708
1302.11	29.017
1305.15	59.215
1306.98	84.126
1307.59	94.017
1309.42	129.085
1310.64	157.131
1311.86	188.397
1312.47	205.045
1313.69	240.370
1315.52	300.116
1319.17	445.903
1321.00	530.018
1322.83	622.404
1324.66	722.816
1325.27	758.000
1326.49	831.255
1327.10	869.933
1328.32	951.700
1330.15	1085.490
1331.98	1232.981
1332.59	1285.288
1334.41	1452.471
1335.63	1572.480
1336.24	1635.048
1337.46	1765.312
1338.07	1833.007
1341.73	2282.511
1343.56	2540.511

Table 64 Caballo Reservoir Physical Data (USBRa)

River	Reservoir Name	Variable	Unit	Expression
Rio Grande_Rio Bravo	Reservoirs\Caballo	Storage Capacity	MCM	432
Rio Grande_Rio Bravo	Reservoirs\Caballo	Initial Storage	MCM	See key assumption
Rio Grande_Rio Bravo	Reservoirs\Caballo	Volume Elevation Curve		See Table
Rio Grande_Rio Bravo	Reservoirs\Caballo	Net Evaporation	mm	ReadFromFile(DamEvap.csv,14)
Rio Grande_Rio Bravo	Reservoirs\Caballo	Top of Conservation	MCM	350
Rio Grande_Rio Bravo	Reservoirs\Caballo	Top of Buffer	MCM	268
Rio Grande_Rio Bravo	Reservoirs\Caballo	Top of Inactive	MCM	26
Rio Grande_Rio Bravo	Reservoirs\Caballo	Buffer Coefficient		0.03
Rio Grande_Rio Bravo	Reservoirs\Caballo	Priority		98

Table 65: Caballo Elevation Capacity Curve Data (USBR 2006a)

Elevation (m)	Capacity (MCM)
1254.25	0
1254.56	0.014
1254.86	0.054
1255.78	0.338
1256.08	0.567
1256.39	0.980
1257.00	2.363
1257.60	4.478
1257.91	5.793
1258.21	7.277
1259.13	12.721
1260.04	19.352
1261.87	36.473
1262.18	39.977
1262.79	47.735
1263.09	51.989
1263.40	56.370
1263.70	61.114
1264.92	82.853
1265.53	95.339
1265.83	101.965
1266.75	123.385
1267.05	131.072
1267.97	155.820
1268.88	182.627
1269.80	211.047
1270.41	231.156
1270.71	241.589
1271.02	252.276
1271.93	286.050
1272.24	297.900
1272.54	310.046
1273.45	348.190
1273.76	361.466
1274.98	417.300
1275.28	431.921

Table 66: Red Bluff Reservoir Physical Data (TWDB 1971)

River	Reservoir Name	Variable	Unit	Expression
Pecos River	Reservoirs\Red Bluff	Storage Capacity	MCM	425.73
Pecos River	Reservoirs\Red Bluff	Initial Storage	MCM	See key assumption
Pecos River	Reservoirs\Red Bluff	Volume Elevation Curve		See Table
Pecos River	Reservoirs\Red Bluff	Net Evaporation	mm	
Pecos River	Reservoirs\Red Bluff	Top of Conservation	MCM	413.39
Pecos River	Reservoirs\Red Bluff	Top of Buffer	MCM	350
Pecos River	Reservoirs\Red Bluff	Top of Inactive	MCM	3.7
Pecos River	Reservoirs\Red Bluff	Buffer Coefficient		See Table
Pecos River	Reservoirs\Red Bluff	Priority		98

Table 67: Red Bluff Volume Elevation Curve Data (TWDB 1971)

Elevation (m)	Storage (MCM)
851.0	29.0
851.9	34.1
852.2	36.0
853.7	48.1
854.4	54.1
855.0	61.0
855.9	72.8
856.5	81.7
856.8	86.4
857.1	91.4
858.0	107.5
859.5	138.4
859.8	145.3
860.5	159.8
860.8	167.5
861.7	192.1
862.0	200.8
862.9	228.7
863.8	259.6
864.7	293.5
865.0	305.6
865.9	343.7
866.2	357.3

Table 68: Balmorhea Dam Physical Data (TWDB 1971)

River	Reservoir Name	Variable	Unit	Expression
Toyah Crk	Reservoirs\Lake Balmorhea	Storage Capacity	MCM	9.51
Toyah Crk	Reservoirs\Lake Balmorhea	Initial Storage	MCM	3.9
Toyah Crk	Reservoirs\Lake Balmorhea	Volume Elevation Curve		VolumeElevation(0, 971.4, 9.51, 985.4)
Toyah Crk	Reservoirs\Lake Balmorhea	Net Evaporation	mm	ReadFromFile(DamEvap.csv,16)
Toyah Crk	Reservoirs\Lake Balmorhea	Top of Conservation	MCM	3.93
Toyah Crk	Reservoirs\Lake Balmorhea	Top of Buffer	MCM	3.9
Toyah Crk	Reservoirs\Lake Balmorhea	Top of Inactive	MCM	
Toyah Crk	Reservoirs\Lake Balmorhea	Buffer Coefficient		0
Toyah Crk	Reservoirs\Lake Balmorhea	Priority		98

Table 69: San Esteban Lake Physical Data (TWDB 1971)

