FINAL REPORT

Conceptual Evaluation of Surface Water Storage in El Paso County

Prepared for
Far West Texas Regional Planning Group

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EPWU Hydrogeology Report 08-02
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Table of Contents

List of Tables

List of Figures

List of Figures
(Page 2 of 2)

1.0 INTRODUCTION

1.1 EPWU Supplies and Conjunctive Use Management

Since the beginning of the 20th century, El Paso Water Utilities (EPWU) has relied on both surface water and groundwater for municipal water supply. Surface water is supplied from the Rio Grande (Figure 1).

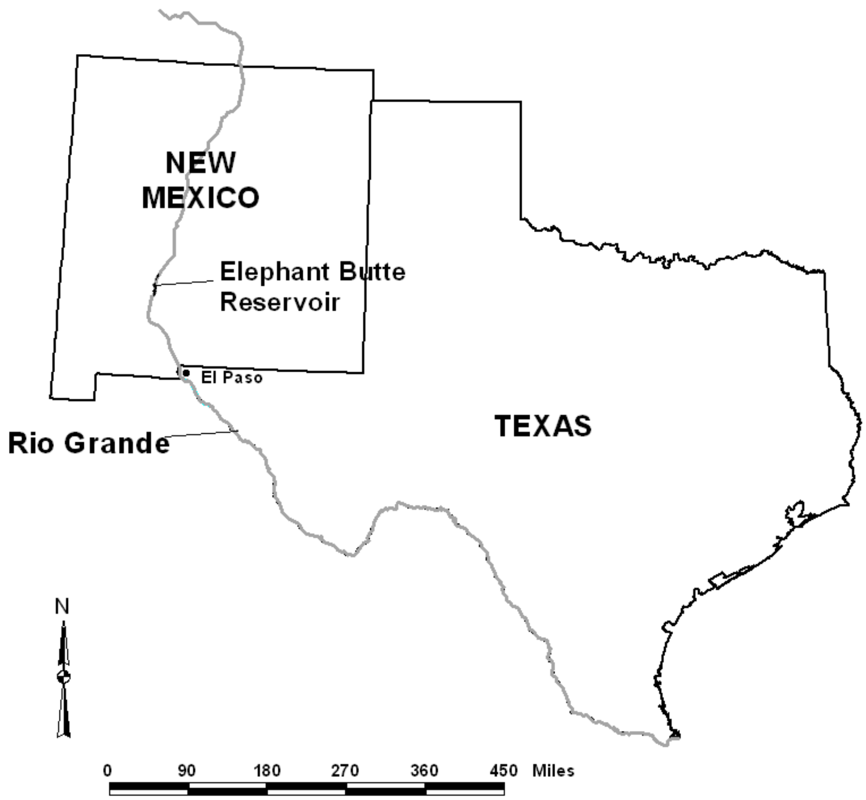


Figure 1. Rio Grande and Elephant Butte Reservoir

The Rio Grande flows that are diverted in the El Paso area are primarily derived from snowmelt runoff in southern Colorado and northern New Mexico. Historically, there are also occasional flood surges associated with storm systems in the summer monsoon season. Spring runoff is stored in Elephant Butte Reservoir in southern New Mexico before releases are made for irrigation and municipal use in southern New Mexico and the El Paso area. EPWU is a customer of the local irrigation district (El Paso County Water Improvement District No.1), and obtains water through ownership of water rights land, or leasing of water rights from agricultural water rights holders (Figure 2).

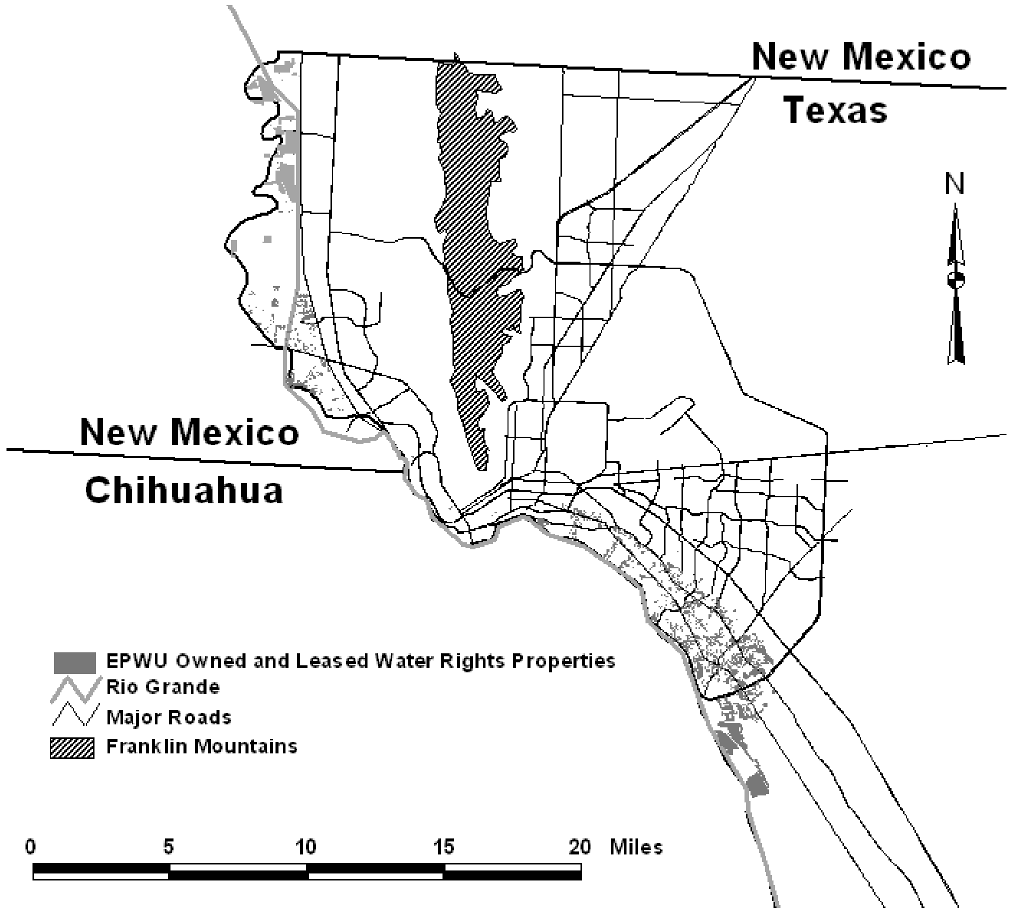


Figure 2. Location of EPWU Water Rights Properties (Owned and Leased)

Groundwater supplies are pumped from the Mesilla Bolson and the Hueco Bolson (Figure 3). The Los Muertos Bolson, adjacent to the Mesilla Bolson is also shown in Figure 3. These groundwater basins underlie portions of New Mexico, Texas and Chihuahua. Groundwater occurs in unconsolidated fluvial, alluvial, and lacustrine sediments. The Rio Grande plays an important role in the recharge and discharge of both groundwater basins.

The location of EPWU wells in the Hueco Bolson and Mesilla Bolson and the location of the two EPWU surface water treatment plants are shown on Figure 4. Annual production from each of these sources is summarized in Figure 5, and the data are summarized in Table 1.

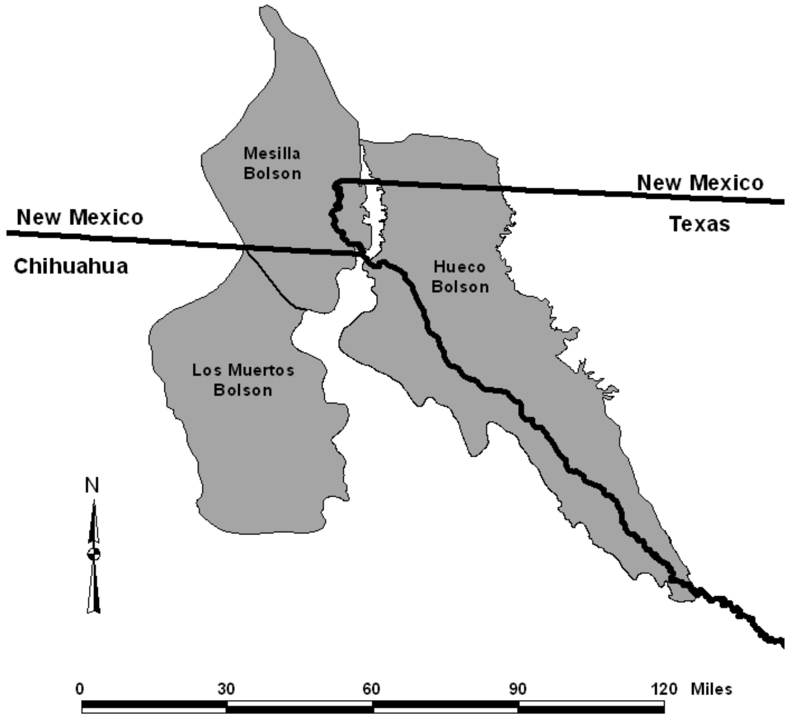


Figure 3. Location of Hueco Bolson, Mesilla Bolson and Los Muertos Bolson

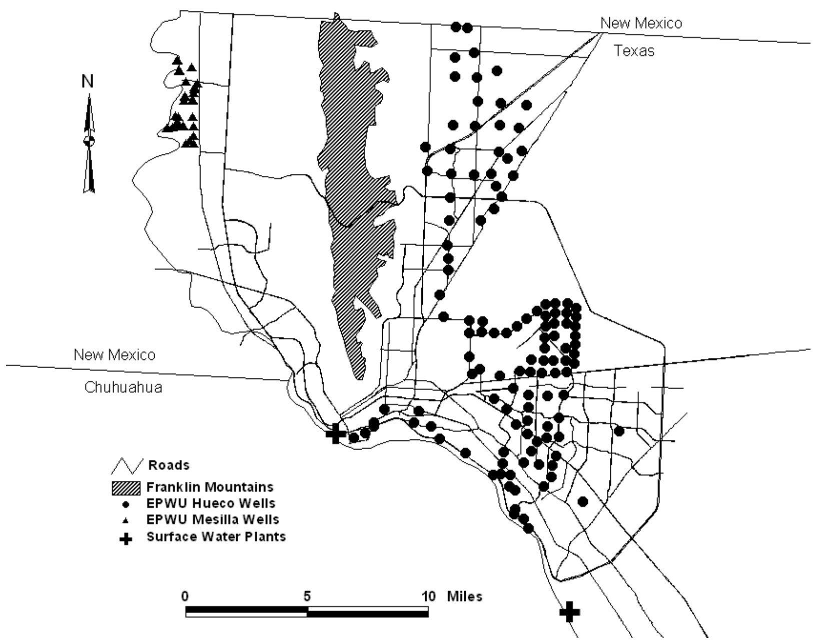


Figure 4. Location of EPWU Wells and Surface Water Plants

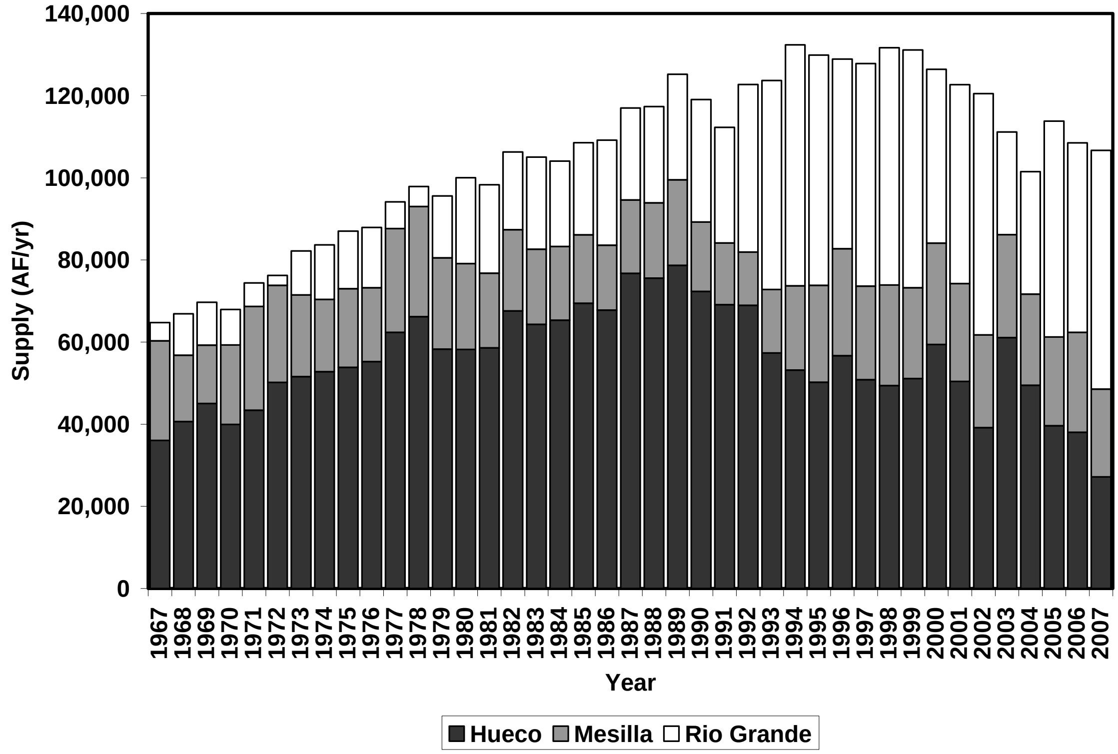


Figure 5. History of EPWU Supplies from Groundwater (Hueco Bolson and Mesilla Bolson) and Surface Water (Rio Grande)

EPWU pumping in the Hueco Bolson peaked at about 80,000 acre-feet per year (AF/yr) in 1989. As a result of concerns regarding the long-term ability to continue this level of pumping, EPWU implemented the following water management strategies: 1) adopted a rate structure that increases the cost of water for high use, 2) promoted water conservation through various incentive programs, 3) increased the use of Rio Grande Water, and 4) expanded the reuse of reclaimed water.

EPWU pumping in the Hueco Bolson in 2002 was below 40,000 AF/yr for the first time since 1967. Hueco Bolson pumping increased in 2003 and 2004 due to drought conditions and the associated reduction in surface water diversions. Hueco Bolson pumping again dropped below 40,000 AF/yr in 2005 as a result of a return of nearly full river allocation conditions. Hueco Bolson pumping continued to drop in 2006 and 2007 due to near-maximum operation of the surface water treatment plants and reduced demand. Pumping in the Hueco Bolson in 2007 was below 30,000 AF/yr which is lower than Hueco Bolson pumping in 1967.

Table 1. Summary of EPWU Supply - 1967 to 2005
All Values in AF/yr

Year	Hueco Pumping	Mesilla Pumping	Surface Water	Total Supply
1967	36,050	24,276	4,426	64,752
1968	40,649	16,147	10,111	66,907
1969	45,055	14,197	10,415	69,668
1970	39,951	19,370	8,631	67,951
1971	43,390	25,291	5,722	74,403
1972	50,190	23,626	2,426	76,243
1973	51,569	19,940	10,674	82,183
1974	52,798	17,596	13,281	83,675
1975	53,865	19,132	14,041	87,039
1976	55,236	18,011	14,680	87,927
1977	62,398	25,258	6,496	94,151
1978	66,212	26,821	4,840	97,873
1979	58,278	22,276	15,038	95,592
1980	58,213	20,917	20,929	100,059
1981	58,587	18,221	21,481	98,289
1982	67,612	19,743	18,922	106,277
1983	64,328	18,298	22,419	105,045
1984	65,309	17,979	20,769	104,058
1985	69,482	16,660	22,423	108,565
1986	67,776	15,822	25,588	109,186
1987	76,741	17,894	22,378	117,014
1988	75,572	18,338	23,448	117,359
1989	78,699	20,841	25,674	125,215
1990	72,332	16,920	29,812	119,064
1991	69,117	15,024	28,153	112,294
1992	68,965	12,956	40,810	122,731
1993	57,363	15,477	50,868	123,709
1994	53,187	20,526	58,667	132,380
1995	50,220	23,605	56,060	129,885
1996	56,711	26,019	46,219	128,948
1997	50,870	22,772	54,194	127,837
1998	49,398	24,509	57,794	131,700
1999	51,127	22,136	57,879	131,142
2000	59,410	24,682	42,329	126,421
2001	50,438	23,823	48,428	122,689
2002	39,151	22,591	58,743	120,485
2003	61,103	25,063	24,992	111,158
2004	49,480	22,221	29,794	101,495
2005	39,630	21,635	52,546	113,721
2006	38,053	24,323	46,156	108,532
2007	27,204	21,339	58,141	106,684

The use of surface water when available and the increase in groundwater pumping in years when surface water availability is limited is termed conjunctive use. The conjunctive use management of surface water and groundwater resources in El Paso County recognizes that there are limits to surface water supplies and limits to groundwater supplies.

The most significant limitation to the surface water supply is that droughts occur, and surface water flows are limited in some years. In these years, groundwater pumping is increased in order to meet demands.

The management of local groundwater requires the recognition of limits with respect to the ability of local groundwater basins to supply water reliably over many decades. Simply increasing local groundwater pumping to meet increased demands has been shown to be an ineffective groundwater management strategy in El Paso in terms of water quantity and water quality. Indeed, the implementation of water management strategies beginning in the early 1990s that included increased diversion from the Rio Grande were primarily designed to reduce Hueco Bolson pumping. More recently, the completion of the Kay Bailey Hutchison Desalination Plant furthers the goals of groundwater management by intercepting brackish groundwater and treating it. This will ensure that fresh groundwater will be available to meet the conjunctive use management objectives of increased groundwater pumping from the Hueco Bolson when drought conditions occur.

1.2 Surface Water Treatment Capacity

The surface water plants have a combined capacity of 100 mgd (307 AF/day). Under normal river flow conditions, the plants operate approximately seven months during the year (i.e. during the irrigation season). EPWU is a customer of El Paso County Water Improvement District No.1, and receives water from the Rio Grande Project via its ownership of lands within the project area or through leases from water rights holders. Currently, El Paso has water rights of about 65,000 AF/yr from the Rio Grande Project.

The irrigation season varies from year to year depending on storage in Elephant Butte reservoir and runoff into the reservoir. In many years, the declaration of a "full allocation" year is not made until well into the irrigation season. A full seven month irrigation season from March 1 to September 30 is 214 days. Many years, the season extends from mid-February to mid-October. Thus, if 30 additional days are added (15 in February and 15 in October), the total irrigation season is 244 days. If releases begin February 1 and end on October 31, the irrigation season is 273 days (274 in a leap year).

Figure 6 summarizes the amount of water that can be treated at EPWU two surface water treatment plants as a function of length of irrigation season. Note that the graphical summary includes flows at plant capacity, as well as 90% of plant capacity and 80% of plant capacity.

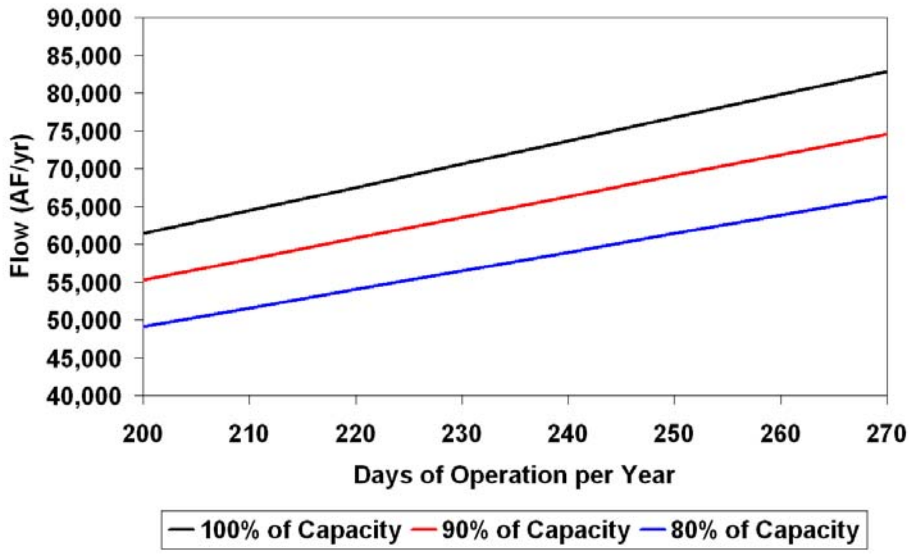


Figure 6. EPWU Surface Water Treatment Capability as a Function of Length of Irrigation Season

Note that surface water treatment capacity ranges from about 49,000 AF/yr (200 days of operation at 80% capacity) to about 83,000 AF/yr (270 days of operation at 100% of capacity). For an irrigation season that lasts from March 1 to September 30, the range is about 53,000 AF/yr (80% capacity) to 66,000 AF/yr (100% capacity). For an irrigation season that lasts from February 15 to October 15 (in a non-leap year), the range is about 60,000 AF/yr (80% capacity) to 75,000 AF/yr (100% capacity).