River	Reservoir Name	Variable	Unit	Expression
Alamito Crk	Reservoirs\San Esteban Lake	Storage Capacity	MCM	3.82
Alamito Crk	Reservoirs\San Esteban Lake	Initial Storage	MCM	3.8
Alamito Crk	Reservoirs\San Esteban Lake	Volume Elevation Curve		
Alamito Crk	Reservoirs\San Esteban Lake	Net Evaporation	mm	
Alamito Crk	Reservoirs\San Esteban Lake	Top of Conservation	MCM	
Alamito Crk	Reservoirs\San Esteban Lake	Top of Buffer	MCM	
Alamito Crk	Reservoirs\San Esteban Lake	Top of Inactive	MCM	
Alamito Crk	Reservoirs\San Esteban Lake	Buffer Coefficient		
Alamito Crk	Reservoirs\San Esteban Lake	Priority		98

Table 70: Lake Casa Blanca Physical Data (TWDB 1971)

River	Reservoir Name	Variable	Unit	Expression
Local Reservoirs	Casa Blanca Lake	Storage Capacity	MCM	23.4
Local Reservoirs	Casa Blanca Lake	Initial Storage	MCM	205
Local Reservoirs	Casa Blanca Lake	Volume Elevation Curve		See Table
Local Reservoirs	Casa Blanca Lake	Net Evaporation	mm	
Local Reservoirs	Casa Blanca Lake	Top of Conservation	MCM	
Local Reservoirs	Casa Blanca Lake	Top of Buffer	MCM	
Local Reservoirs	Casa Blanca Lake	Top of Inactive	MCM	
Local Reservoirs	Casa Blanca Lake	Buffer Coefficient		
Local Reservoirs	Casa Blanca Lake	Priority		98

Table 71: Lake Casa Blanca Elevation Capacity Curve Data (TWDB 1971)

Elevation (m)	Storage (MCM)
1370	0
1387.8	0.37
1391.1	1.11
1397.6	1.85
1400.9	2.34
1404.2	2.78
1410.8	3.70
1417.3	4.81
1420.6	5.37
1427.2	6.85
1430.4	7.77
1437.0	9.62
1440.3	10.92
1443.6	12.21
1446.9	13.32
1450.1	14.80
1453.4	16.65
1460.0	20.35
1476.4	31.08

Appendix H. U.S. Groundwater Demand Nodes

Table 72a: Maximum Annual Withdrawal to U.S. Groundwater Demand Nodes

Groundwater Demand Site	Aquifer	Maximum Flow Volume (MCM/yr)
to US_GW_Brewster CO GW Demand	from Brewster Other	0.247
to US_GW_Brewster CO GW Demand	from Capitan Reef_BS	2.467
to US_GW_Brewster CO GW Demand	from Edwards Trinity Plateau_JD BS Co	27.704
to US_GW_Brewster CO GW Demand	from Marathon	36.955
to US_GW_Brewster CO GW Demand	from Igneous	77.019
to US_GW_Cameron Co GW Demand	from Gulf Coast_ CF Co	10.511
to US_GW_Crane CO GW Demand	from Crane Other	0.165
to US_GW_Crane CO GW Demand	from Cenozoic Pecos Alluvium	3.700
to US_GW_Crane CO GW Demand	from Edwards Trinity Plateau F	6.339
to US_GW_Crockett Co GW Demand	from Edwards Trinity plateau	101.670
to US_GW_Culberson Co GW Demand	from Culberson Other	0.247
to US_GW_Culberson Co GW Demand	from Rustler	4.934
to US_GW_Culberson Co GW Demand	from Edwards Trinity Plateau CU	6.562
to US_GW_Culberson Co GW Demand	from West Texas Bolson_HU CU Co	154.679
to US_GW_Culberson Co GW Demand	from Capitan Reef	472.427
to US_GW_Dimmit Co GW Demand	from Carrizo Wilcox	4.755
to US_GW_Hidalgo CO GW Demand	from Gulf Coast_HG Co	63.265
to US_GW_Hudspeth Co GW Demand	from Hueco Mesilla Bolson	0.617
to US_GW_Hudspeth Co GW Demand	from Capitan Reef	6.617
to US_GW_Hudspeth Co GW Demand	from Hudspeth Other	15.690
to US_GW_Hudspeth Co GW Demand	from West Texas Bolson_HU CU Co	29.752
to US_GW_Hudspeth Co GW Demand	from Bone Spring Victorio Peak	173.921
to US_GW_Jeff Davis Co GW Demand	from Jeff Davis Other	2.368
to US_GW_Jeff Davis Co GW Demand	from Edwards Trinity Plateau_JD BS Co	10.016
to US_GW_Jeff Davis Co GW Demand	from Igneous	32.687
to US_GW_Jeff Davis Co GW Demand	from West Texas Bolson	129.072

Table 73b: Maximum Annual Withdrawal to U.S. Groundwater Demand Nodes

Groundwater Demand Site	Aquifer	Maximum Flow Volume (MCM/yr)
to US_GW_Jim Hogg CO GW Demand	from Gulf Coast_JH Co	61.585
to US_GW_Loving Co GW Demand	from Dockum	1.061
to US_GW_Loving Co GW Demand	from Cenozoic Pecos Alluvium_LV Co	10.147
to US_GW_Maverick Co GW Demand	from Maverick Other	1.495
to US_GW_Maverick Co GW Demand	from Carrizo Wilcox	10.499
to US_GW_Pecos Co GW Demand	from Dockum_PC Co	1.343
to US_GW_Pecos Co GW Demand	from Pecos Other	1.842
to US_GW_Pecos Co GW Demand	from Cenozoic Pecos Alluvium _PC Co	25.173
to US_GW_Pecos Co GW Demand	from Edwards Trinity Plateau_PC TE Co	156.177
to US_GW_Presidio Co GW Demand	from Presidio Other	0.247
to US_GW_Presidio Co GW Demand	from Igneous	113.678
to US_GW_Presidio Co GW Demand	from West Texas Bolson	393.530
to US_GW_Reeves Co GW Demand	from Reeves Other	0.123
to US_GW_Reeves Co GW Demand	from Dockum RV Co	3.781
to US_GW_Reeves Co GW Demand	from Cenozoic Pecos Alluvium_RV Co	71.815
to US_GW_Reeves Co GW Demand	from Edwards Trinity Plateau _ RV Co	102.438
to US_GW_Starr CO GW Demand	from Starr Other	9.509
to US_GW_Starr CO GW Demand	from Gulf Coast_SR Co	105.395
to US_GW_Terrell Co GW Demand	from Terrell Other	0.247
to US_GW_Terrell Co GW Demand	from Edwards Trinity Plateau_PC TE Co	222.520
to US_GW_Upton Co GW Demand	from Cenozoic Pecos Alluvium	0.339
to US_GW_Upton Co GW Demand	from Dockum_UT Co	0.983
to US_GW_Upton Co GW Demand	from Edwards Trinity Plateau F	22.611
to US_GW_Val Verde Co GW Demand	from Edwards Trinity plateau	78.935
to US_GW_Ward Co GW Demand	from Dockum	2.886
to US_GW_Webb Co GW Demand	from Gulf Coast_WB Co	2.029
to US_GW_Webb Co GW Demand	from Webb Other	6.069
to US_GW_Webb Co GW Demand	from Carrizo Wilcox_WB Co	12.535
to US_GW_Zapata CO GW Demand	from Zapata Other	12.335
to US_GW_Zapata CO GW Demand	from Gulf Coast_ZP Co	13.845
to US_GWKinney Co GW Demand	from Kinney Other	1.860
to US_GWKinney Co GW Demand	from Edwards Trinity plateau	18.591