It is important to note that EPWU has water rights for about 65,000 AF/yr of Rio Grande water, and has the treatment capacity to treat more than 65,000 AF/yr under ideal conditions. This capacity was in place in 2002 when the Jonathan Rogers plant expansion was completed. In that year, nearly 59,000 AF of water was treated. From 2003 to 2006, reduced surface water allocations limited plant operation. In 2007, under a return to full surface water allocations, diversions were slightly over 58,000 AF. Current daily EPWU demands in the early portion of the irrigation season (March and April) are typically less than the 100 mgd treatment capacity. Thus, while it is often feasible to treat 100 mgd in the early months of the irrigation season, there is no demand for the water.

One of the limitations of conjunctive use management in El Paso County is the lack of local storage of surface water, or some other means to utilize the full treatment capacity of the plants even when demand is less than available water. Local surface water storage facilities could extend and enhance the use of surface water. Such facilities could be used to temporarily store Rio Grande Project water or capture monsoon storm runoff and put it to beneficial use. Previous studies have identified the benefits of a surface water treatment plant in the Upper Valley and discussions between El Paso Water Utilities and the El Paso County Water Improvement District No. 1 regarding the use of the Socorro Ponds as a surface water storage facility are ongoing.

1.3 Future El Paso County Supplies

The recently completed Regional Water Plan included a study of alternative means of supplying nonagricultural water to El Paso County through the year 2060. Based on current capacities of wells and surface water plants, and the limitation that surface water is only available during the irrigation season, total available municipal supply in El Paso County is about 150,000 AF/yr. This total includes about 5,000 AF/yr of reclaimed water supply that is available independent of drought conditions. Under full surface water allocation conditions, municipal surface water supply is about 60,000 AF/yr. Under these conditions, Hueco Bolson groundwater pumping supply is about 50,000 AF/yr, and Mesilla Bolson pumping supply is about 35,000 AF/yr for the entire County. Under drought-of-record conditions, it is expected that surface water supplies would drop to 10,000 AF/yr. During drought-of-record conditions, pumping supplies in the Hueco Bolson increase to 90,000 AF/yr and Mesilla Bolson pumping supplies increase to 45,000 AF/yr in order to maintain the full supply of 150,000 AF/yr.

Figure 7 summarizes these conjunctive use scenarios. Scenario 1 represents a full surface water allocation scenario. Scenario 6 represents a drought-of-record scenario. Scenarios 2 through 5 represent intermediate surface water allocation scenarios that are between drought-of-record and full allocation conditions.

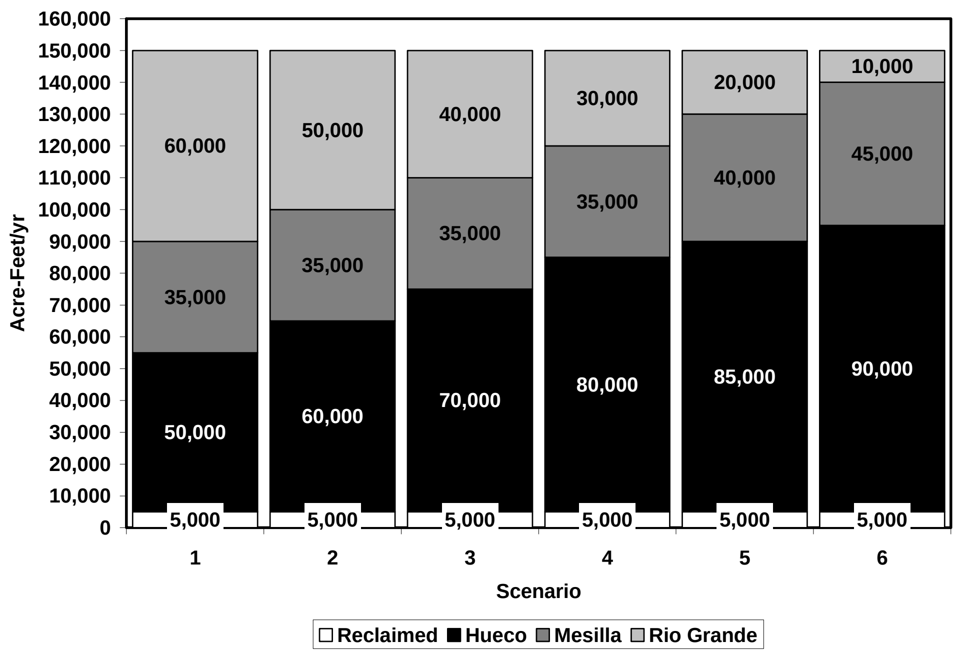


Figure 7. Current Conjunctive Use Supplies in El Paso County

Future demands are projected to increase as a result of increasing population. The 2006 regional plan included the development of six alternative integrated strategies to meet future demands though 2060. The strategies were "integrated" in that they included local surface water, local groundwater, expansion of reclaimed water and imported groundwater. Potential areas considered for importation of groundwater included properties currently owned by EPWU as follows:

1. "Capitan Reef Properties" located in Hudspeth and Culberson Counties that overlie the Capitan Reef Aquifer (about 30,000 acres)
2. Wildhorse Ranch in Culberson County that overlies the Wildhorse Flat area of the West Texas Bolson Aquifer (about 21,000 acres)
3. Antelope Ranch in Presidio and Jeff Davis Counties that overlies the Ryan Flat area of the West Texas Bolson Aquifer (about 25,000 acres)

The plan also considered properties in the Dell City area that overlie the Bone Spring/Victorio Peak Aquifer. EPWU does not currently own any land or water rights in the Dell City area. The location of properties owned by EPWU and the Dell City area properties are shown in Figure 8.

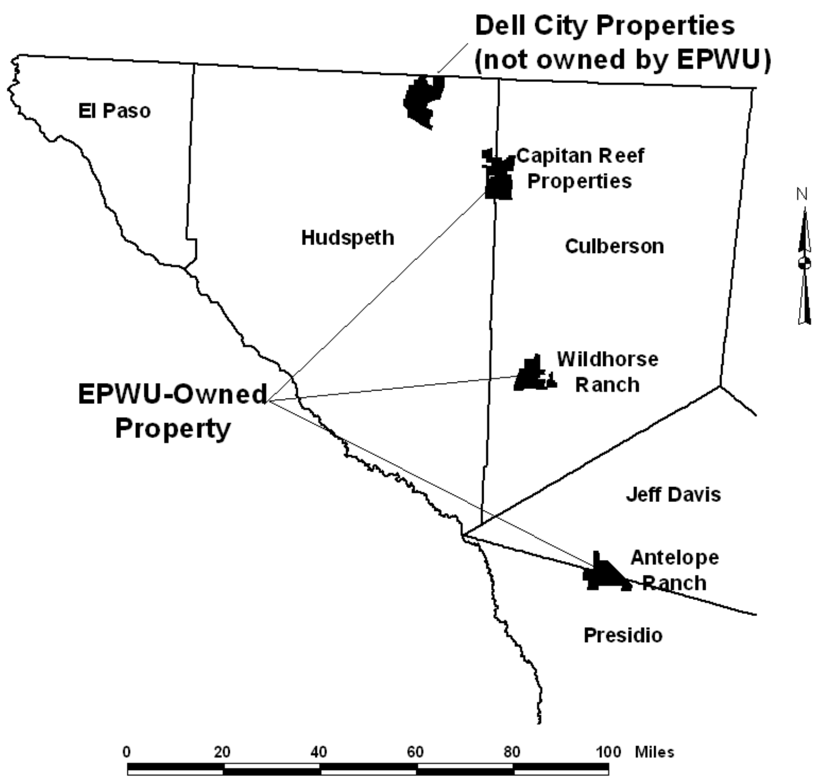


Figure 8. Location of Properties in Hudspeth, Culberson, Jeff Davis, and Presidio Counties for Potential Future Groundwater Importation Projects

Litigation regarding the water rights in the Dell City area is ongoing, and EPWU has decided to suspend negotiations to purchase any Dell City property until the litigation is resolved. However, for purposes of long-term planning, the Far West Texas Regional Water Plan considered the Dell City properties as a potential source of supply for El Paso.

The 2006 regional plan provided for meeting all future non agricultural demands in El Paso County through the adoption of Alternative 6, which included expanding the conjunctive use of local surface and groundwater resources, expansion of reclaimed water use, and the importation of groundwater from the Dell City area and from the Capitan Reef Aquifer, located southeast of Dell City. Alternative 6 is summarized in Table 2. Other potential imported supplies identified in other alternatives from Antelope Ranch and Wildhorse Ranch will not be used prior to 2060 under the adopted alternative.

Table 2. Summary of Future El Paso County Water Supplies – Alternative 6, Far West Texas Regional Water Plan
all values (except population) in acre-ft/yr

	Year					
	2010	**2020**	**2030**	**2040**	**2050**	**2060**
Existing Conjunctive Use Supply	145,000	145,000	145,000	145,000	145,000	145,000
Existing Reclaimed Water Supply	5,000	5,000	5,000	5,000	5,000	5,000
Additional Reclaimed Water Supply	2,387	5,531	8,676	11,820	14,964	18,109
Additional Rio Grande Diversions	0	10,000	15,000	20,000	20,000	20,000
Dell City Groundwater	0	0	15,000	16,000	33,000	50,000
Capitan Reef Groundwater	0	0	0	10,000	10,000	10,000
Total Supply	152,387	165,531	188,676	207,820	227,964	248,109
Projected Demand	138,905	164,672	187,557	207,317	227,299	247,424
Projected Population	714,375	823,104	918,534	1,000,838	1,083,142	1,165,446

Of note in Table 2 is the projected increase in EPWU Rio Grande diversions after 2020. The plan calls for increasing diversions by 10,000 AF/yr in 2020, 15,000 AF/yr in 2030, and 20,000 AF/yr in 2040. Increased storage of surface water could be used to meet part of this projected supply.

The objective of this study is to conceptually evaluate three specific surface water storage options: 1) surface storage of Rio Grande water during high flow events for later use in the surface water plants, 2) store treated surface water in the Hueco Bolson, and 3) treat, store and utilize local stormwater runoff. This work was completed as an interim study for the Far West Texas Regional Planning Group.

2.0 STORAGE OF EXCESS RIO GRANDE FLOWS

Analysis of potential storage of Rio Grande water to extend beneficial use begins with an analysis of flows in the Rio Grande at El Paso. Data for Rio Grande flow at the El Paso gage is maintained by the International Boundary and Water Commission. Daily records were evaluated from 1938 to 2007, the period of record that includes Elephant Butte and Caballo Reservoirs upstream of El Paso. Data were summarized for annual flows, monthly flows, and daily flows.

2.1 Annual Rio Grande Flows at El Paso

Based on actual records, annual Rio Grande flow at El Paso from 1938 to 2007 is 409,801 AF/yr. This record can be extended through the use of tree-ring data available for "cool-season" precipitation in northern New Mexico. This analysis relies on using the tree-ring data to develop estimates of Elephant Butte reservoir inflow. Estimates of reservoir evaporation and Elephant Butte outflow were also developed. Finally, Rio Grande flow at El Paso is estimated.

2.1.1 Elephant Butte Inflow

Elephant Butte inflows are measured by the US Bureau of Reclamation at San Marcial. The historic record runs from 1912 to present. Ni and others (2002) published a study that resulted in the estimation of "cool-season" precipitation in Arizona and New Mexico from the year 1000 to the year 1989, for a 989-year record of precipitation estimates, using 19 tree-ring chronologies in the southwestern United States. The precipitation data from the tree-ring chronologies from Rio Grande watershed in northern New Mexico was used to develop a relationship with Elephant Butte inflows through multiple regression analysis. The resulting regression equation is:

$$\text{EB Inflow} = 0.180828(\text{PCP-1})^3 + 0.46426(\text{PCP})^3$$

where: EB Inflow = Elephant Butte Inflow (AF/yr)
PCP = Annual Precipitation from Ni and others (2002) expressed as percent average
PCP-1 = Annual Precipitation from the preceding year from Ni and others expressed as percent of average

The adjusted multiple r-squared value for the resulting regression equation is 0.821. A comparison of the actual inflow data and the estimated inflow from the regression is shown in Figure 9.

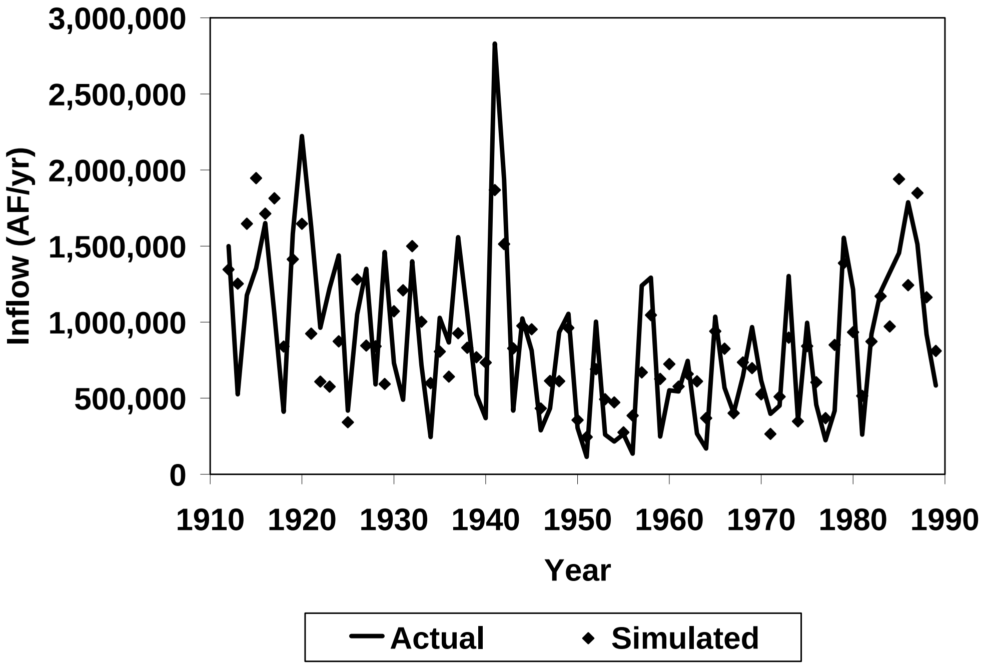


Figure 9. Actual vs. Simulated Elephant Butte Inflow

The resulting regression relationship can be used to estimate Elephant Butte inflows from the years 1001 to 1989. Extending the data are actual inflow data from 1990 to 2007, for a total record from 1001 to 2007, or 1007 years. The annual estimates using the regression equation and the running 50-year average for inflow are shown in Figure 10. Figure 11 shows the 50-year running average inflow.

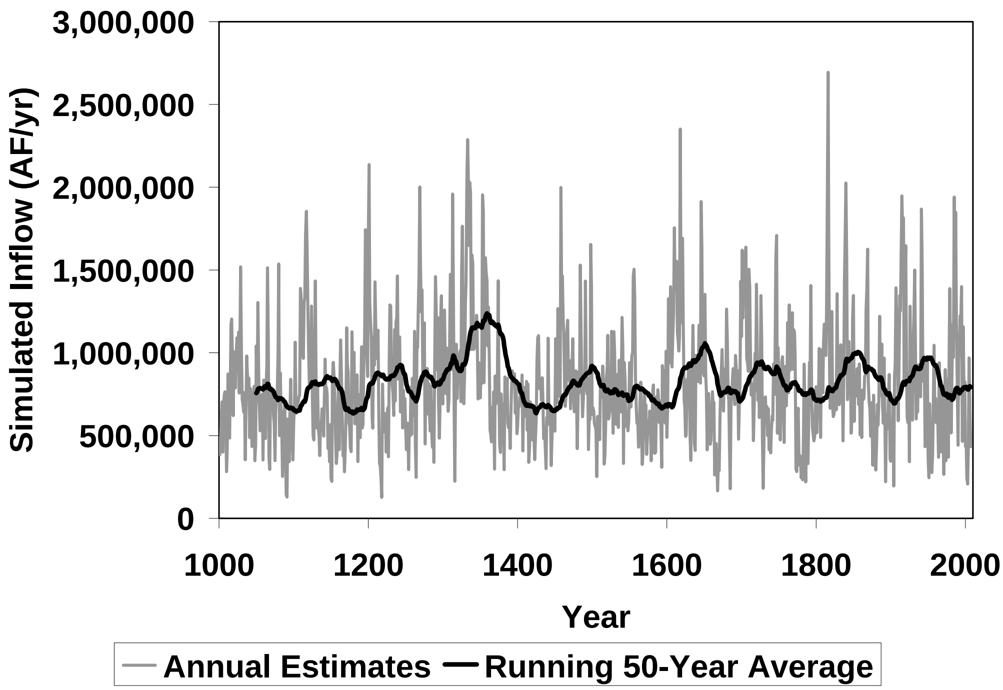


Figure 10. Simulated Elephant Butte Inflow, 1001 to 2007 with 50-year Running Averages

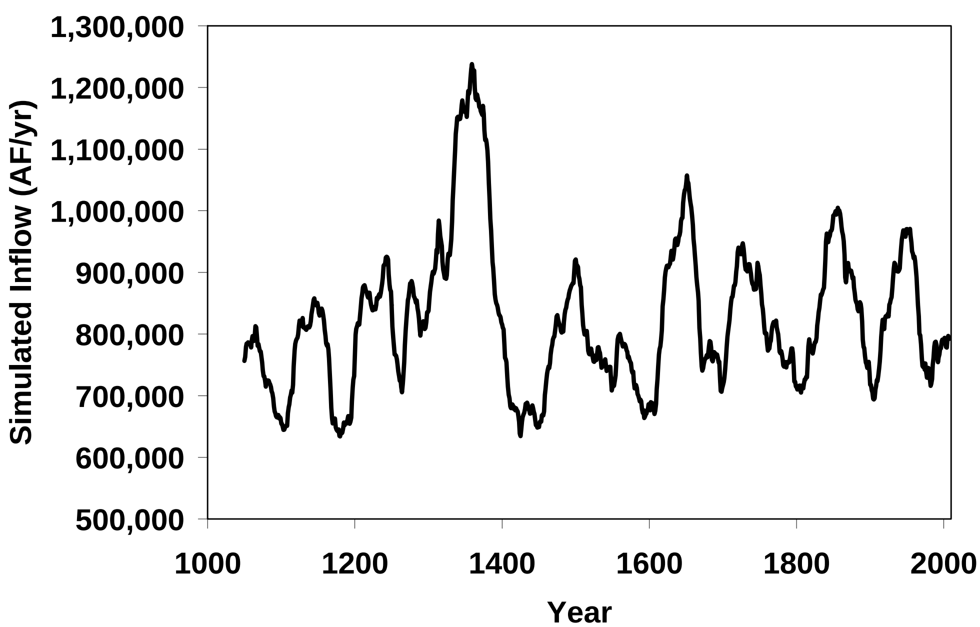


Figure 11. Simulated 50-Year Running Average Elephant Butte Inflow

The 50-year averages depict a wide range of inflows over the last millennium. Note that in 1362, the average inflow for the preceding 50 years was about 1.23 million AF/yr. By 1426, the 50-year average inflow was 644,000 AF/yr. Current 50-year average is about 800,000 AF/yr.

2.1.2 Reservoir Evaporation

Water is released from Elephant Butte into Caballo Reservoir, a relatively small regulating reservoir. The June 30 storage at Elephant Butte was regressed against the total annual evaporation estimates made by the US Bureau of Reclamation to develop an empirical relationship between storage and evaporation for use in the analysis. The summary of the data and the regression equation are shown in Figure 12.

Based on the end of the month storage records from 1915 to 2007, June 30 has the highest average storage. Thus, it is the most conservative estimate to base the regression of annual evaporation.