Appendix I. Reservoir Testing

Upper Rio Grande

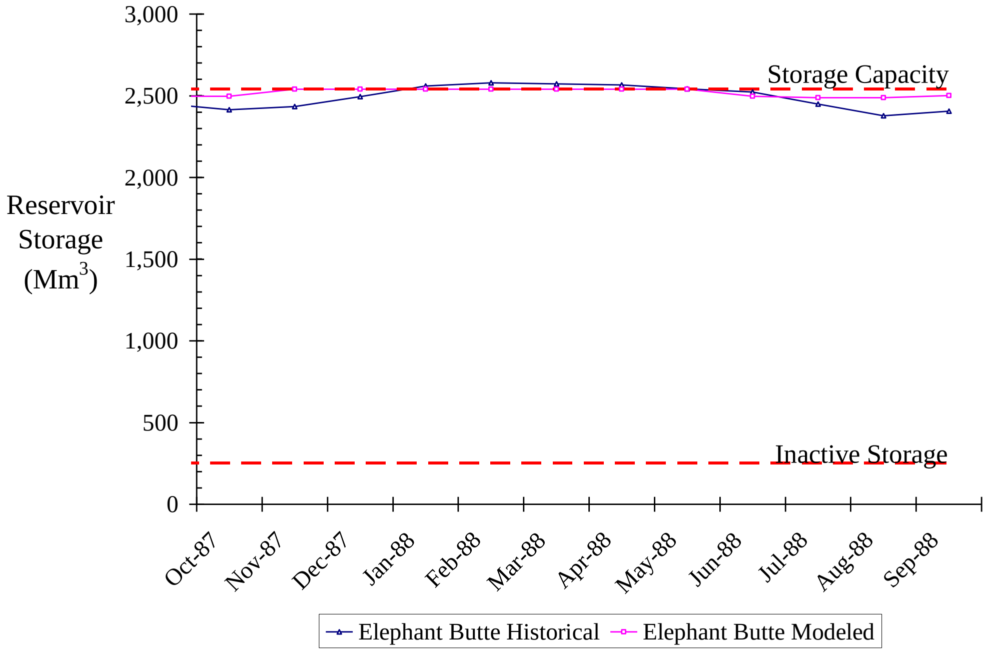

Figure 38 Elephant Butte Historical and Modeled Storage Comparison

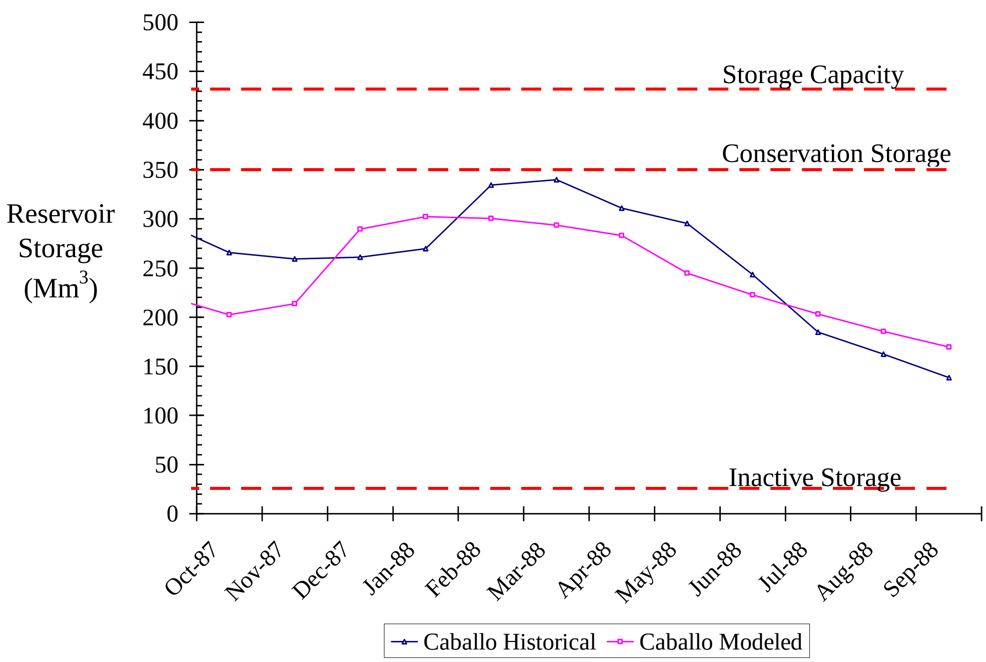

Figure 39 Caballo Historical and Modeled Storage Comparison

Rio Conchos

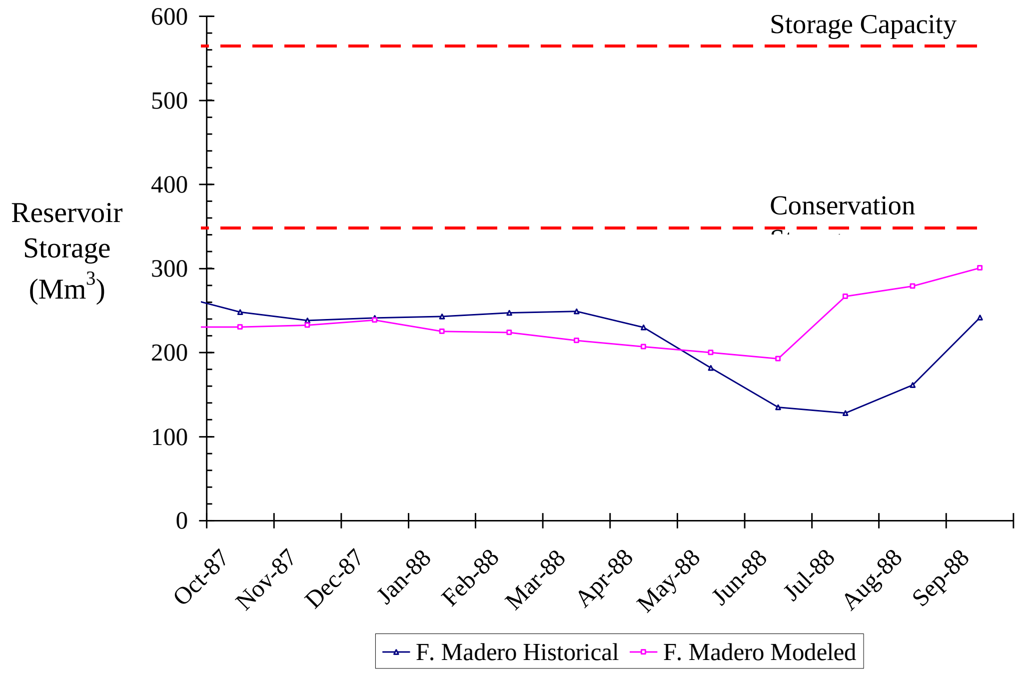

Figure 40: F. Madero Historical and Modeled Storage Comparison

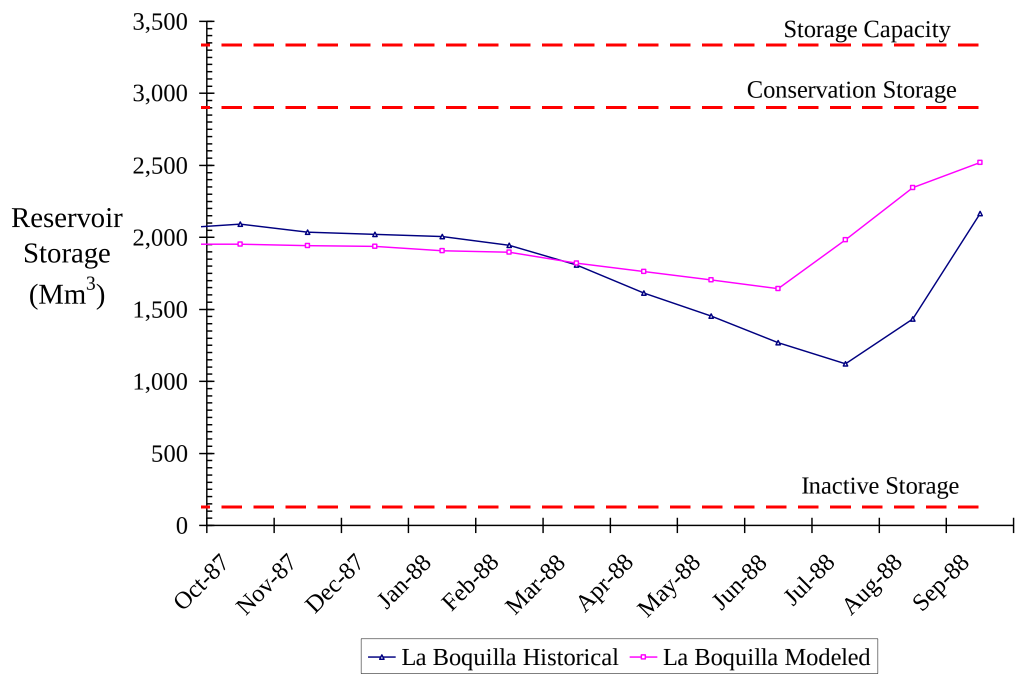

Figure 41: La Boquilla Historical vs. Modeled Reservoir Storage

Pecos River

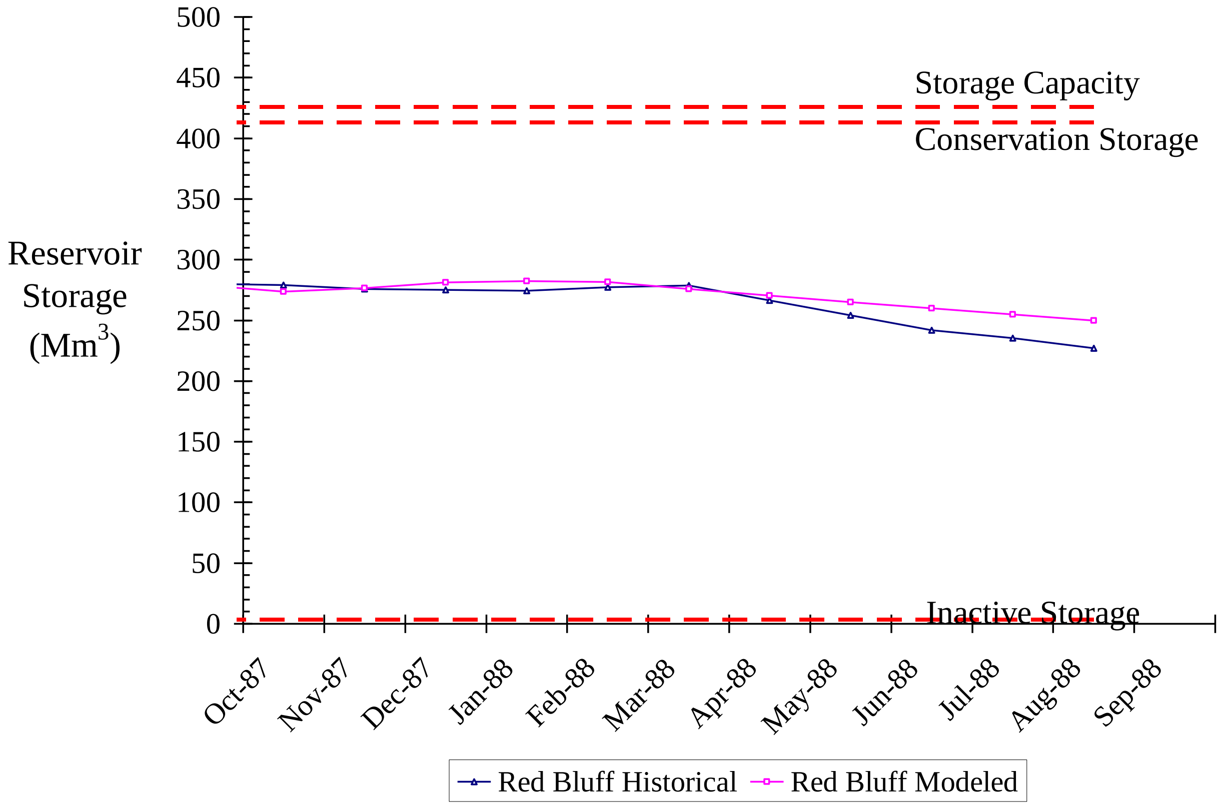

Figure 42: Red Bluff Historical vs. Modeled Reservoir Storage

Lower Rio Grande/Bravo