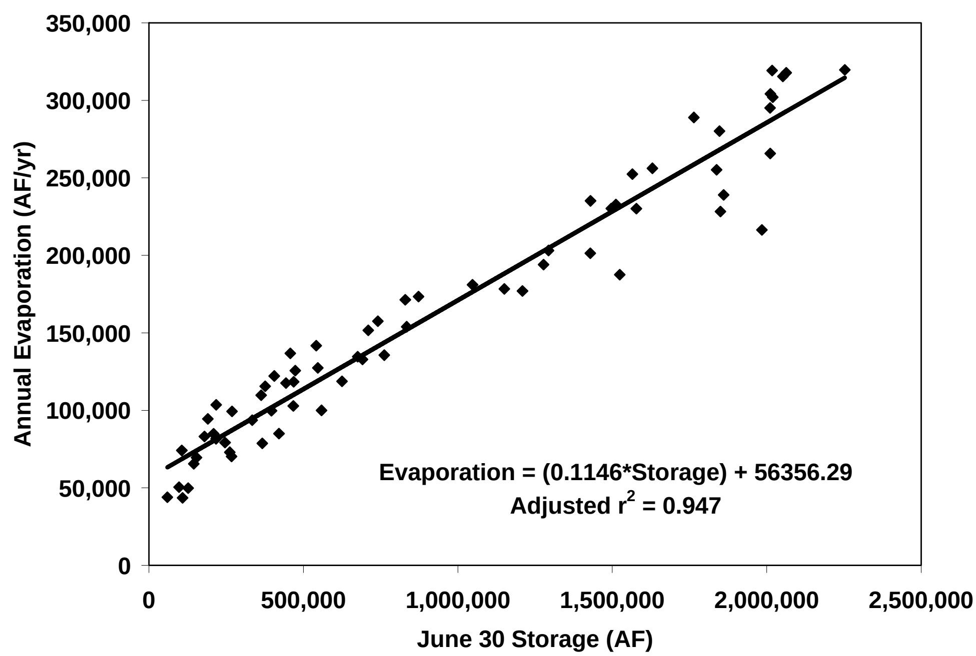


Figure 12. Elephant Butte Storage on June 30 vs.
Annual Evaporation from Elephant Butte and Caballo Reservoirs

2.1.3 Rio Grande at El Paso

Water released from Caballo flows through southern New Mexico, where it is diverted for use by the Elephant Butte Irrigation District. Return flows reenter the river at various points. Flow at El Paso is gauged by the US Geological Survey. In order to develop estimates of flow at El Paso under a wide range of release flows, an empirical relationship between Caballo releases and flow at El Paso was developed. A key assumption in the application of this relationship is that patterns of diversions and returns upstream of this gage remain unchanged. The summary of the data and the regression equation are shown in Figure 13.

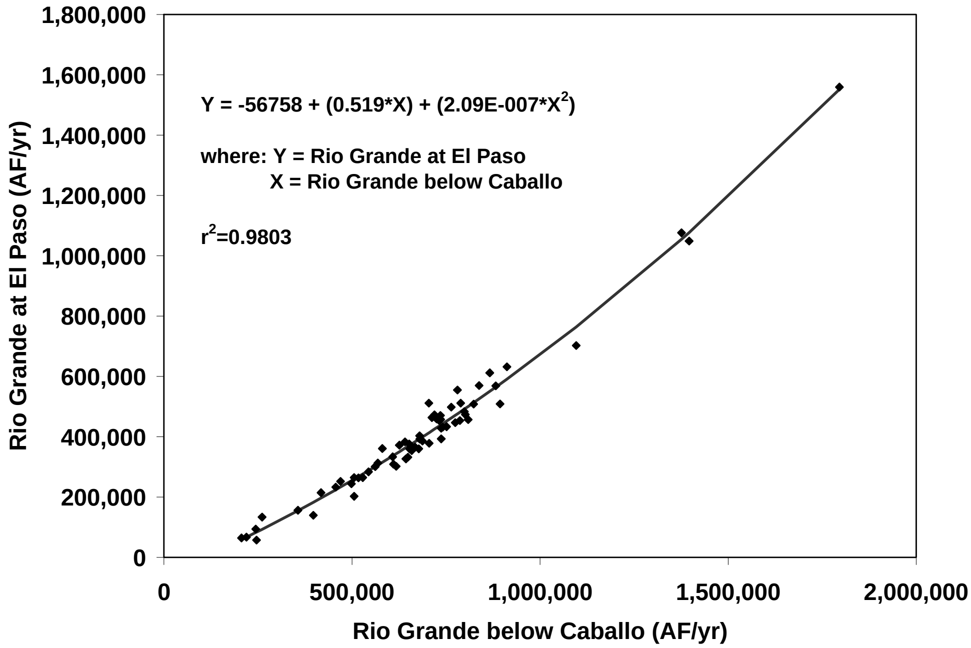


Figure 13. Rio Grande below Caballo vs. Rio Grande at El Paso

2.1.4 Reservoir Operations

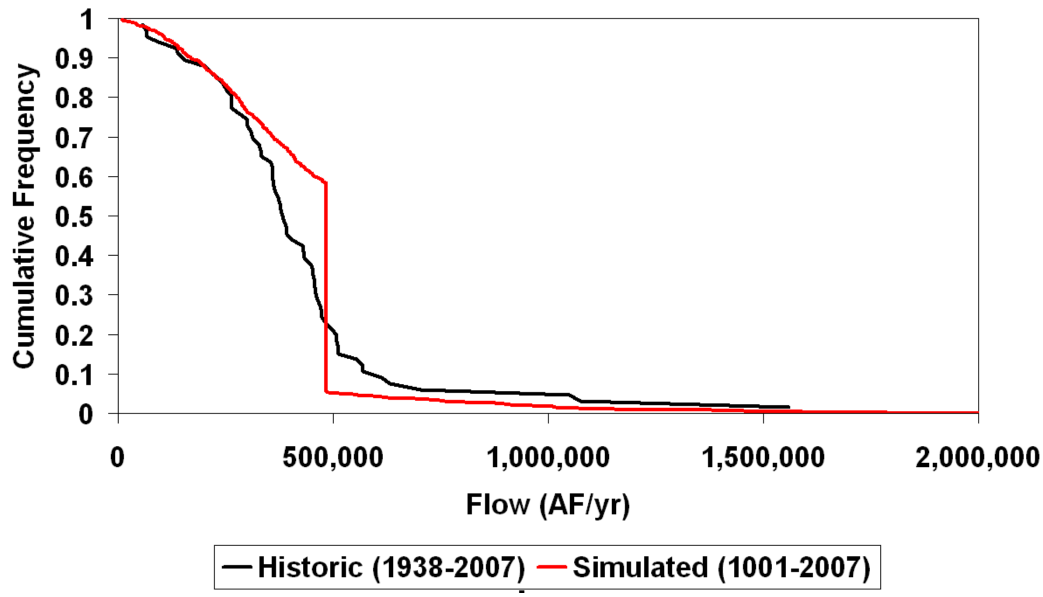
Through the tree-ring analysis and the simple operations model, estimates of Elephant Butte outflow and Rio Grande flow at El Paso from 1001 to 2007 were developed, and represent a wide range of climatic variability "observed" during the last millennium.

The simple operations model assumes that the initial storage in the reservoir is 1,000,000 AF. Annual reservoir evaporation is estimated and subtracted from the initial storage, and annual inflow is added to the result. Dead storage is assumed to be 75,000 AF. If there is sufficient storage (after inflow and evaporation) to release 790,000 AF, that amount is released and storage is recalculated. Otherwise, release is the amount available above the dead storage.

Based on the simulation, average Rio Grande flow at El Paso was 419,130 AF/yr based on the hydrologic record from 1001 to 2007.

2.1.5 Frequency Analysis of Annual Rio Grande Flow at El Paso

Figure 14 summarizes the frequency of annual Rio Grande flows at El Paso for both the historic record and the simulated flows based on the tree-ring record and the simple operations model. Note that the flows at plotted against the cumulative frequency of exceedance. For example, using the historic record, there is a 20% chance that annual flow at El Paso will exceed about 500,000 AF/yr.



Exceedance Probability	Annual Flow (AF/yr)	
	Historic Record (1938 to 2007)	Simulated (1001 to 2007)
0.05	1,048,937	514,422
0.10	569,953	483,689
0.20	508,002	483,689
Average Flow	409,801	419,130

Figure 14. Rio Grande at El Paso – Annual Flow Exceedance

Note that the simulated frequency curve contains a vertical section at a flow of about 484,000 AF/yr. This is the expected flow at El Paso when a full release is made at Elephant Butte (790,000 AF/yr). Under the simple operations model that was developed, the target flow was exactly met 531 of the 1007 years (53%). Elephant Butte outflow was higher than 790,000 AF/yr in 55 of the 1007 years (5%), and denotes when the reservoir "spills" due to high inflow and high antecedent storage conditions. Elephant Butte outflow was less than 790,000 AF/yr in 421 of the 1007 years (42%), and represents years when antecedent storage and inflow were not sufficient to make the full release.

The associated table in Figure 14 demonstrates the limitation of the simulated annual data regarding high flows. Note that in the historic record, Rio Grande flow at El Paso would exceed 1,000,000 AF/yr 5% of the time. However, in the simulated record, the 5%

exceedance flow is only slightly over 500,000 AF/yr. This suggests that runoff from monsoon storms contribute to the extremely high flows. The tree-ring analysis and associated simulated flows from 1001 to 2007 only consider "cool-season" precipitation, and ignore summer monsoon runoff contributions.

2.2 Monthly Rio Grande Flows at El Paso

Monthly Rio Grande flows at El Paso for the period 1938 to 2007 are summarized in Table 3. The summary includes average monthly flow and the exceedance flows for 20%, 10% and 5% levels.

Table 3. Rio Grande at El Paso
Average Monthly Flow and Monthly Flow Exceedance Values

Month	**Monthly Flow (AF/mo)**			
	Average	**Exceedance Probability**		
		0.20	**0.10**	**0.05**
January	13,193	17,167	20,135	24,109
February	15,834	24,251	27,067	33,787
March	60,393	78,469	89,822	96,769
April	63,880	88,532	102,621	121,554
May	68,592	90,212	107,184	116,038
June	86,372	100,952	121,522	154,739
July	97,984	115,648	126,128	215,527
August	90,335	111,042	126,215	135,578
September	61,696	73,880	95,273	102,361
October	28,912	42,235	48,686	65,589
November	15,248	20,622	25,763	28,439
December	15,049	17,019	25,495	26,250

Graphical summaries for the data in Table 3 are presented for average flow (Figure 15), 20% exceedance flow (Figure 16), 10% exceedance flow (Figure 17), and 5% exceedance flow (Figure 18). The 20% exceedance flows represent the monthly flow that is exceeded 20% of the time. The 10% exceedance flows represent the monthly flow that is exceeded 10% of the time. The 5% exceedance flows represent the monthly flow that is exceeded 5% of the time.

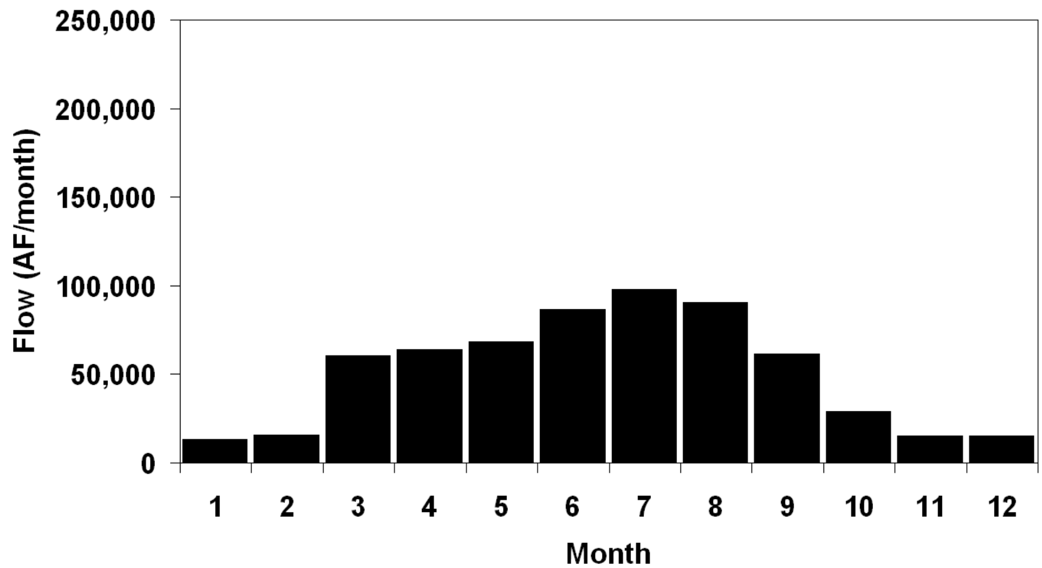


Figure 15. Rio Grande at El Paso – Average Monthly Flow

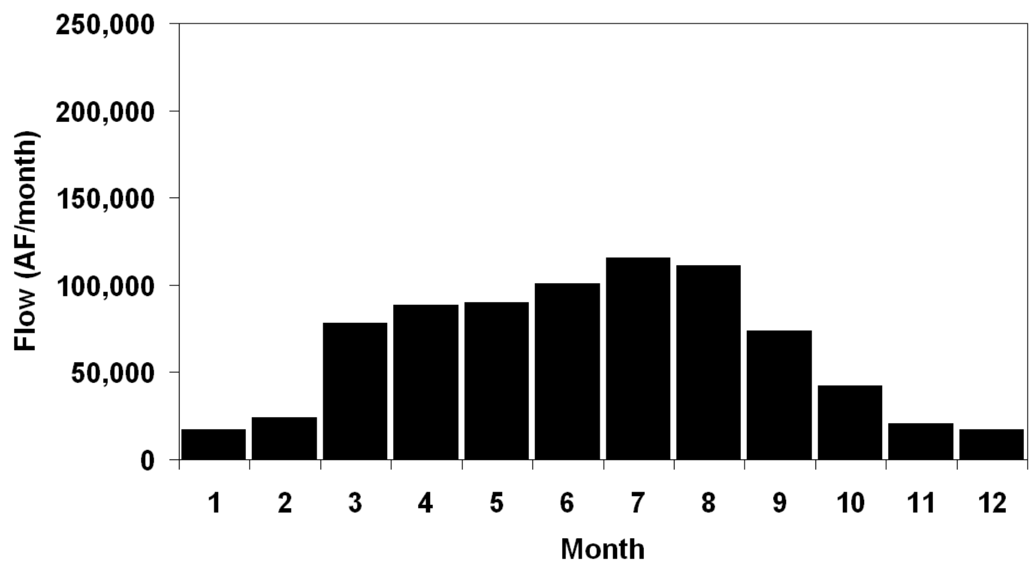


Figure 16. Rio Grande at El Paso – 20% Exceedance Monthly Flow

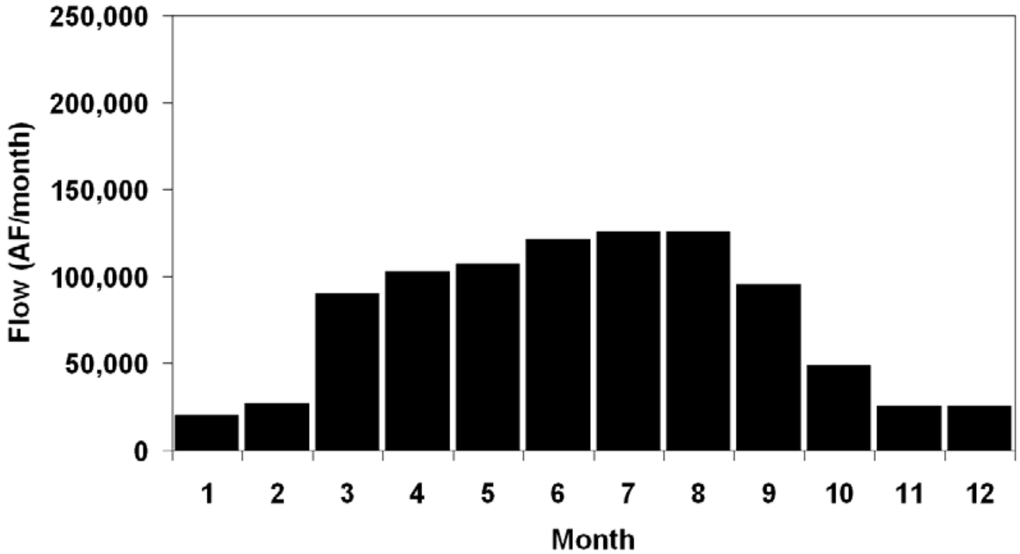


Figure 17. Rio Grande at El Paso – 10% Exceedance Monthly Flow

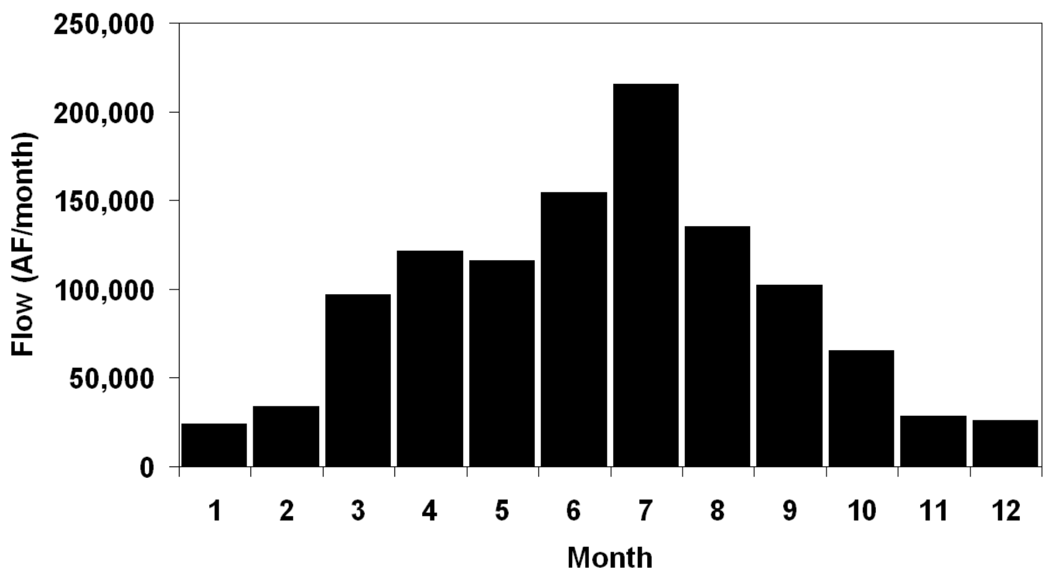


Figure 18. Rio Grande at El Paso – 5% Exceedance Monthly Flow

Figure 19 presents the monthly flow vs. cumulative frequency for December, January and February. Figure 20 presents the monthly flow vs. cumulative frequency for March, April and May. Figure 21 presents the monthly flow vs. cumulative frequency for June, July and August. Figure 22 presents the monthly flow vs. cumulative frequency for September, October and November.