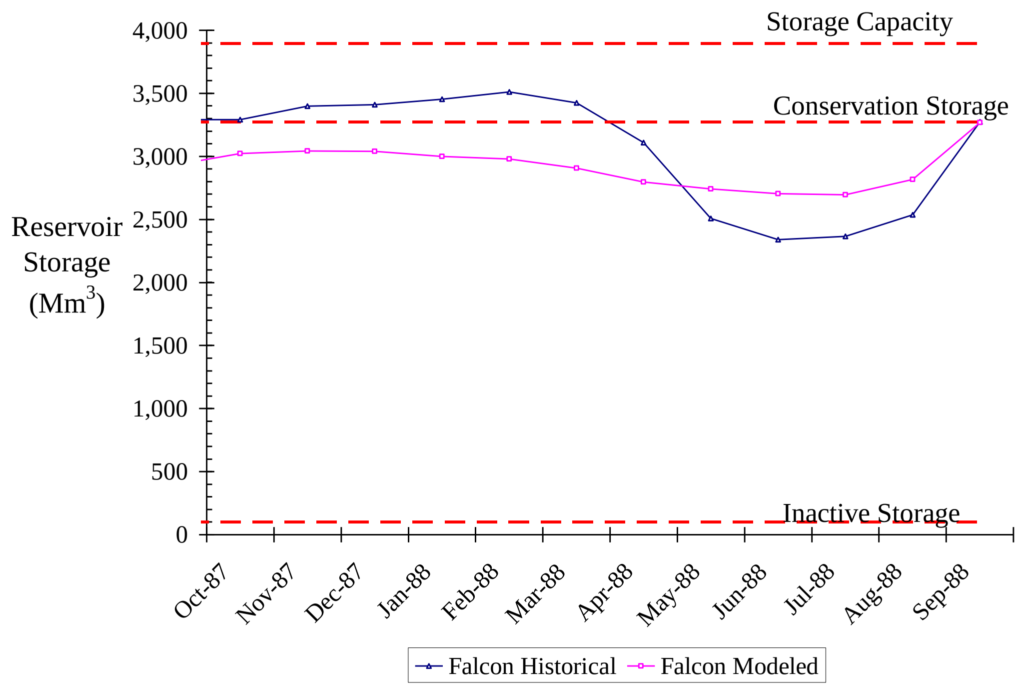

Figure 43: Falcon Historical vs. Modeled Reservoir Storage

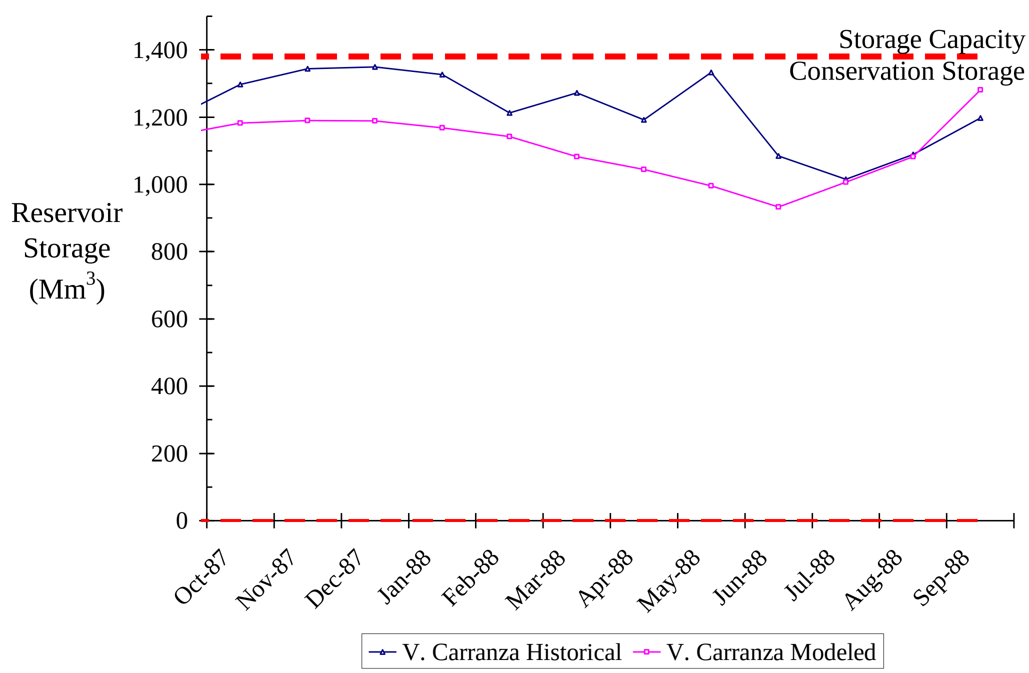

Figure 44 V. Carranza Historical vs. Modeled Reservoir Storage

Appendix J. IBWC Streamflow Gage Comparison Tables Graphs

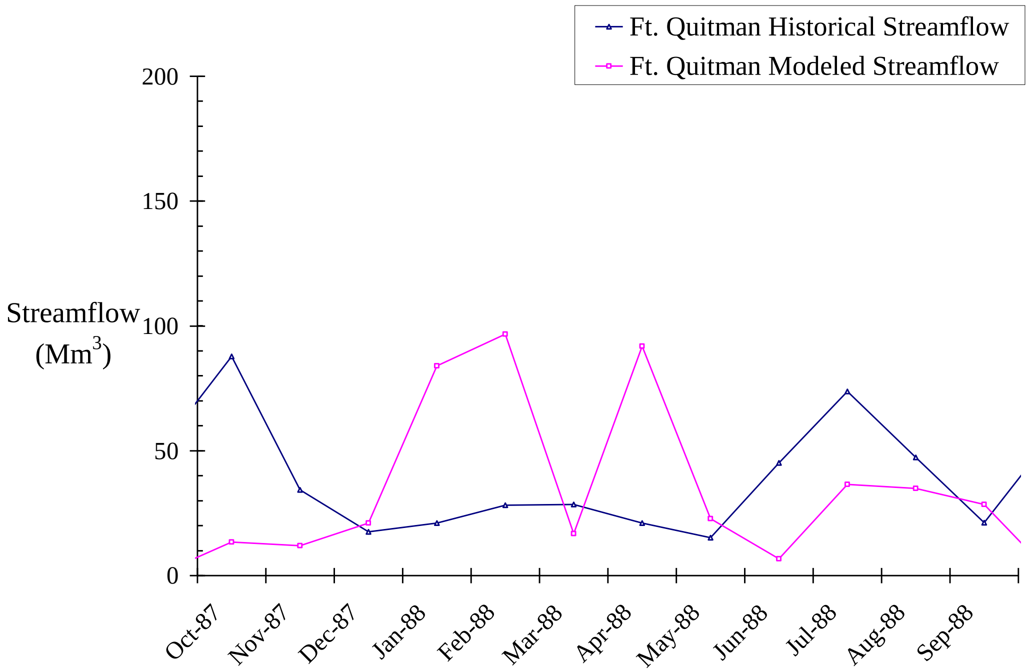

Figure 45 Ft. Quitman Historical and Modeled Streamflow Comparison

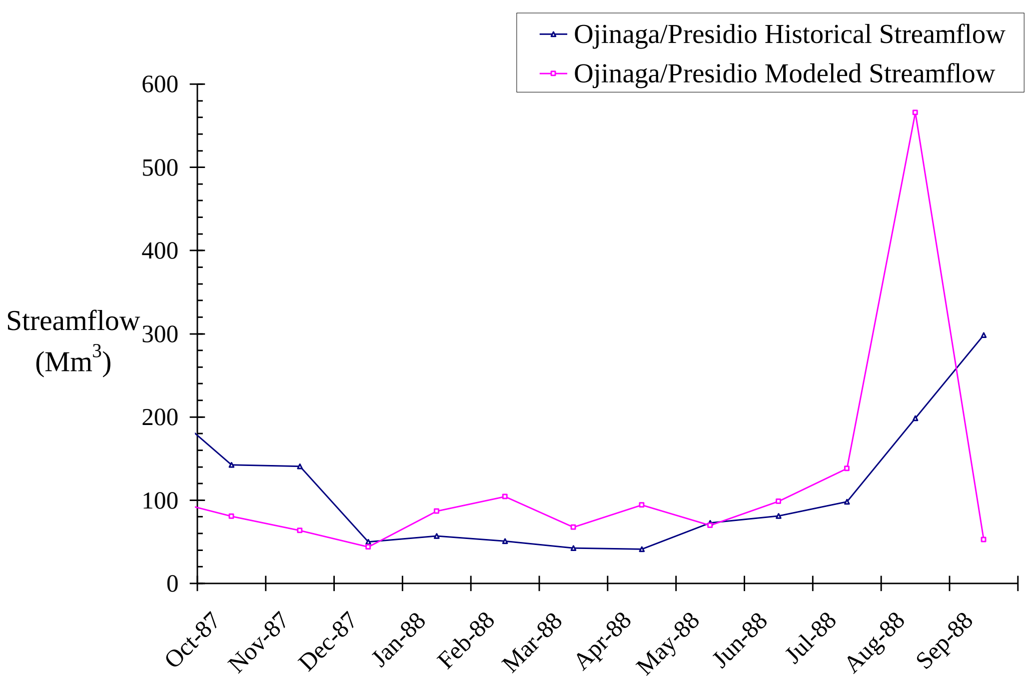

Figure 46 Ojinaga/Presidio Historical and Modeled Streamflow Comparison

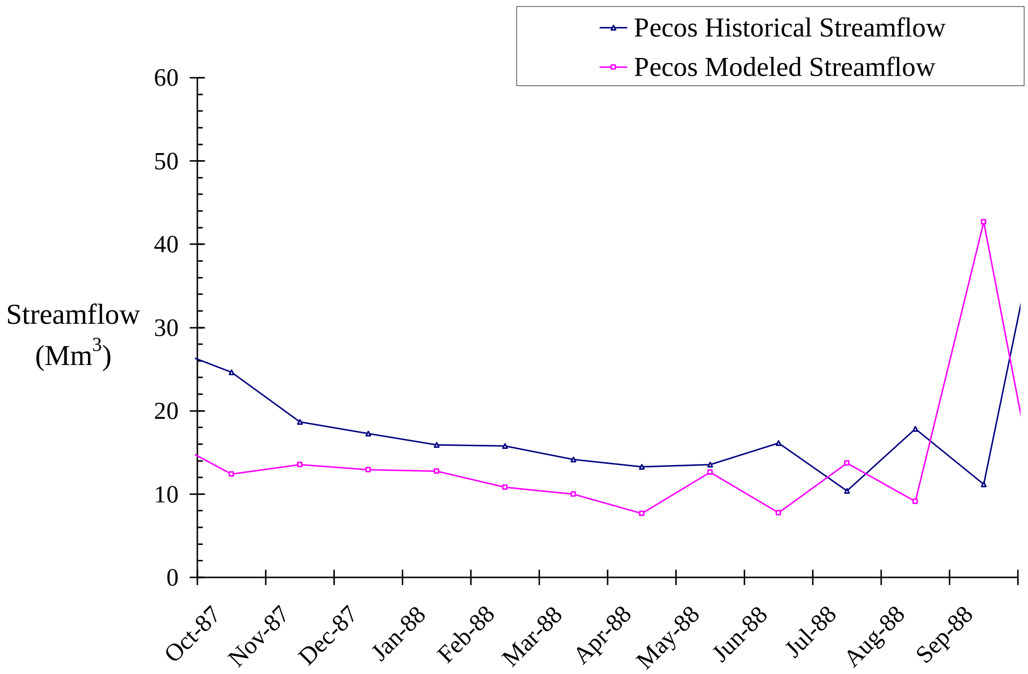

Figure 47 Pecos Historical and Modeled Streamflow Comparison