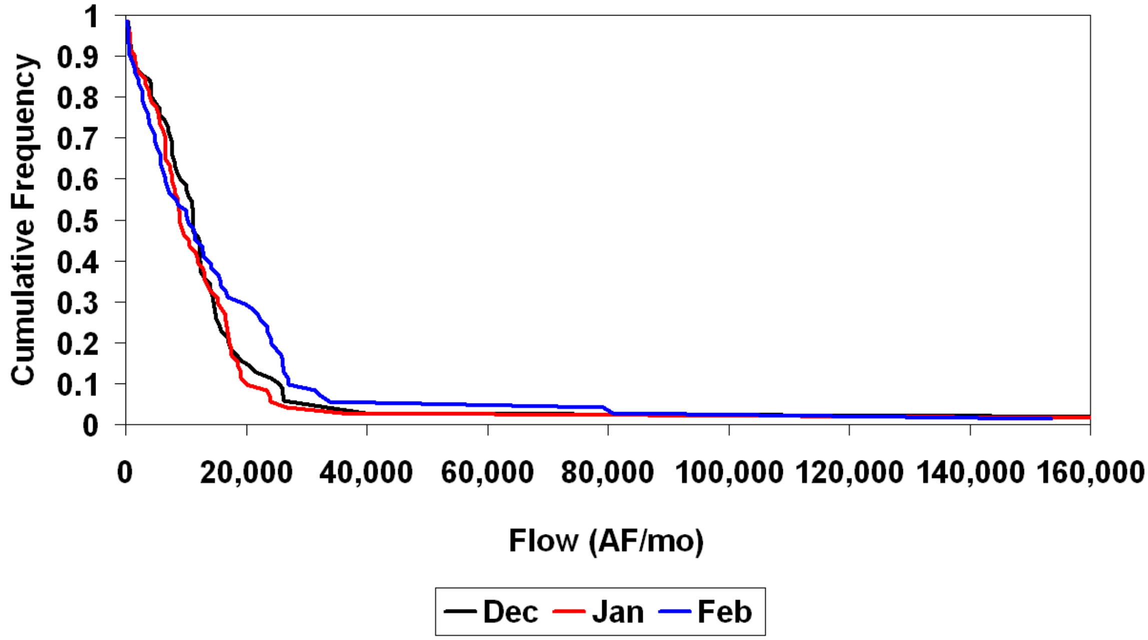


Figure 19. Rio Grande at El Paso – Monthly Flow Exceedance (1938 to 2007)
December, January and February

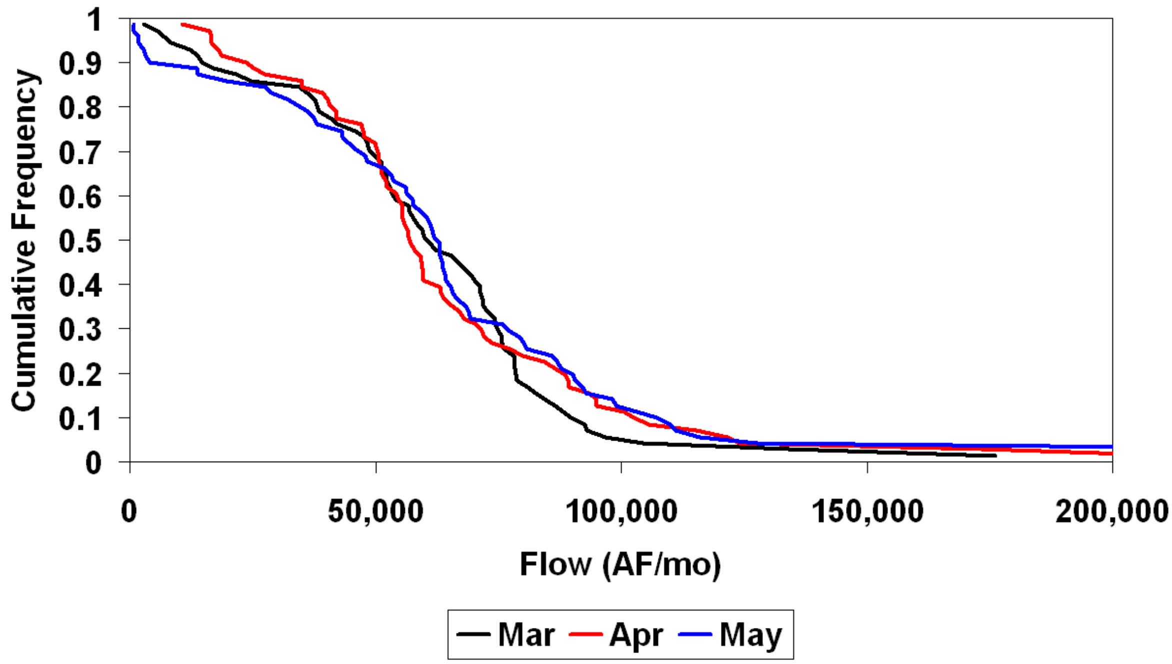


Figure 20. Rio Grande at El Paso – Monthly Flow Exceedance (1938 to 2007)
March, April and May

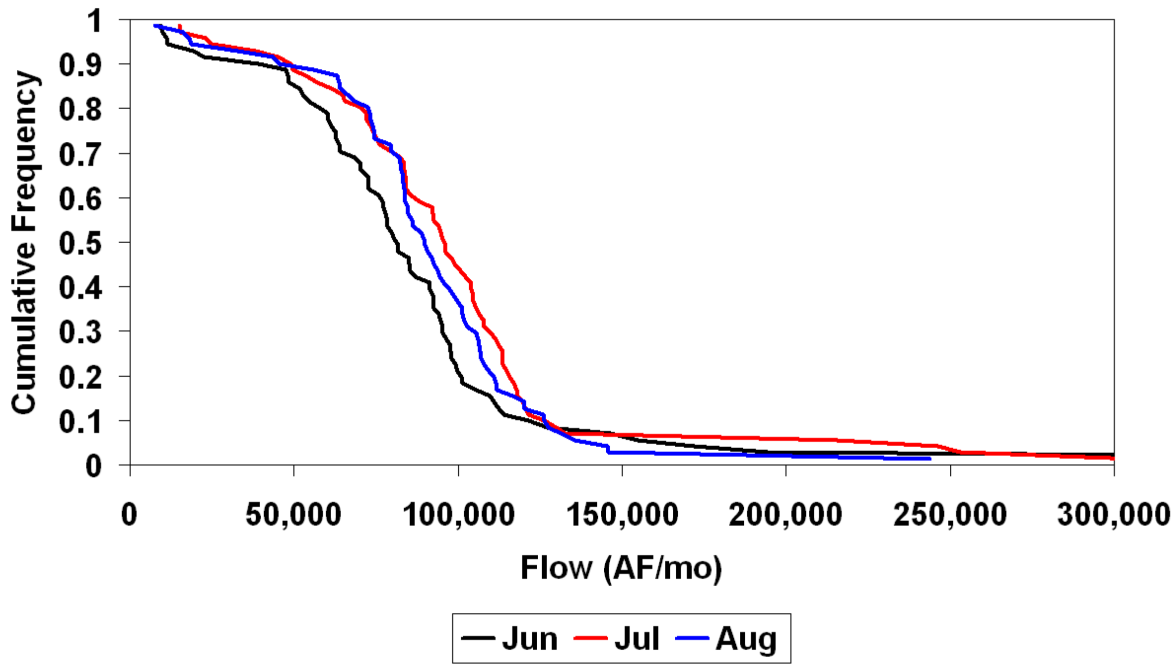


Figure 21. Rio Grande at El Paso – Monthly Flow Exceedance (1938 to 2007)
June, July and August

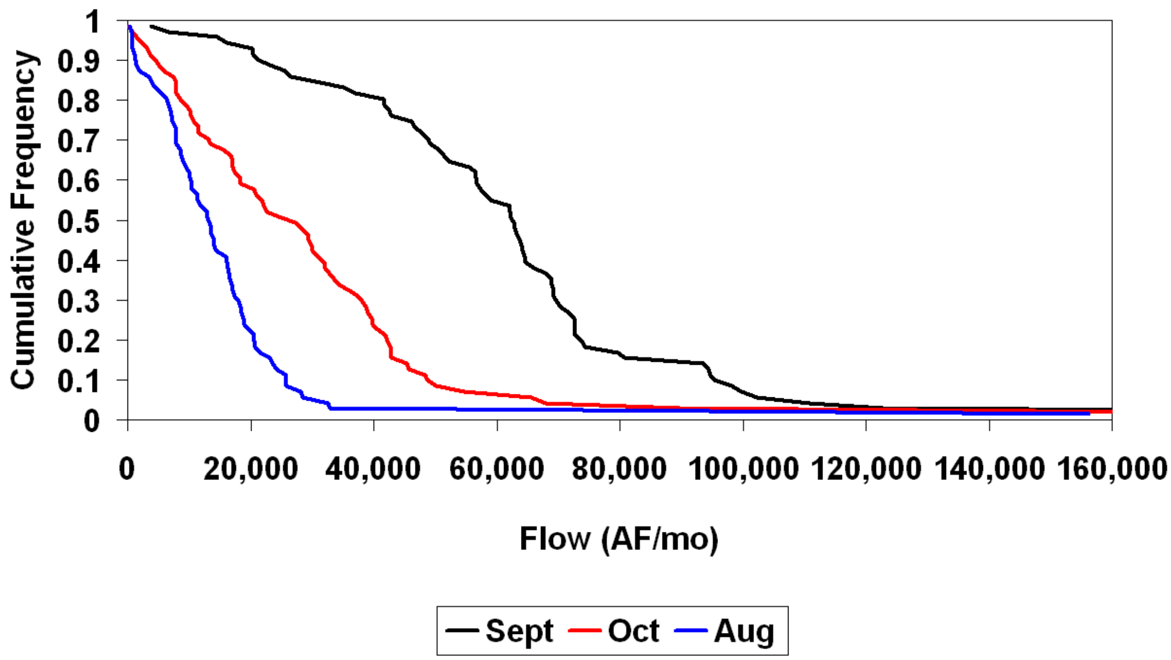


Figure 22. Rio Grande at El Paso – Monthly Flow Exceedance (1938 to 2007)
September, October and November

The analysis of monthly flow frequencies for the 70-year period (1938 to 2007) can be used to draw some conceptual conclusions regarding the amount and frequency of water that might be available for storage. In March, for example, average flow is about 60,000 AF/mo, and the 20% exceedance flow is about 78,000 AF/mo. Therefore, there is a 20% chance that flow will exceed the average by 18,000 AF in March. If 10% of that "excess" water was available for storage, then 1,800 AF could be stored for later use. If 25% of that "excess" water was available for storage, then 4,500 AF could be stored for later use. If 50% of that "excess" water was available for storage, then 9,000 AF could be stored for later use. This type of conceptual analysis can be extended for all months from March to September, and is summarized in Table 4.

Table 4. "Excess" Monthly Flows (AF/mo)
(20% Exceedance Flow minus Average Flow)

Month	**Average (A)**	**20% Exceedance Probability (B)**	**Excess= (A-B)**	**Availability (Percentage of Excess)**		
				10%	**25%**	**50%**
March	60,393	78,469	18,076	1,808	4,519	9,038
April	63,880	88,532	24,652	2,465	6,163	12,326
May	68,592	90,212	21,620	2,162	5,405	10,810
June	86,372	100,952	14,580	1,458	3,645	7,290
July	97,984	115,648	17,664	1,766	4,416	8,832
August	90,335	111,042	20,707	2,071	5,177	10,353
September	61,696	73,880	12,184	1,218	3,046	6,092

A-average values listed in Table 3
B-20% exceedance values listed in Table 3.

Conceptually, it could be reasonably argued that monthly flows in excess of monthly average is not an appropriate definition of "excess" since the average flow is less than the target flow due to drought conditions. Thus, the analysis could be altered to redefine "excess" as the difference in the 10% exceedance flow and the 20% exceedance flow. This analysis is summarized in Table 5.

Table 5. “Excess” Monthly Flows (AF/mo)
(10% Exceedance Flow minus 20% Exceedance Flow)

Month	10% Exceedance Probability (A)	20% Exceedance Probability (B)	Excess =(A)-(B)	Availability (Percentage of Excess)		
				10%	25%	50%
March	89,822	78,469	11,353	1,135	2,838	5,677
April	102,621	88,532	14,089	1,409	3,522	7,045
May	107,184	90,212	16,972	1,697	4,243	8,486
June	121,522	100,952	20,570	2,057	5,143	10,285
July	126,128	115,648	10,480	1,048	2,620	5,240
August	126,215	111,042	15,173	1,517	3,793	7,587
September	95,273	73,880	21,393	2,139	5,348	10,697

A-10% exceedance values listed in Table 3.
B-20% exceedance values listed in Table 3.

The definition of “excess” flow could also be the difference between the 5% exceedance flow and the 10% exceedance flow. This analysis is summarized in Table 6.

Table 6. “Excess” Monthly Flows (AF/mo)
(5% Exceedance Flow minus 10% Exceedance Flow)

Month	5% Exceedance Probability (A)	10% Exceedance Probability (B)	Excess= (A)-(B)	Availability (Percentage of Excess)		
				10%	25%	50%
March	96,769	89,822	6,947	695	1,737	3,474
April	121,554	102,621	18,933	1,893	4,733	9,467
May	116,038	107,184	8,854	885	2,214	4,427
June	154,739	121,522	33,217	3,322	8,304	16,609
July	215,527	126,128	89,399	8,940	22,350	44,700
August	135,578	126,215	9,363	936	2,341	4,682
September	102,361	95,273	7,088	709	1,772	3,544

A- 5% exceedance values listed in Table 3
B-10% exceedance values listed in Table 3

For project costing purposes, the annual yield of the scenarios presented in Tables 4, 5 and 6 is the amount of "excess" flow (assuming it could all be stored), times the frequency (0.05, 0.10 or 0.20). Assuming that 25% of the excess flow is available (the middle column in Tables 4, 5 and 6), the annual yield of each of these scenarios is summarized in Table 7.

Table 7. Annual Yield defined as the 25% Available Excess Flows times probabilistic frequency (0.2, 0.1, 0.05)

Month	**(A)**	**Annual Yield = (A) * 0.2**	**(B)**	**Annual yield = (B) * 0.1**	**(C)**	**Annual yield = (C) * 0.05**
March	4,519	**904**	2,838	**284**	1,737	**87**
April	6,163	**1,233**	3,522	**352**	4,733	**237**
May	5,405	**1,081**	4,243	**424**	2,214	**111**
June	3,645	**729**	5,143	**514**	8,304	**415**
July	4,416	**883**	2,620	**262**	22,350	**1,118**
August	5,177	**1,035**	3,793	**379**	2,341	**117**
September	3,046	**609**	5,348	**535**	1,772	**89**

A-25% Available Excess Flow from Table 4
B-25% Available Excess Flow from Table 5
C-25% Available Excess Flow from Table 6

Conceptually, not all the water could be stored, especially extremely high flows, so the annual yields estimated in Table 7 are considered optimistic. A more detailed design analysis would need to be completed in order to properly estimate annual yields. This conceptual level analysis, however, does highlight the general size of any storage facility and the high-end of the expected yield of such a project. For example, if "excess flow" was defined as the difference between the 10% exceedance flow and the 20% exceedance flow, and 25% of that water was available for storage (the middle column in Table 5), a storage facility that could hold 5,400 AF of water could be reasonably expected to handle the excess flow in all months. However, the highest excess flow under this scenario occurs in September, when demands are starting to decrease. If such a flow was captured in September, it would reasonable to expect that the stored water would be held until the following spring, when demands increased again.

The length of time to hold the stored water would generally be a detailed analysis at the design phase of a project. However, conceptually, it can be seen that holding times more than one month would be advisable in most cases. For this conceptual analysis, data from the 14 highest flows (the 0.20 exceedance level) were examined in the context of the flow the following month. Qualitatively, Table 8 summarizes the analysis.

Table 8. Flow Increases and Decreases in Subsequent Month of
14 Highest Flows (1938 to 2007)

Month	**Increase**	**Decrease**
April	5	9
May	8	6
June	10	4
July	2	12
August	1	13
September	1	13

Note that in the early part of the irrigation season (April, May and June), flows generally increase the subsequent month during high flow events. This suggests that opportunities to use stored water within a few weeks to a few months would be limited, and it would be expected that stored water would need to be held for as much as possibly a year.

Conceptually, storage facilities that would hold about 4,000 AF would be sufficient to capture "excess flows", and storage would be held for several months. This would result in annual yields of less than 1,500 AF/yr. Analyses of the daily data are necessary to conceptually evaluate the diversion capacity of a storage project.

2.3 Daily Rio Grande Flows at El Paso

Daily Rio Grande flows at El Paso for the period 1938 to 2007 are summarized in Table 9. The summary includes average daily flow for three time periods (January to December, April to September, and July to September) and the exceedance flows for 20%, 10% and 5% levels. Table 9 presents the data in terms of AF/day, million gallons per day (mgd), and cubic feet per second (cfs).

Table 9. Rio Grande at El Paso
Average Daily Flow and Daily Flow Exceedance Values
Flow Values in AF/day, mgd, and cfs

Exceedance Probability	**Daily Flow (AF/day)**		
	January to December	**April to September**	**July to September**
0.05	2,655	3,012	3,173
0.10	2,276	2,536	2,655
0.20	1,870	2,199	2,297
Average Flow	1,093	1,657	1,758

Exceedance Probability	Daily Flow (mgd)		
	January to December	**April to September**	**July to September**
0.05	865	981	1,034
0.10	742	826	865
0.20	609	717	749
Average Flow	356	539	573

Exceedance Probability	Daily Flow (cfs)		
	January to December	**April to September**	**July to September**
0.05	1,338	1,519	1,600
0.10	1,148	1,278	1,338
0.20	943	1,109	1,158
Average Flow	551	835	866

Figure 23 presents the daily flow vs. cumulative frequency for each of the three time periods expressed in AF/day. Figure 24 presents the daily flow vs. cumulative frequency for each of the three time periods expressed in mgd. Figure 25 presents the daily flow vs. cumulative frequency for each of the three time periods expressed in cfs.

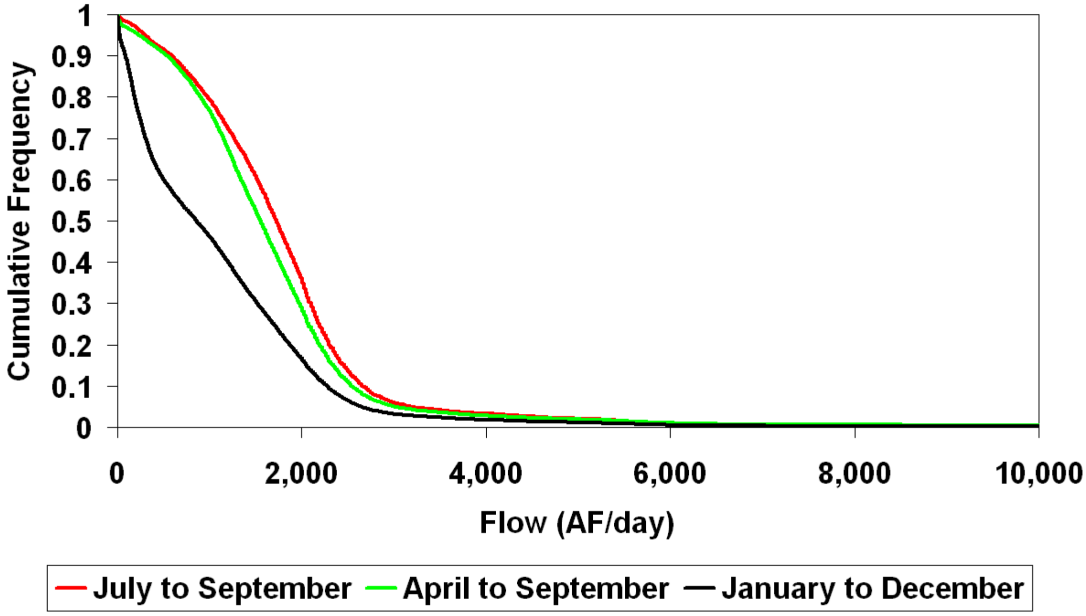


Figure 23. Rio Grande at El Paso – Daily Flow Exceedance (1938 to 2007)
Flow in AF/day

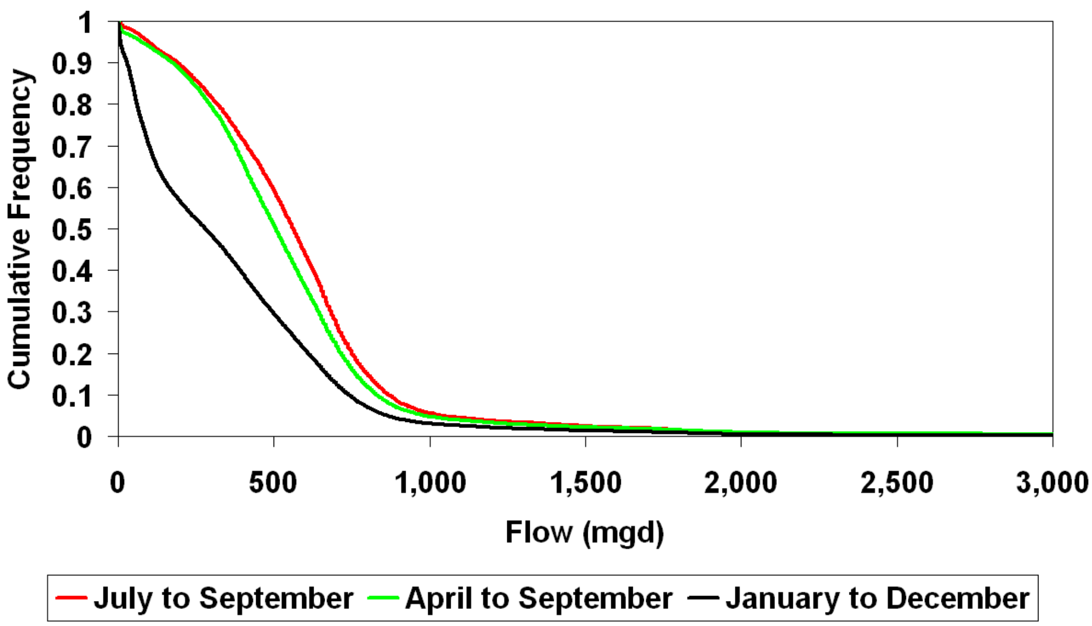


Figure 24. Rio Grande at El Paso – Daily Flow Exceedance (1938 to 2007)
Flow in mgd

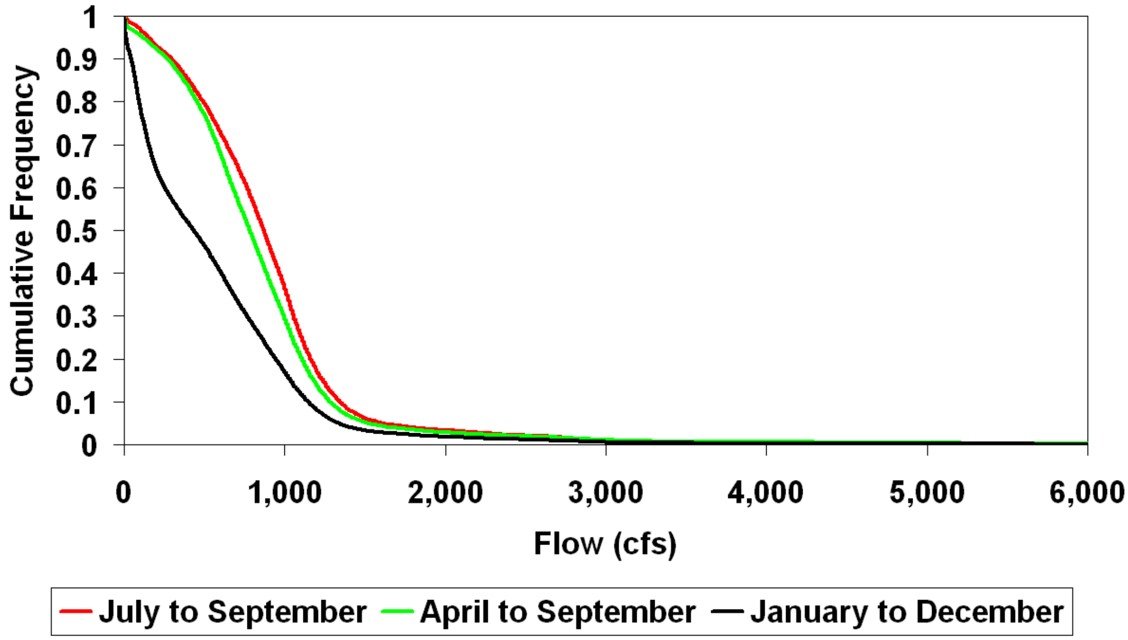


Figure 25. Rio Grande at El Paso – Daily Flow Exceedance (1938 to 2007)
Flow in cfs

Similar to the conceptual analysis of monthly flow data to estimate the range of "excess flow", Table 10 summarizes a similar analysis for daily flow. Note that the flows are expressed in acre-feet per day (AF/day), million gallons per day (mgd), and cubic feet per second (cfs) to facilitate future use of these data for potential design level studies. Recall that the monthly excess flows generally were in the range of 4,000 AF to obtain an annual yield of generally less than 1,000 AF/yr. Note that under the daily excess flows, diversions would last approximately 5 to 10 days if the storage capacity was 4,000 AF. Actual design calculations of diversion structures and equipment would be dependent on site specific parameters and are beyond the scope of this conceptual level investigation.

Table 10. Rio Grande at El Paso "Excess" Daily Flow (flows in AF/day, mgd, and cfs)

Excess Flow Definition	**Daily Flow (AF/day)**		
	January to December	**April to September**	**July to September**
5% Exceedance Flow minus 10% Exceedance Flow	379	476	518
10% Exceedance Flow minus 20% Exceedance Flow	406	337	358
20% Exceedance Flow minus Average Flow	777	542	539

Excess Flow Definition	**Daily Flow (mgd)**		
	January to December	**April to September**	**July to September**
5% Exceedance Flow - 10% Exceedance Flow	123	155	169
10% Exceedance Flow - 20% Exceedance Flow	133	109	116
20% Exceedance Flow - Average Flow	253	178	176

Excess Flow Definition	**Daily Flow (cfs)**		
	January to December	**April to September**	**July to September**
5% Exceedance Flow - 10% Exceedance Flow	190	241	262
10% Exceedance Flow - 20% Exceedance Flow	205	169	180
20% Exceedance Flow - Average Flow	392	274	292

2.4 Potential Storage Sites

Three potential sites were identified to store excess Rio Grande flows: 1) Socorro Ponds located near the Jonathan Rogers Water Treatment Plant, 2) Ascarate Lake located in Ascarate Park, and 3) the Upper Valley Water Treatment Plant area. The location of these sites is shown in Figure 26.

Boyle Engineering and Parsons Engineering completed a conceptual study of Socorro Ponds in 2000 as part of the evaluation of the El Paso-Las Cruces Sustainable Water Project. Their report is included as Appendix A. In order to facilitate comparisons between the three sites and with the other options discussed later in this report (storage of excess flows in the Hueco Bolson and treatment and storage of local stormwater), cost estimates that were developed by Boyle and Parsons were used in this report. Updated costs would be required as part of developing any of these conceptual alternatives into Regional Planning Strategies.

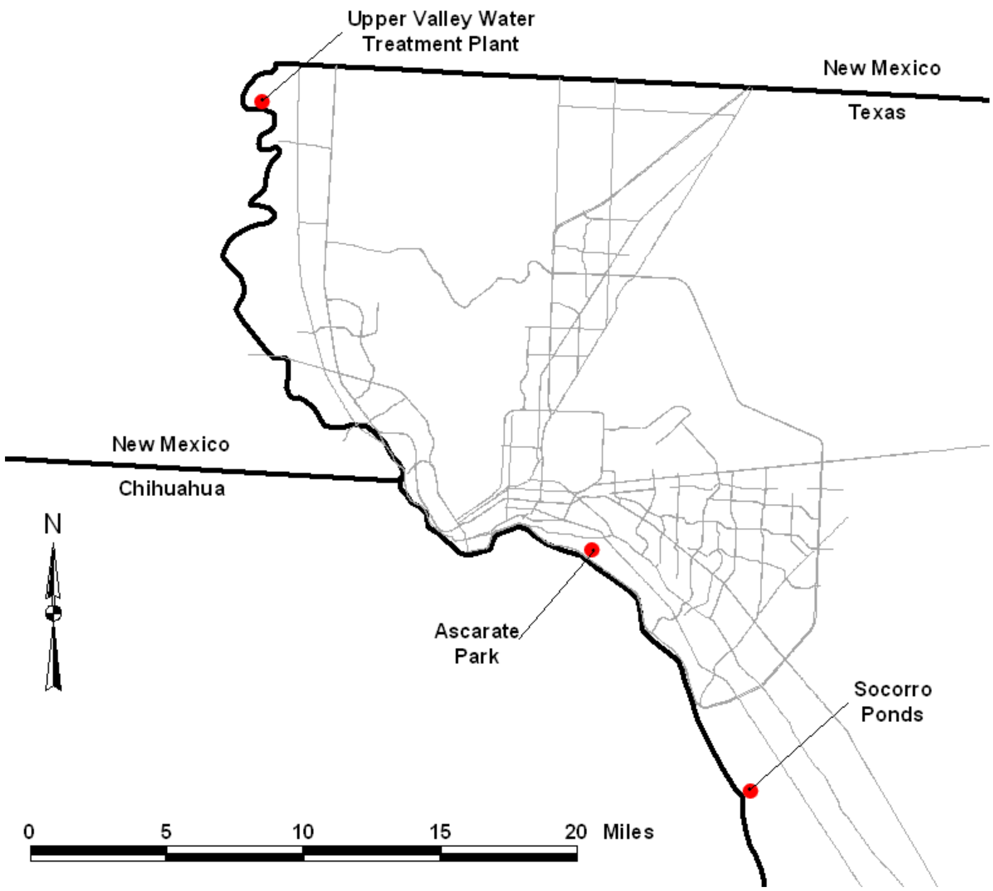


Figure 26. Location of Three Potential Sites for the Storage of Excess Rio Grande Flows

2.4.1 Socorro Ponds

The Socorro Ponds are a series of abandoned wastewater treatment ponds from the decommissioned Socorro Wastewater Treatment Plant located near the community of Socorro, Texas (Figure 27). The previous investigation evaluated how they could be converted into raw water collection and storage ponds for the Jonathan Rogers Water Treatment Plant (JRWTP) located northwest of the ponds' location. The total area of the Socorro Ponds site is approximately 320 acres. The abandoned wastewater treatment ponds make up 160 acres of this area. The total storage capacity of the ponds is approximately 780 acre-ft of water. The previous study included conceptual designs for modifying the site to create five ponds with a depth of 17 ft for a total storage of approximately 4,100 acre-ft of water.

As described in the previous study of the area by Boyle and Parsons (attached as Appendix A), the total cost of improvements to the Socorro site is roughly $37.9 million to store approximately 4,100 acre-ft of water. Based on these estimates, cost would be about $9,200/AF of storage.

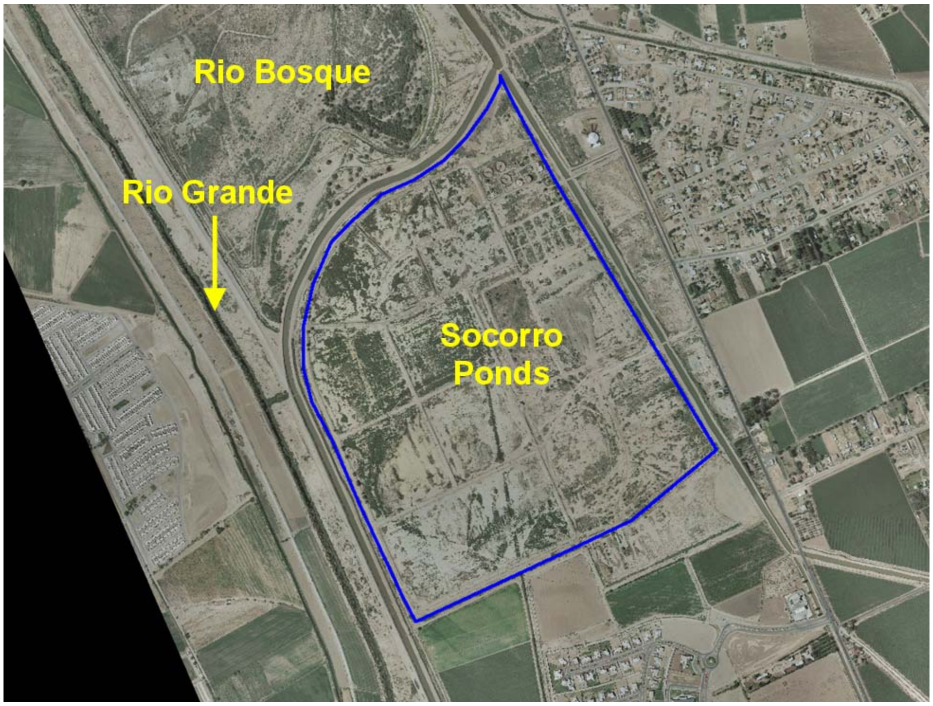


Figure 27. Detailed Location of Socorro Ponds

Assuming an annual operating cost of $400,000/yr (based on the previous study), the undiscounted cost of water for a range of annual project yields for a 50-year project is summarized in Figure 28. Note that the range in annual yields was generally based on the range of estimates previously presented in Table 7.

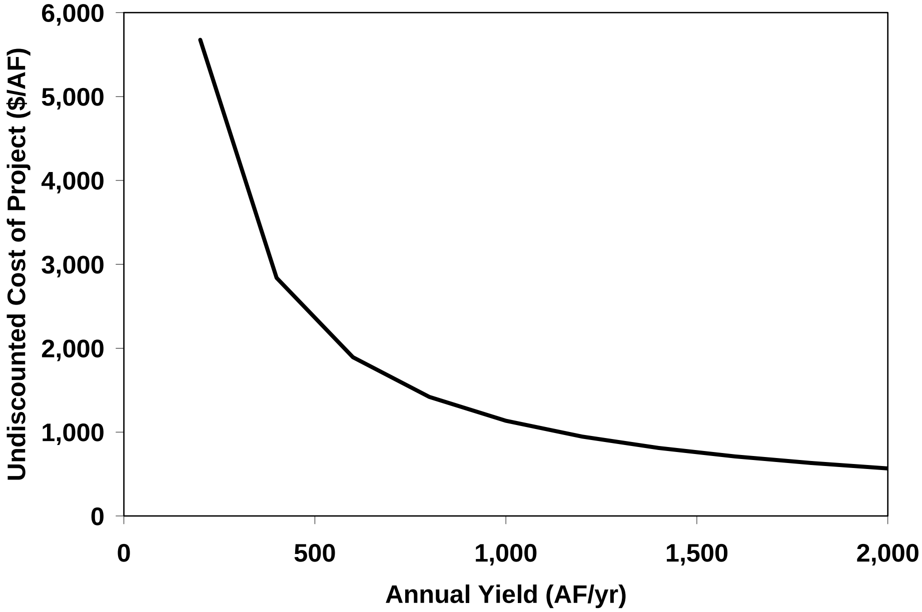


Figure 28. Undiscounted Project Cost of Socorro Ponds as a Function of Annual Yield

2.4.2 Ascarate Park

Ascarate Park is owned and operated by El Paso County (Figure 29). The total area of the park is about 450 acres, and the lake is about 48 acres. The lake had been identified as a potential surface water storage location. However, given the need to store about 4,000 AF of water based on the excess flow analysis previously presented, it is doubtful that the 48-acre lake would be sufficient. Indeed, storing the entire 4,000 AF within the 48-acre lake would require a depth of over 80 feet. If depth were limited to 10 feet, storage would be about 480 AF. This small storage could possibly contribute to a comprehensive storage project.

Operationally, utilizing the lake as a storage site would necessitate widely varying lake levels. Lake levels would have to be drastically reduced at the beginning of each summer to create storage space for the upcoming monsoon season. This decline in lake levels corresponds to high use of the park, and would likely be considered undesirable. If monsoon storms did not produce any meaningful storms, the lake level would likely remain at a minimum level throughout the summer, which would also likely be viewed as undesirable.

If the entire park was converted to a storage facility, depth would be between 8 and 10 feet depending on the configuration. Given the high use of the park, it appears highly unlikely that there would be any support for such a project. No further analysis of this site was completed.

Figure 29. Detailed Location of Ascarate Park

2.4.3 Upper Valley Water Treatment Plant

In 2006, EPWU completed construction on the Upper Valley Water Treatment Plant (Figure 30). This plant treats groundwater pumped from the Canutillo area to remove naturally occurring arsenic. The PSB (the governing board of EPWU) owns land in the area of the plant. This site could be used for a surface water storage project. One of its main advantages is that water stored at this site could be released for a variety of uses (i.e. irrigation diversion, or municipal diversion at either of EPWU's surface water treatment plants). In contrast, water stored at the Socorro Ponds site could only be used at the Jonathan Rogers plant.

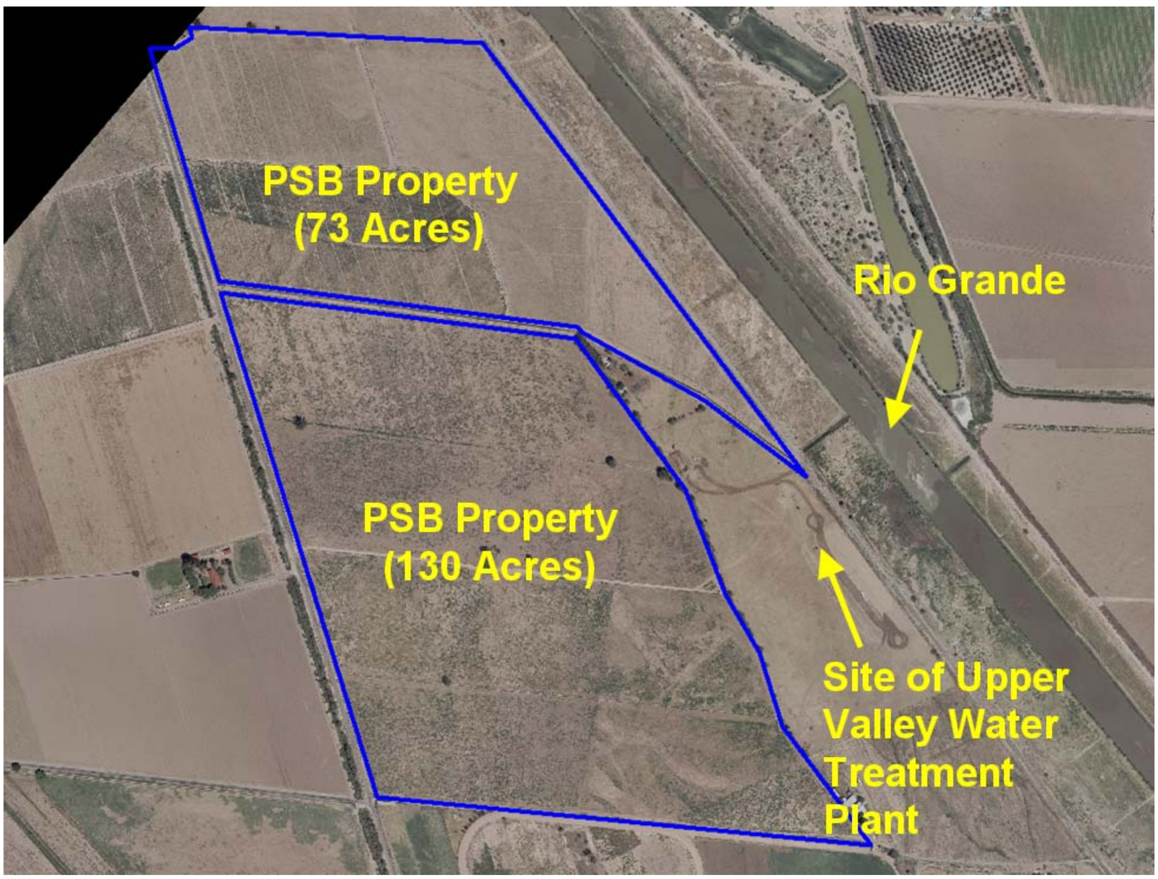


Figure 30. Detailed Location of Upper Valley Water Treatment Plant

The combined acreage of the property shown in Figure 30 is about 303 acres. If 4,000 AF were stored, depth would need to be 13 to 15 feet. Conceptually, it would be expected that costs to develop storage ponds at this site would be higher than costs to develop the Socorro Ponds. For purposes of this conceptual analysis, it was assumed that the construction costs would be about $50,000,000 (about 30% higher than Socorro Ponds), and operating costs were about the same as Socorro Ponds. Assuming the annual operating costs would be $400,000/yr, the undiscounted cost curve for a 50-year project as a function of annual yield based these assumptions is presented in Figure 31.