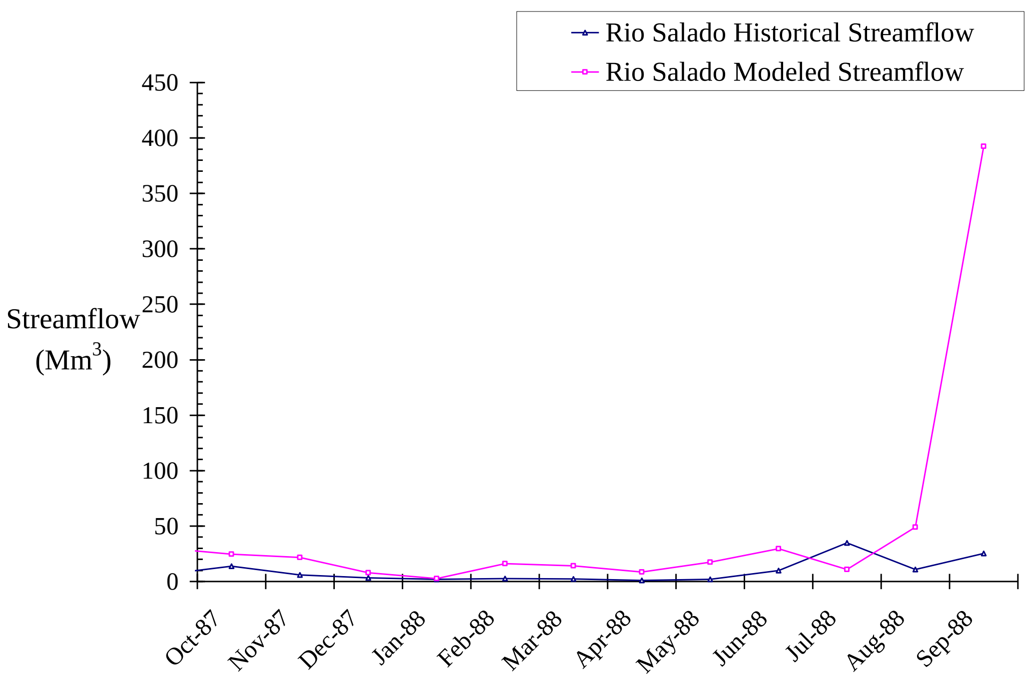

Figure 48 Rio Salado Historical and Modeled Streamflow Comparison

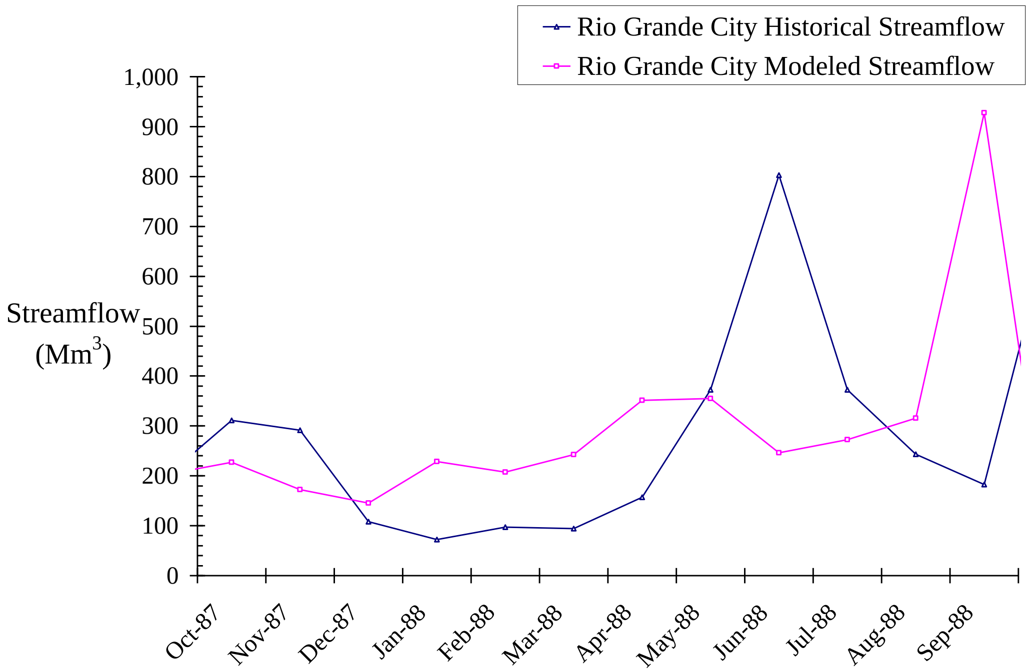

Figure 49 Rio Grande City Historical and Modeled Streamflow Comparison

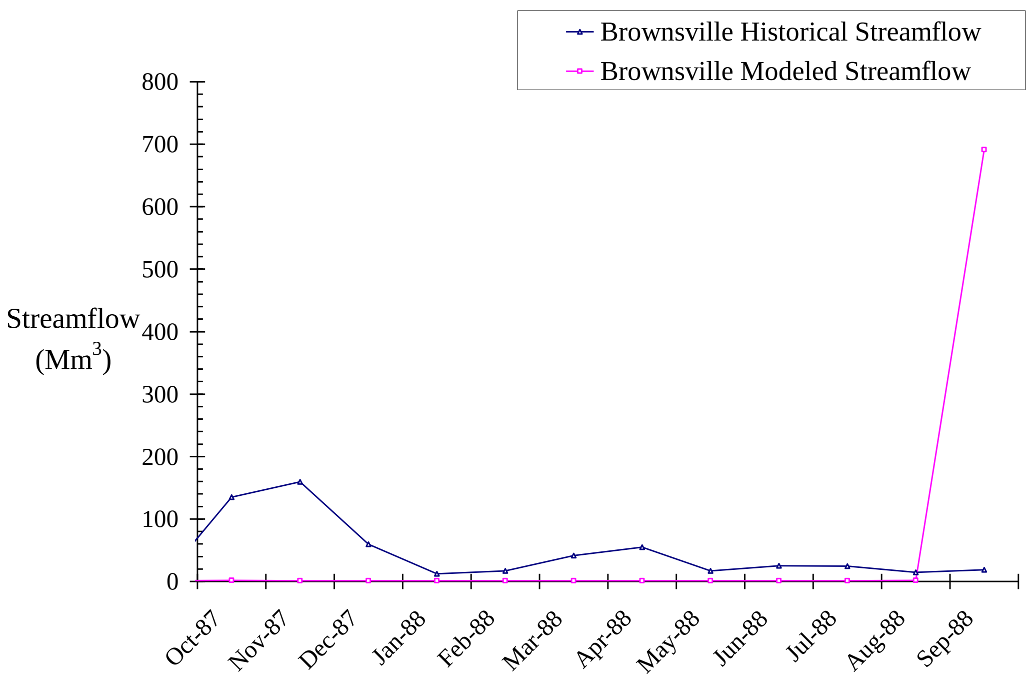

Figure 50 Brownsville Historical and Modeled Streamflow Comparison