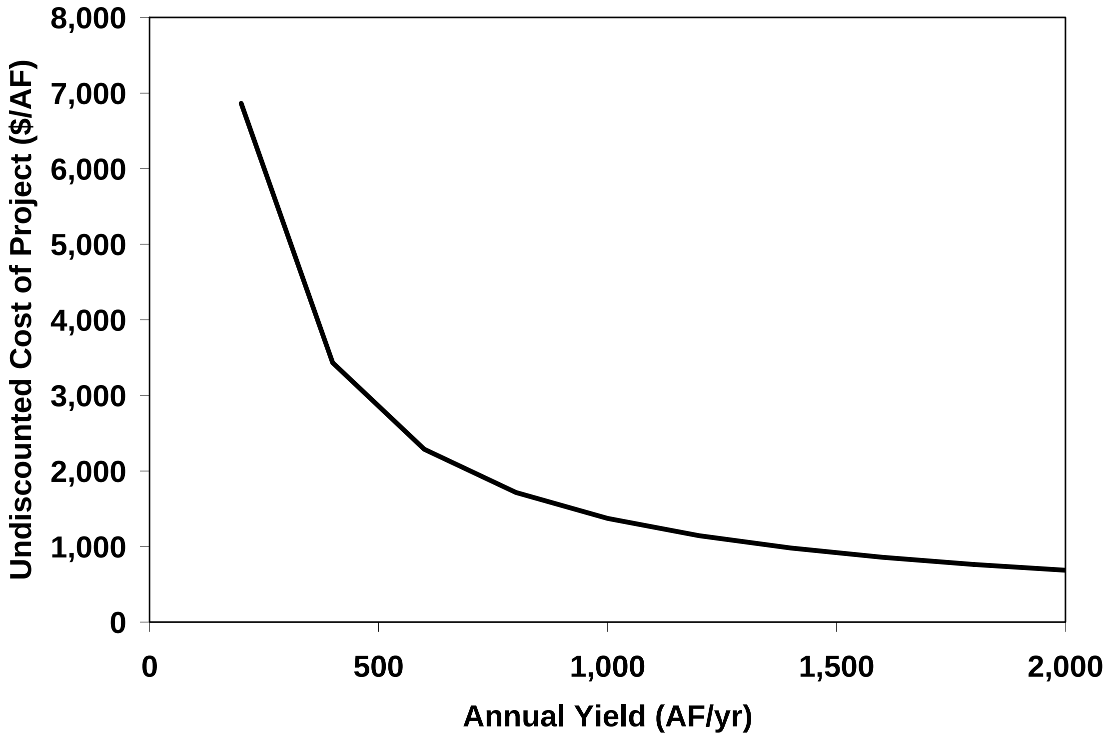


Figure 31. Undiscounted Project Cost of Upper Valley Water Treatment Plant Storage Site as a Function of Annual Yield

3.0 STORAGE OF TREATED SURFACE WATER IN THE HUECO BOLSON

As discussed previously, EPWU currently has water rights for about 65,000 AF/yr of Rio Grande water, and has the treatment capacity to treat more than 65,000 AF/yr under ideal conditions. This capacity was in place in 2002 when the Jonathan Rogers plant expansion was completed. In that year, nearly 59,000 AF of water was treated. From 2003 to 2006, reduced surface water allocations limited plant operation. In 2007, under a return to full surface water allocations, diversions were slightly over 58,000 AF. Current daily EPWU demands in the early portion of the irrigation season (March and April) are typically less than the 100 mgd treatment capacity. Thus, while it is often feasible to treat 100 mgd in the early months of the irrigation season, there is no demand for the water.

For purposes of this conceptual analysis, it was assumed that, in full allocation years, an additional 5,000 AF/yr could be treated at the Jonathan Rogers plant and delivered to a series of spreading basins located in northeast El Paso (Figure 32 for general location and Figure 33 for detailed location) where spreading has been occurring since 2001. Studies of that area suggest that spreading 5,000 AF/yr is feasible. Furthermore, it is assumed that the additional 5,000 AF/yr is available in 80% of the years. During drought years (20% of the time), it is assumed that no additional surface water would be diverted for storage. Therefore, the annual yield of this project would be 3,200 AF/yr.

EPWU's experience with injection wells in the Hueco Bolson has led to the shift to using spreading basins. The injection wells are expensive to construct and maintain, and have a relatively short life before replacement is required. To date, spreading basins (which have been in operation since 2001) are proving to be a more effective and economical approach.

Figure 32. Location of Existing Hueco Bolson Spreading Facilities

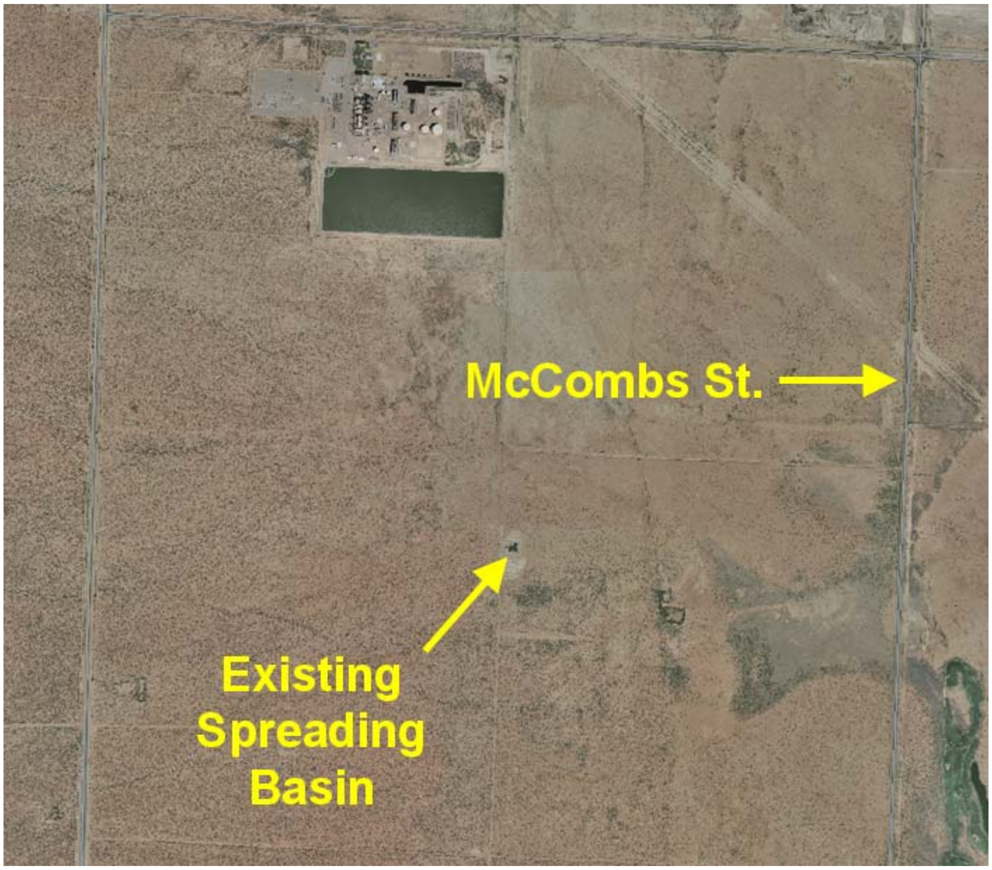


Figure 33. Detailed Location of Existing Hueco Bolson Spreading Facilities

Water would be delivered to up to three spreading basins (two existing and one new) by running a 16-inch line from the McCombs Street line. Cost for the new basin is estimated to be $100,000 based on the cost of the most recently constructed basin. Assuming the cost of the 16-inch line is $70/ft and 10,000 ft of line is required, and assuming that 6 valves are required at a cost of $5,000 per valve, total construction cost is estimated to be $830,000.

Annual costs can be estimated by considering that current cost to treat and deliver surface water by EPWU is about $300/AF. If the project is viewed as treating and delivering treated surface water for storage, then annual operating costs are $300/AF. It can reasonable be argued that pumping the stored water is also a project cost. Current EPWU cost to pump fresh groundwater is about $150/AF. Thus, annual costs are between $150 and $450 per acre-foot. Undiscounted unit costs for the project (assuming a 50-year project and an annual yield of 3,200 AF/yr) are therefore between $305 and $455 per acre-foot, depending on whether the pumping costs are included or not.

4.0 STORAGE OF LOCAL STORMWATER

The other potential source of surface water that could be stored is local storm runoff. AS part of the current effort to develop a master stormwater plan, EPWU has retained URS Consultants for assistance. URS has subdivided El Paso into five watershed areas: west, northeast, central, east and lower valley. The locations for the west, northeast, central and east areas are shown in Figure 34. The details of the lower valley watershed area have not yet been developed by URS.

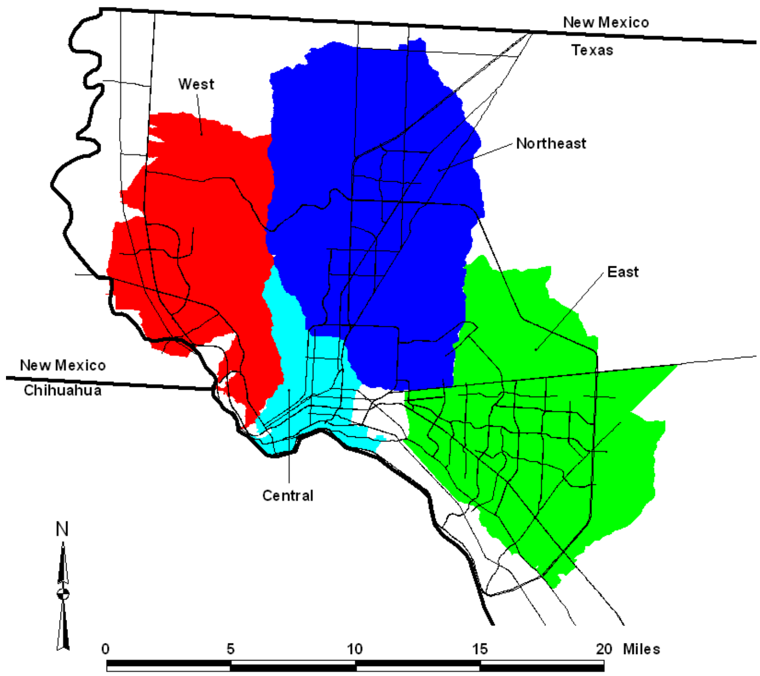


Figure 34. Location of El Paso Watershed Areas

Based on current EPWU well locations and the interface between fresh groundwater and brackish groundwater, the northeast area is potentially promising to treat and store local stormwater. Wells on the west side of El Paso are located northwest of the defined watershed area, and groundwater flow is generally to the south. Therefore, storage of stormwater in the subsurface would not benefit EPWU wells. There are few wells in the central area, and high degree of urbanization in the central area makes locating and constructing storage facilities difficult. Groundwater in the east area is generally brackish, and is therefore a poor candidate to store stormwater and capture it through wells.

URS delineated 50 individual watersheds in the northeast area, and combined them into three larger areas: Northeast Ponding, Range Dam, and Ft. Bliss Sump. These three areas and their acreage are shown in Figure 35.

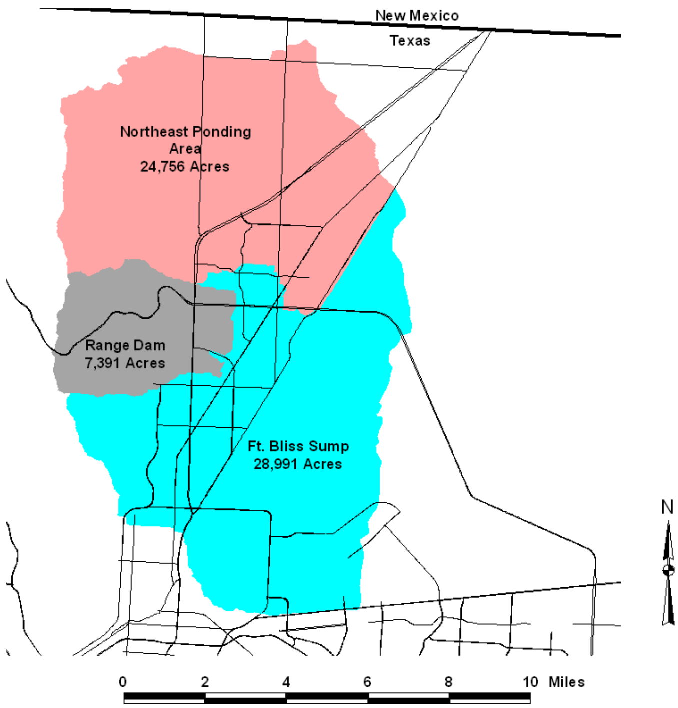


Figure 35. Northeast Watershed Areas

After the storm events of 2006 in El Paso, the Federal Emergency Management Agency (FEMA) contracted with Mapping Alliance Partnership of Albuquerque to evaluate flood frequencies in the El Paso area. Part of the analysis was a compilation of precipitation data from the precipitation gages at the El Paso Airport, La Tuna and Ysleta. Data analysis was most complete at the El Paso Airport gage due to the quality of the record. Based on this analysis, it was estimated that the 24-hour rainfall at the El Paso Airport gage with 0.2, 0.1 and 0.04 return probabilities was 1.68 in, 1.95 in and 2.26 in, respectively.

Unfortunately, precipitation gages in the El Paso are limited. In particular, precipitation data at higher elevations are lacking. Precipitation at higher elevations is generally higher at higher elevations. Because much of the watershed area shown in Figure 35 is located in the Franklin Mountains, using El Paso Airport precipitation data exclusively to estimate precipitation from a 24-hour storm will result in an underestimation of precipitation. Based on other regional analyses, it is possible that at higher elevation, 24-hour rainfall could be as much as twice that recorded at the El Paso Airport.

With these limitations in mind, Table 11 summarizes the total “rain crop” for the listed 24-hour storm events. This estimated “rain crop” is simply the amount of rainfall multiplied by the watershed area. The rainfall amounts are multiplied by 1.0, 1.25, 1.5, 1.75 and 2.0 to develop the potential range associated with the rainfall at higher elevations.

Table 11. Estimated "Rain Crop" of Listed 24-Hour Storms in the Northeast Area
All values in AF

Scenario Definition

	Scenario A	**Scenario B**	**Scenario C**
24-hr rainfall (in)	1.68	1.95	2.26
Return Probability	0.2	0.1	0.04

Total "Rain Crop" in Ft Bliss Sump Watershed (28,891 Acres)

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	4,045	4,695	5,441
1.25	5,056	5,868	6,801
1.50	6,067	7,042	8,162
1.75	7,078	8,216	9,522
2.00	8,089	9,390	10,882

Total "Rain Crop" in Northeast Ponding Watershed (24,756 Acres)

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	3,466	4,023	4,662
1.25	4,332	5,029	5,828
1.50	5,199	6,034	6,994
1.75	6,065	7,040	8,159
2.00	6,932	8,046	9,325

Total "Rain Crop" in Range Dam Watershed (7,391 Acres)

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	1,035	1,201	1,392
1.25	1,293	1,501	1,740
1.50	1,552	1,802	2,088
1.75	1,811	2,102	2,436
2.00	2,069	2,402	2,784

Rainfall will either evaporate, infiltrate or runoff. In urbanized areas, runoff will be greater than in undeveloped areas. In heavy storm events, runoff (even in undeveloped areas) will be higher than in less intense precipitation events. Due to a lack of rainfall and flow data in the El Paso area, it is difficult to estimate how much of the total "rain crop" would result in runoff. Furthermore, it is difficult to estimate how much of this runoff would be available for capture and storage for later beneficial use.

For project costing purposes, the annual yield of the scenarios presented in Table 12, 13, and 14 are summarized assuming 75% availability, 50% availability, and 25%

availability, respectively. Annual yield is estimated by multiplying the rain crop by the availability factor and multiplying the product by the return frequency (0.04, 0.10 or 0.20).

Table 12. Estimated Annual Stormwater Yields for the Northeast Area Assuming 75% Availability

Scenario Definition

	Scenario A	**Scenario B**	**Scenario C**
24-hr rainfall (in)	1.68	1.95	2.26
Return Probability	0.2	0.1	0.04

Ft Bliss Sump Watershed (28,891 Acres)
Annual Yield - 75% of Total Rain Crop Available

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	607	352	163
1.25	758	440	204
1.50	910	528	245
1.75	1,062	616	286
2.00	1,213	704	326

Northeast Ponding Watershed (24,756 Acres)
Annual Yield - 75% of Total Rain Crop Available

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	520	302	140
1.25	650	377	175
1.50	780	453	210
1.75	910	528	245
2.00	1,040	603	280

Range Dam Watershed (7,391 Acres)
Annual Yield - 75% of Total Rain Crop Available

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	155	90	42
1.25	194	113	52
1.50	233	135	63
1.75	272	158	73
2.00	310	180	84

Table 13. Estimated Annual Stormwater Yields for the Northeast Area Assuming 50% Availability

Scenario Definition

	Scenario A	**Scenario B**	**Scenario C**
24-hr rainfall (in)	1.68	1.95	2.26
Return Probability	0.2	0.1	0.04

Ft Bliss Sump Watershed (28,891 Acres)
Annual Yield - 50% of Total Rain Crop Available

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	404	235	109
1.25	506	293	136
1.50	607	352	163
1.75	708	411	190
2.00	809	469	218

Northeast Ponding Watershed (24,756 Acres)
Annual Yield - 50% of Total Rain Crop Available

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	347	201	93
1.25	433	251	117
1.50	520	302	140
1.75	607	352	163
2.00	693	402	186

Range Dam Watershed (7,391 Acres)
Annual Yield - 50% of Total Rain Crop Available

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	103	60	28
1.25	129	75	35
1.50	155	90	42
1.75	181	105	49
2.00	207	120	56

Table 14. Estimated Annual Stormwater Yields for the Northeast Area Assuming 25% Availability

Scenario Definition

	Scenario A	**Scenario B**	**Scenario C**
24-hr rainfall (in)	1.68	1.95	2.26
Return Probability	0.2	0.1	0.04

Ft Bliss Sump Watershed (28,891 Acres)
Annual Yield - 25% of Total Rain Crop Available

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	202	117	54
1.25	253	147	68
1.50	303	176	82
1.75	354	205	95
2.00	404	235	109

Northeast Ponding Watershed (24,756 Acres)
Annual Yield - 25% of Total Rain Crop Available

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	173	101	47
1.25	217	126	58
1.50	260	151	70
1.75	303	176	82
2.00	347	201	93

Range Dam Watershed (7,391 Acres)
Annual Yield - 25% of Total Rain Crop Available

Precipitation Multiplier	**Scenario A**	**Scenario B**	**Scenario C**
1.00	52	30	14
1.25	65	38	17
1.50	78	45	21
1.75	91	53	24
2.00	103	60	28

As described in the previous discussion of the Socorro Ponds, development of storage ponds for 4,100 AF of water would cost about $37.9 million, or about $9,200/AF of storage. Given the rain crop estimates summarized in Table 11, if 25% of the rain crop was available for capture and storage, and applying the cost estimate of $9,200/AF for storage construction, the range of construction costs for storage facilities would be between $2 million and $38 million. If 50% of the rain crop were available for storage and capture, applying the $9,200/ AF of storage construction estimate yields a range of between $5 million and $75 million. In addition, treatment of the stormwater would be required prior to infiltration or injection. For this conceptual level analysis, it was assumed that these costs could range between $100 and $500 per acre-foot. Based on these assumptions, it is possible to develop a series of cost curves under varying capital and operating costs and annual yields. For purposes of this discussion, Figure 36 presents the cost curves for an assumed annual yield of 200 AF/yr. Note that each curve represents an alternative capital cost. The x-axis shows the range of operating costs ($100/AF to $500/AF). The y-axis provides estimated undiscounted project costs for a 50-year project.

Figure 37 presents the scenario where annual yield is 500 AF/yr. Finally, Figure 38 presents the scenario where annual yield is 1,000 AF/yr.

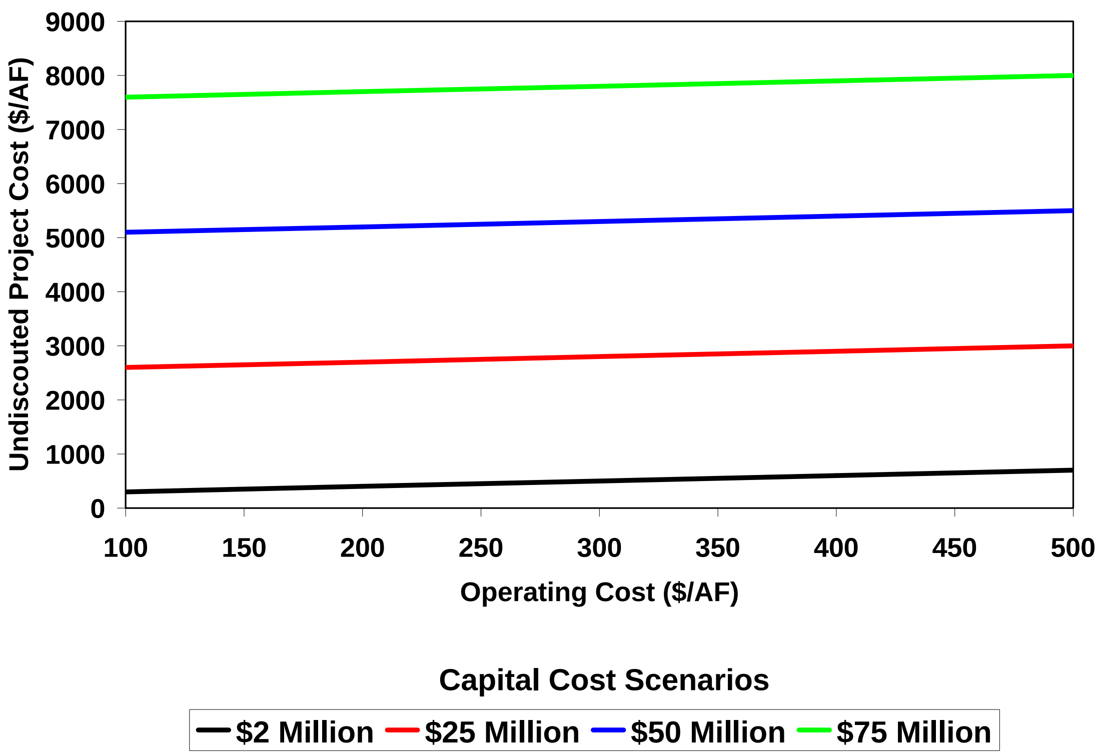


Figure 36. Undiscounted Project Cost of Conceptual Northeast Area Stormwater Storage Project as a Function of Construction Cost and Annual Operating Cost
Annual Yield = 200 AF/yr

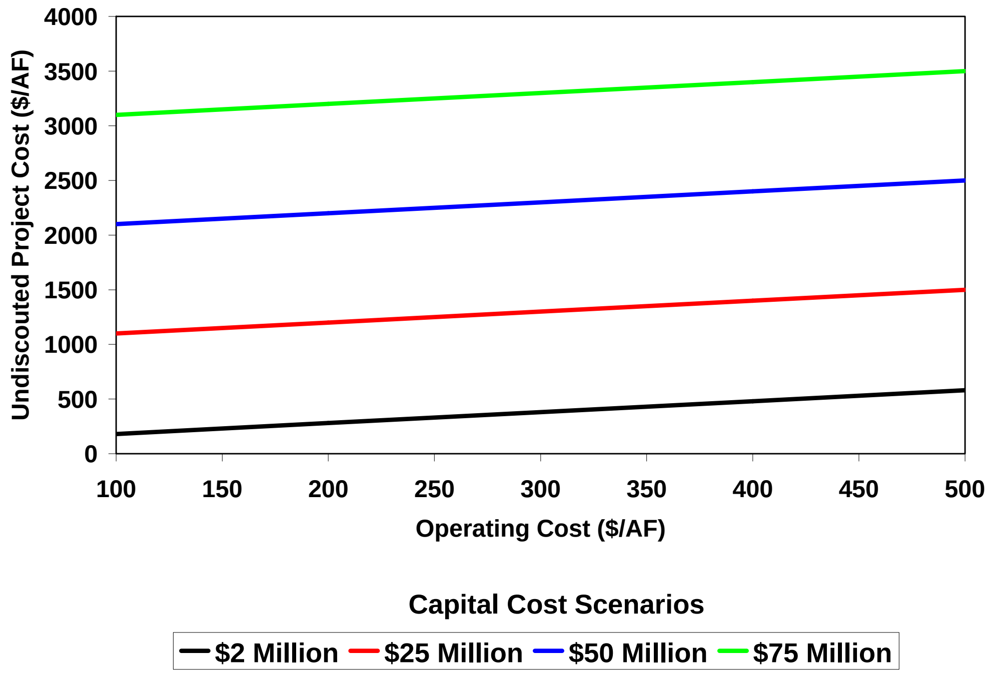


Figure 37. Undiscounted Project Cost of Conceptual Northeast Area Stormwater Storage Project as a Function of Construction Cost and Annual Operating Cost
Annual Yield = 500 AF/yr

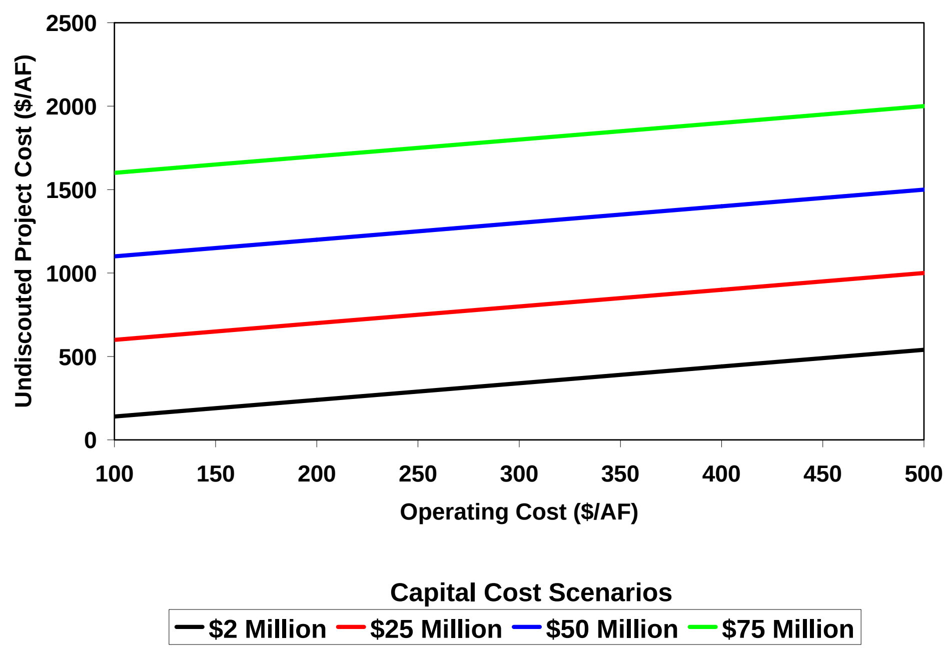


Figure 38. Undiscounted Project Cost of Conceptual Northeast Area Stormwater Storage Project as a Function of Construction Cost and Annual Operating Cost
Annual Yield = 1,000 AF/yr

If the project annual yield was 200 AF/yr or 500 AF/yr, the undiscounted project cost would be less than $1,000 AF/yr if the capital cost was $2 million under any of the operating cost scenarios. If the annual yield was 1,000 AF/yr, undiscounted project cost would remain below $1,000/AF if the capital cost was less than $25 million under all operating cost scenarios.

It is reasonable to observe that the lower capital costs likely do not fit well in the higher annual yield scenarios, and the higher capital costs likely do not fit well in the lower annual yield scenarios. However, at this conceptual level, it is not possible to precisely identify the link between annual yield of a potential project and the construction cost. However, at a conceptual level, the range presented is sufficient to guide and focus future investigations.

5.0 CONCLUSIONS

The conceptual evaluation of potential surface water storage projects in the El Paso area considered three general options: 1) storage of excess Rio Grande Flows, 2) storage of treated Rio Grande water in the Hueco Bolson, and 3) storage of local stormwater.

Cost summaries for 10 conceptual projects are summarized in Table 15. These projects include:

- Two alternative projects at Socorro Ponds by varying the annual yield (depending on the definition of "excess Rio Grande flows")
- A project at Ascarate Park that is not evaluated in detail due to the likely view that such a project would interfere with operation of the park
- Two alternative projects at the Upper Valley Water Treatment Plant by varying the annual yield (depending on the definition of "excess Rio Grande flows")
- Two alternative projects that would store treated surface water in the Hueco Bolson by varying the operating costs (depending on whether the subsequent pumping should be included in the annual operating costs)
- Three alternative projects that would store local stormwater in northeast El Paso by varying the required storage and associated construction costs.

Table 15. Summary of Project Elements and Costs for Ten Conceptual Projects

Conceptual Project	Storage (AF)	Capital Cost (millions)	Operating Cost	Annual Yield (AF/yr)	Undiscounted Unit Cost - 50 Year Project ($/AF)
Socorro Ponds - 1	4,100	37.9	$ 400,000/yr	2,000	567
Socorro Ponds - 2	4,100	37.9	$ 400,000/yr	1,000	1,135
Ascarate	480	N/A	N/A	N/A	N/A
Upper Valley Water Treatment Plant - 1	4,000	50	$ 400,000/yr	2,000	686
Upper Valley Water Treatment Plant - 2	4,000	50	$ 400,000/yr	1,000	1,372
Hueco Bolson Storage - 1	N/A	0.83	$ 300/AF	3,200	305
Hueco Bolson Storage - 2	N/A	0.83	$ 450/AF	3,200	455
Northeast Stormwater - 1	2,000	2	$ 100/AF	250	300
Northeast Stormwater - 2	2,500	25	$ 100/AF	500	1,100
Northeast Stormwater - 3	7,000	64	$ 100/AF	1,000	1,380

The unit costs of the potential projects need to be viewed in the context of the costs of other EPWU sources of water. The current estimate for pumping and delivering fresh groundwater is about $150/AF and $300/AF for treated surface water. Desalinated groundwater costs are projected to be about $530/AF, and reclaimed water costs are about $700/AF.

Based on these conceptual descriptions of the projects, their potential operation and the associated costs, it appears that the most feasible is the storage of treated surface water in the Hueco Bolson. If the capital costs for stormwater storage were low (e.g. less than $5 million), storage of stormwater could also be viewed as feasible when compared to other EPWU sources of water.

Clearly, additional detailed analyses of any project would be required prior to making any decisions to develop one or more of these alternatives into a Regional Water Plan strategy or into an actual project. However, the information in this study have identified some opportunities to enhance the use of local water resources that could result in a change in the schedule of groundwater importation currently planned for 2030.

6.0 REFERENCES

Ni, Fenbiao; Cavazos, Tereza; Hughes, Malcolm K., Comrie, Andrew C., and Funkhouser, Gary (2002). Cool-season precipitation in the southwestern USA since AD 1000: comparison of linear and nonlinear techniques for reconstruction. International Journal of Climatology, Vol. 22, Issue 13, pp. 1645-1662.

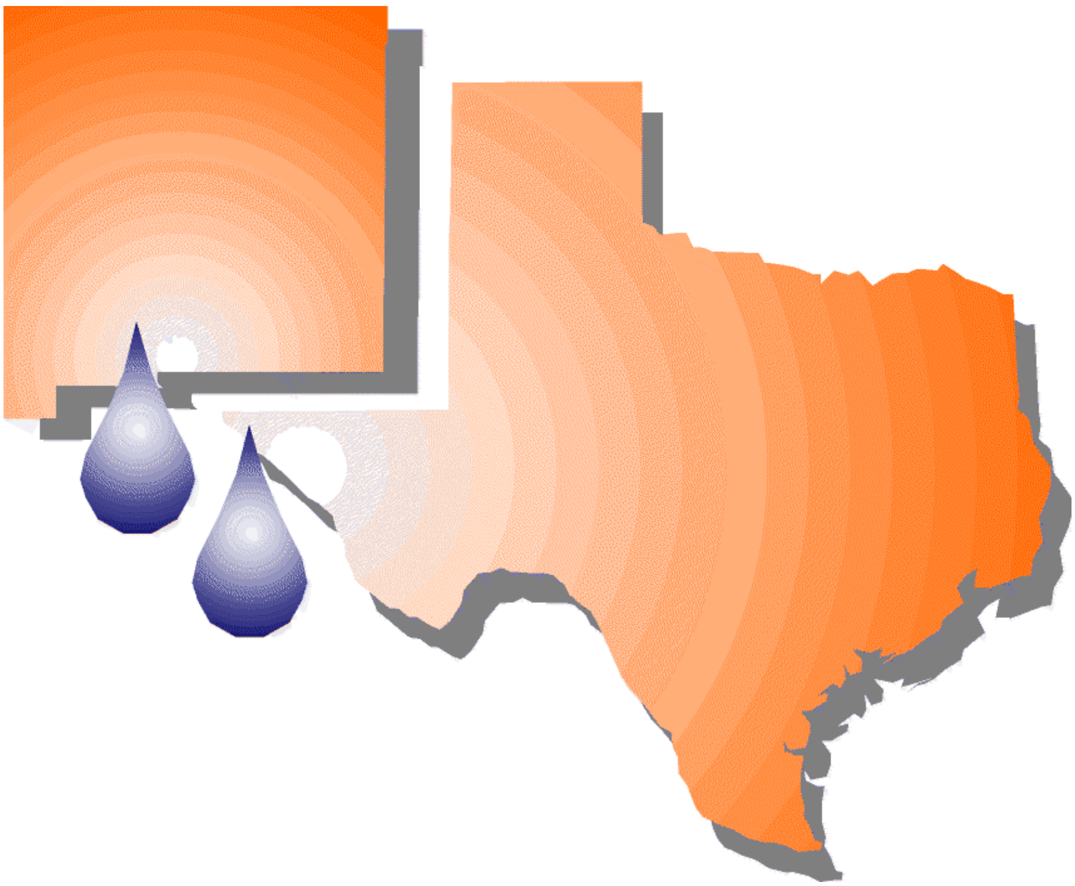
APPENDIX A

Boyle and Parsons Report on Socorro Ponds

EL PASO – LAS CRUCES REGIONAL SUSTAINABLE WATER PROJECT

EVALUATION OF SOCORRO PONDS STORAGE AND DEVELOPMENT OF ENVIRONMENTAL ENHANCEMENTS OPTIONS – RIO BOSQUE WETLANDS PARK

Task Order No. 5, Part 1



PREPARED FOR:

New Mexico-Texas Water Commission
Final - March 2000

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Table of Contents

Executive Summary

In an effort to collect Rio Grande storm event runoff, improve the Rio Bosque Wetlands Park environment, provide a flow regulation pond for El Paso County Water Improvement District No. 1 (EP No. 1), and provide raw water storage for El Paso Water Utilities, a preliminary design for several water storage ponds is presented. This conceptual design has the capacity to store a significant volume of water during short periods of time when water would be available to divert into the ponds. Also, this design can create and maintain indigenous open water, wetland, and riparian wildlife habitat using one of the Rio Bosque Options presented. Figure E.S.1 below shows both the Socorro Ponds site and the Rio Bosque Wetlands Park in their present condition.

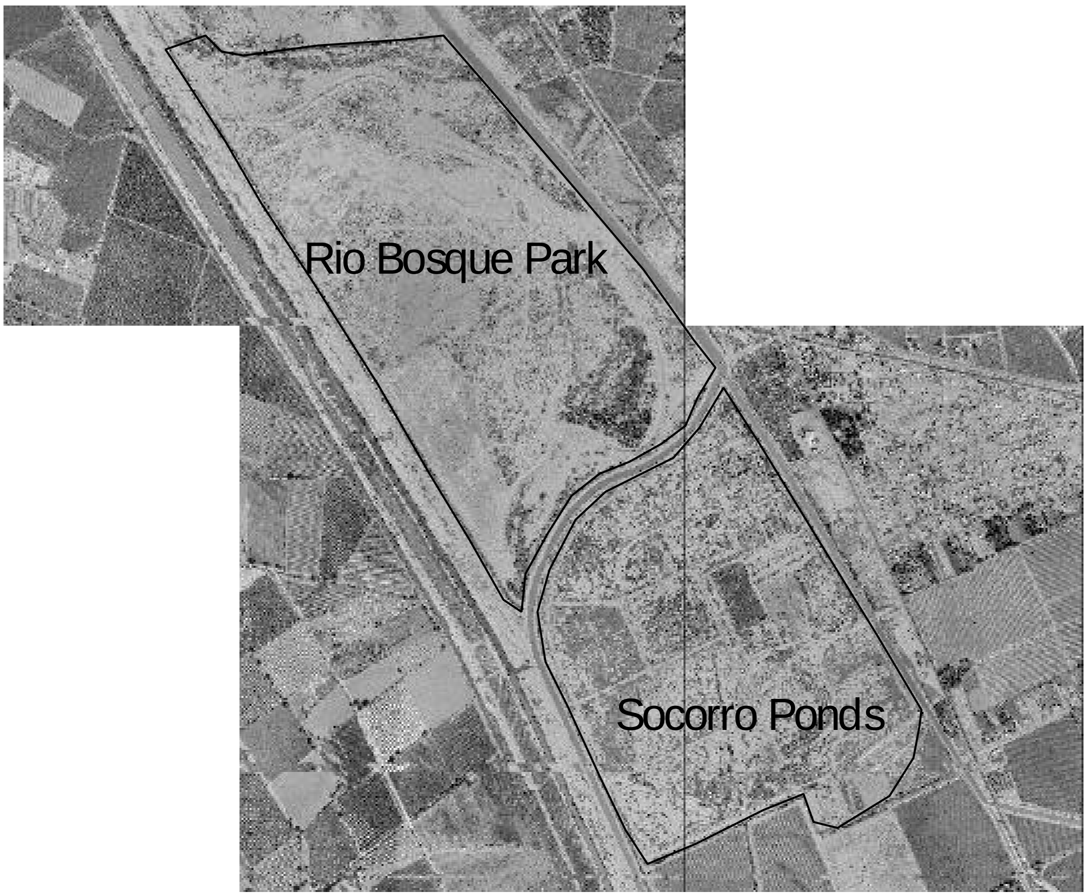

Figure E.S.1. The Rio Bosque Wetlands Park and the Socorro Ponds Site.

The Socorro Ponds site would provide a maximum storage capacity of nearly 4,100 acre-ft using the entire site of the abandoned wastewater treatment plant. The abandoned wastewater ponds would be expanded in depth and in height. Also, two new water storage ponds would be constructed at the site. The maximum hydraulic depth of the ponds without intercepting the ground water and still allowing gravity inflow from the Riverside Canal is 17 feet. The stored water would be available to regulate the Riverside Canal and to be delivered to the Jonathan Rogers Water Treatment Plant using a pump station located at the site. The estimated cost for the facilities associated with the Socorro Ponds is approximately $9,200 per acre-ft of storage capacity. The total capital cost is approximately $37.9 million.

The Rio Bosque Wetlands Park is property of the City of El Paso and carries a requirement that it be developed into a park. The area is being developed into a park designed to create a natural area and wildlife refuge to restore the riparian habitat that was once a part of the Rio Grande River floodplain and to provide an educational resource for the area schools. Part of that plan includes the development of wetlands within the park. Any storage pond developed within the park must adhere to the conceptual design of the park. To accommodate this requirement, the conceptual water storage pond for this study will provide habitat for waterfowl or other wildlife. The Center for Environmental Resource Management (CERM), University of Texas at El Paso (UTEP) is responsible for development of the park and has provided two preliminary options for the location of a water storage pond within the park boundary.

One of the Rio Bosque options would provide an additional 750 acre-ft with Rio Bosque Option A or 600 acre-ft of storage volume with Rio Bosque Option B. Each of the conceptual designs adheres to the park concept by having a dedicated area within the pond footprint for environmental enhancement. This dedicated area would provide an area for channel, wetland, and riparian habitat when water would be available to be diverted into the park. In addition to this dedicated area, the storage pond shape would also reflect the maximum environmental enhancement to the park while still providing significant water storage capacity. The two options located in the Rio Bosque Wetlands Park would provide the Jonathan Rogers Water Treatment Plant (JRWTP) with water by means of a pump station located near either storage pond. The cost associated with developing the Rio Bosque Option A is nearly $12,600 per acre-ft of storage capacity. Rio Bosque Option B is estimated to cost approximately $8,800 per acre-ft of storage capacity. The total capital cost for Rio Bosque Option A is $9.4 million and $5.3 million for Option B.

These preliminary designs reflect the maximum storage capacity of the two sites studied. The original scope of this study was not completed because the investigation was concluded by the New Mexico Texas Water Commission before its full completion based on information in the initial draft of this report provided as a technical memorandum dated October 14, 1999.

Introduction

Based on information in the initial draft of this report provided as a draft technical memorandum to the New Mexico Texas Water Commission dated October 14, 1999, this study was concluded before completion of the study's original scope.

In an effort to collect Rio Grande storm event runoff, improve the Rio Bosque Wetlands Park environment, provide a flow regulation pond for El Paso County Water Improvement District No. 1 (EP No. 1), and provide raw water storage for El Paso Water Utilities, a preliminary design for several water storage ponds is presented. This conceptual design has the capacity to store a significant volume of water during the short period of time each year when water would be available to be diverted into the ponds. Also, this design can create and maintain indigenous open water, wetland, and riparian wildlife habitat using one of the Rio Bosque Options presented. Figure 1 below shows both the Socorro Ponds site and the Rio Bosque Wetlands Park in their present condition.

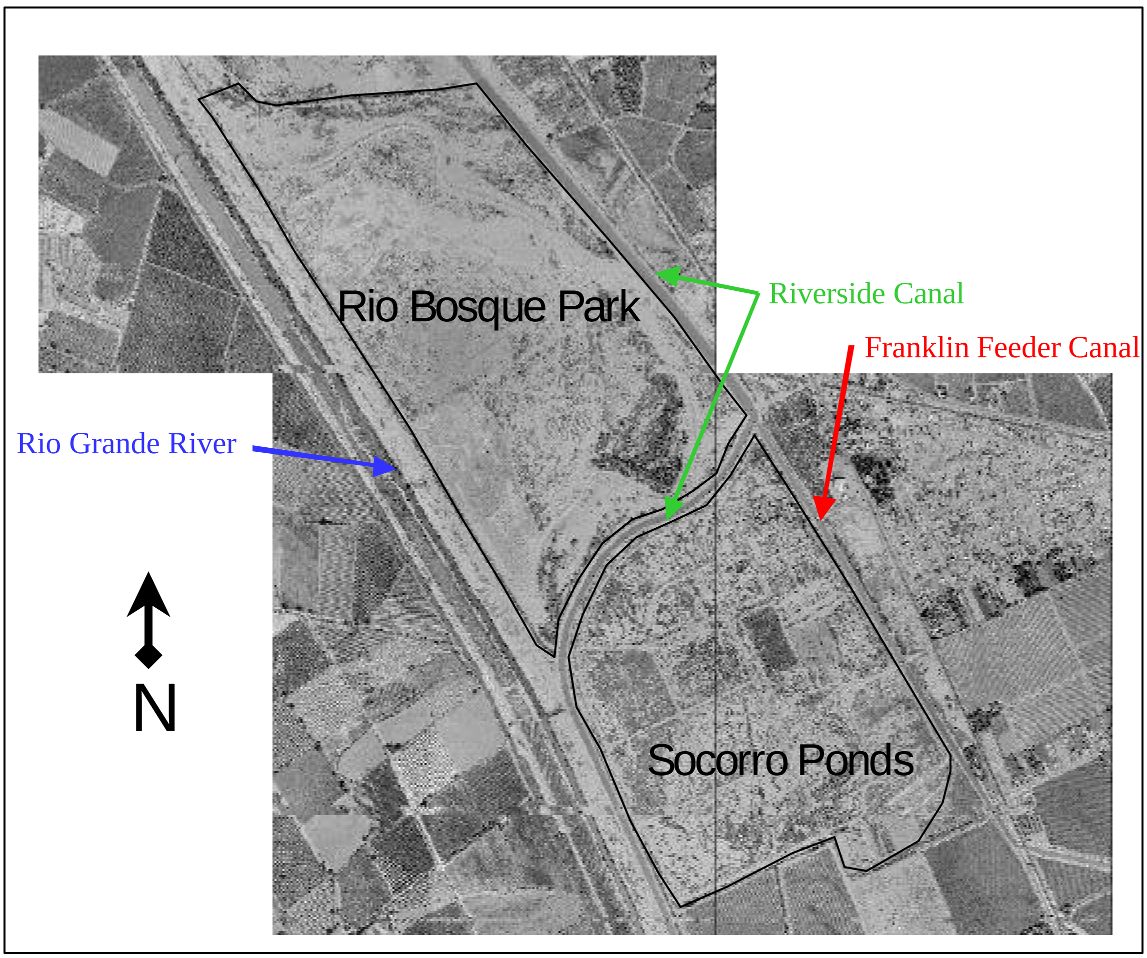

Figure 1. The Rio Bosque Wetlands Park and the Socorro Ponds Site.

The Rio Grande River is the west boundary of the park. The Riverside canal is the east and south boundaries of the Rio Bosque Park. The north boundary of the park is the Roberto Bustamonte Wastewater Treatment Plant (RBWWTP). The Socorro Ponds site is bordered by agricultural land to the south. The Riverside Canal is the north and west boundaries of the

Socorro Ponds site. At the northeast corner of the Socorro Ponds site is the check structure for the Franklin Feeder Canal that begins there and flows south along the east border of the Socorro Ponds site.

Figure 2 shows the Rio Bosque Wetlands Park and the Socorro Ponds site in relation to the U.S. and Mexico international border, the Rio Grande River, and its location south of El Paso, Texas.

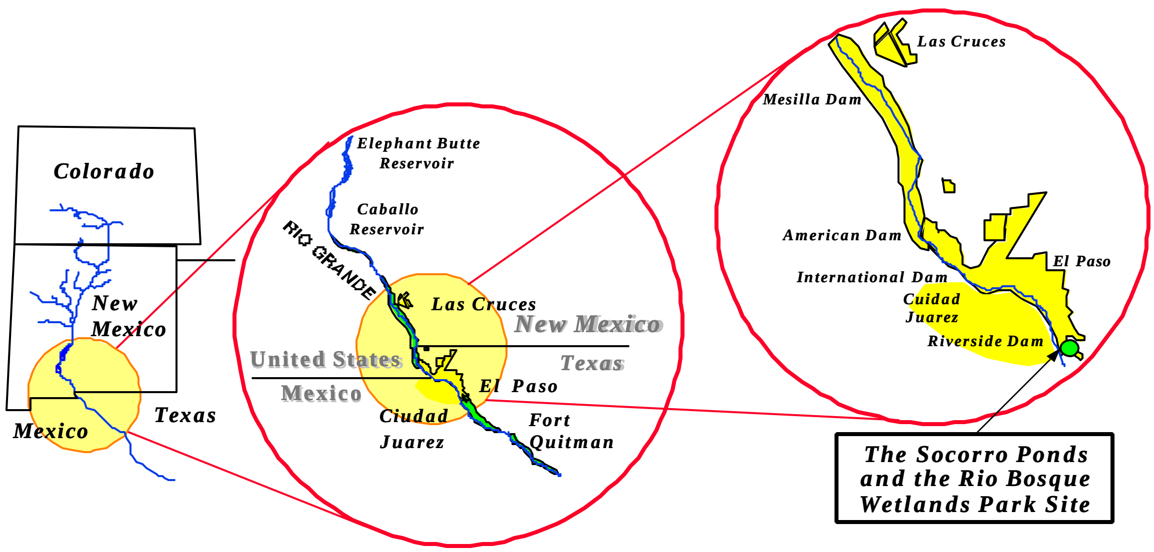

Figure 2. Location of the Rio Bosque Wetlands Park and Socorro Ponds Site.

Scope of Study

The scope of this study was based on EP No. 1 and El Paso Water Utilities utilizing the full potential of two specified sites for canal regulation and potable water storage. The objectives included:

- Determining the maximum possible storage using the Socorro Ponds site and available lands in Rio Bosque Wetlands Park.
- Determining the hydraulics of a system for delivery into and out of the reservoirs.
- Determining the potential for environmental enhancement of Rio Bosque Wetlands Park.
- Determining the cost to provide environmental enhancement of Rio Bosque Wetlands Park.
- Developing a more detailed cost estimate for modifying the Socorro Ponds or constructing additional storage.
- Identifying potential environmental enhancement opportunities associated with the Socorro Ponds.
- Identifying opportunities for providing regulating storage for the Riverside Canal as an additional conjunctive use of the facility.

Study Objectives

Operational spills and storm events create flows in the river that could provide additional water supply if they could be cost-effectively captured and stored. The objectives of this study are comprised of two basic components: 1. Determine the maximum storage capacity possible at the two given sites and 2. Estimate the cost associated with the water storage and delivery systems.

Existing Conditions

The Socorro Ponds are a series of abandoned wastewater treatment ponds from the decommissioned Socorro Wastewater Treatment Plant located near the community of Socorro, Texas. This series of seven ponds were studied to evaluate how they could be converted into raw water collection and storage ponds for the Jonathan Rogers Water Treatment Plant (JRWTP) located northwest of the ponds' location.

Currently the seven ponds range in volume from 78 to 240 acre-ft. The total storage capacity of the ponds is approximately 780 acre-ft of water. The total area of the Socorro Ponds site is approximately 320 acres. The abandoned wastewater treatment ponds make up 160 acres of this area. Figure 3 shows the current configuration of the ponds. Ponds One and Two were combined sometime after the original design plans were completed. The pond number reflects the same original numbering.

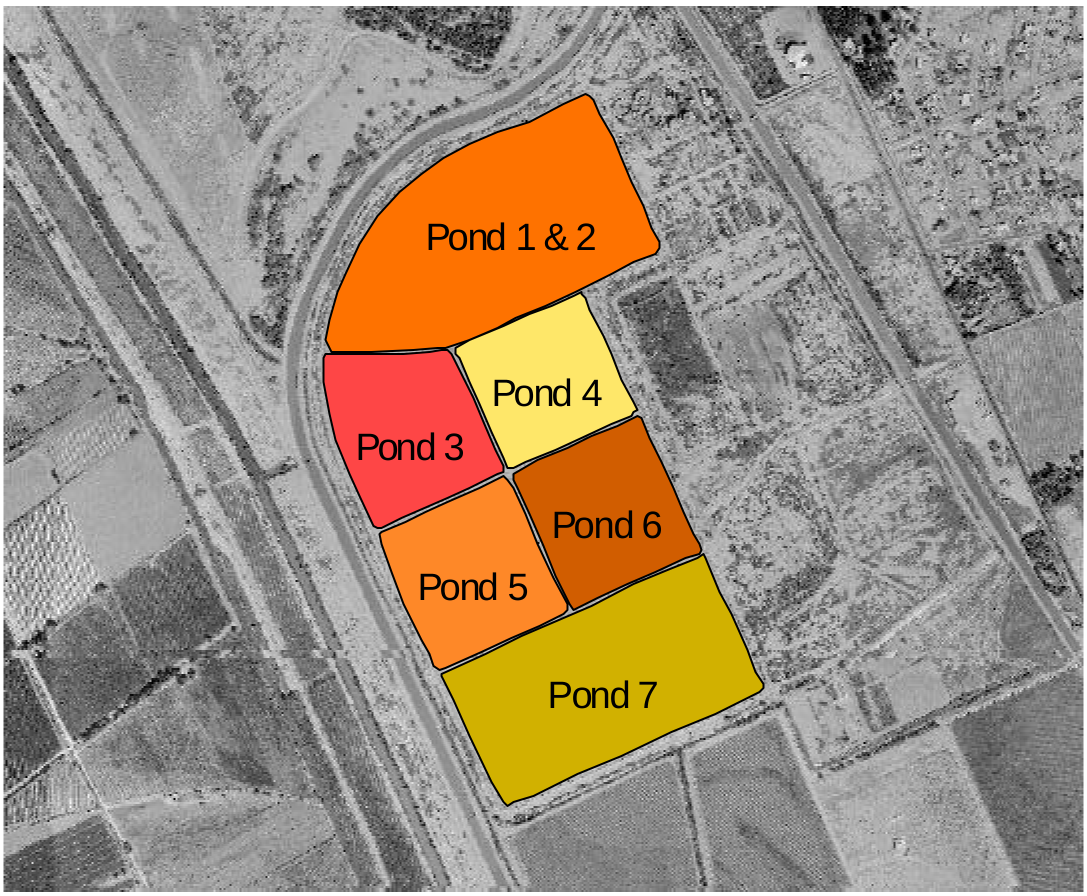

Figure 3. Location of the Existing Socorro Ponds.

The Rio Bosque Wetlands Park is property of the City of El Paso and carries a requirement that it be developed into a park. The area is being developed into a park designed to create a natural area and wildlife refuge in order to restore the riparian habitat that was once a part of the Rio Grande River floodplain and to provide an educational resource for the area. Part of that plan includes the development of wetlands within the park. Any storage pond developed within the park must adhere to the conceptual design of the park. To accommodate this requirement, a water storage pond for this study is planned to also provide habitat for waterfowl or other wildlife. The Center for Environmental Resource Management (CERM), University of Texas at El Paso (UTEP) is responsible for development of the park and has provided two options for the location of a water storage pond within the park boundary. These options are Rio Bosque Option A, containing a storage pond of 750 acre-ft and Rio Bosque Option B, a 600 acre-ft storage pond.

When the study was concluded, operational plans for the ponds, such as detention times, frequency of filling the storage ponds and the Riverside Canal regulation requirements were not determined.

Study Assumptions

The assumptions established prior to performing this study include the following:

- The available capacity of the Riverside Canal to deliver water to the conceptual site will be sufficient to convey the available water. Negotiations will be successful with EP No. 1 to use available capacity in the canal.
- The Socorro Ponds site and Rio Bosque Wetlands Park are the only sites to be evaluated.
- All materials necessary in the modification and construction of the storage ponds will be found at the site. No new material will be hauled to the site.
- Soil data, adequate tests for contaminants, aerial photography, topography, pond designs and other property data is available from El Paso Water Utilities or other entities.
- Developed water will be used for storage reserves and municipal uses.
- Storage will be used conjunctively for regulation of Riverside Canal.
- The pond design will conform to TNRCC requirements for raw water storage for potable water supply.
- For the study, it is assumed that lining to prevent seepage will not be necessary.
- Lining to prevent leaching of contaminants may be necessary.

Assumptions developed during the study include:

- 1,500 cfs of water would be available to divert into the ponds at the Socorro site.
- 50 cfs would be delivered to the JRWTP from the Socorro Ponds site.
- 200 cfs would be available to divert into the storage pond at Rio Bosque Wetlands Park.
- 10 cfs would be delivered to the JRWTP from the Rio Bosque Wetlands Park site.
- To size the delivery pumps, the Socorro Ponds would be emptied before the Rio Bosque pond water would be pumped.
- The existing Socorro ponds are suitable to use as raw water storage ponds, particularly since the inverts of the ponds will be over-excavated several feet.
- Water rights will be obtained to allow diversion and storage of excess flows in the Rio Grande.

Modification of the Socorro Ponds Site

The Socorro Ponds site is 320 acres. Conceptual designs for five new ponds were completed yielding a total storage of approximately 4,100 acre-ft of water. Of the available area, nearly 275 acres are used for storage, leaving approximately 45 acres for maintenance, construction, or other uses. Figure 4 shows the conceptual configuration of the new ponds. Table A.1 in the Appendix shows each new pond's size.

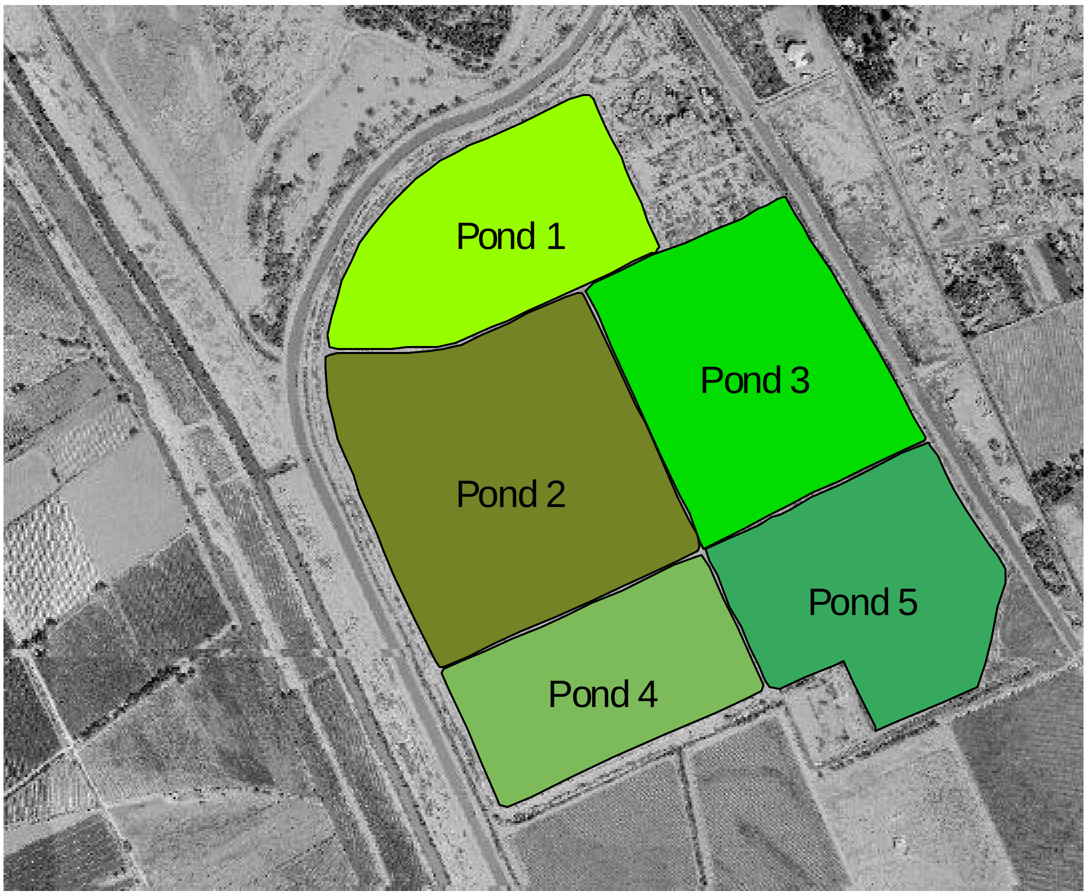

Figure 4. Conceptual Storage Pond Configuration at the Socorro Ponds Site.

Each of the five ponds has a hydraulic depth of 17 feet. The difference between the bottom of each storage pond and the assumed ground water surface is nearly five feet. This minimum separation was calculated using the lowest elevation within the storage ponds and the highest known elevation of the ground water. The depth is based on maximizing the ponds' sizes without intercepting the ground water which has an approximate interception location of 18 feet below the highest ground surface elevation based on a 1998 CERM report on the soil salinity concentration in the area (Hendrickx, et al, 1998). In the report, the ground water was located, but not monitored, at eleven well points during February 1997. This provided the only information on ground water depth available for this evaluation of storage ponds for the Socorro Ponds site and the Rio Bosque Wetlands Park. Additional ground water information is being collected by EP No. 1 for design studies of the Riverside Canal. However, at the time this study was concluded no additional ground water data was available. Prior to final designs, long-term ground water data would be needed to ensure that the ponds do not intercept saline ground water.

If monitoring or investigating determines the assumed ground water elevation of 18 feet to be incorrect and the newly determined elevation to be higher, the maximum storage capacity of the Socorro Ponds site may be reduced. If the ponds' hydraulic depth were decreased by five feet the storage capacity would be reduced by 1,000 acre-ft. Cost estimates for reduced storage options were not developed.

The dikes have a conceptual design slope of 3:1. The maximum dike height above the ground surface is approximately 11 feet. The existing dikes at the Socorro site would be increased in height 1.5 feet. All of the soil needed for this improvement is located on site. The greatest depth below the ground surface of a storage pond is 13 feet. Construction of the new ponds would require the excavation of nearly 3.7 million cubic yards of soil. Most of this soil would have to be removed from the site. The conceptual designs do not include pond lining. The height of above ground embankment ranges between six and ten feet and below ground excavation ranges between thirteen and eight feet.

A level survey was completed to ensure that water could be diverted by gravity from the Riverside Canal into Socorro Ponds and to verify the datum used for Rio Bosque (WWREC, 1995) and Socorro Ponds (PS&C, 1966) design drawings. It was determined from the survey that Riverside Canal could be checked to the same elevation as the water surface at the Franklin Feeder Canal check and that water can gravity feed into the Socorro Ponds.

Water would be diverted into the ponds from the Riverside Canal after the split of the Franklin Feeder Canal. At a point one-quarter mile down stream from the Franklin Feeder Canal Check structure, a new check structure would be constructed in the Riverside Canal. From this point, a series of overflow weirs would feed each pond.

The design flow into the ponds used for this study is 1500 cfs. This flow rate is the anticipated maximum capacity of Riverside Canal after the lining improvements are completed. Therefore, the design flow corresponds to the maximum flow rate possible if the entire capacity of the Riverside Canal were available to capture storm events or operational spills. An investigation of the probable flow rate available for diversion into the ponds was outside the scope of this project. However, before a final design could be completed, a statistical analysis of the storm events and operational spills would more accurately determine an economical flow rate to divert into the storage ponds.

Based on simple evaluations of Rio Grande flow records and discussion with EP No. 1 staff about the available capacity of the Riverside Canal to deliver water to the pond, the 1500 cfs inflow rate was reevaluated. Available flow from the Rio Grande is only 200 cfs at the 90th percentile frequency. Therefore, this study overestimates the cost of the weirs and canal structures. However, these are minor costs compared to the cost for the excavation work. Also, the evaporation and infiltration losses had not been investigated when the project was concluded.

The 1500 cfs flow rate requires a minimum head of 1.5 feet over approximately 183 feet of weir. To maximize the weir length over a narrower canal width a Z-weir or labyrinth weir would be constructed. As each pond reaches its maximum water depth, it begins to spill into the next pond until every pond has reached its storage capacity. Weir size and flow calculations are shown in Table A.3 in the Appendix. Also Table A.4 in the Appendix shows the time to fill each pond, excluding evaporation and infiltration losses. The total filling time for all the ponds is nearly 33 hours at the design flow and 248 hours or 10.3 days at a flow of 200 cfs.

Waterfowl habitat enhancement was considered for the Socorro Ponds. To maximize the habitat availability in the proximity of the water's edge and to reduce the effects of the volume change in the pond, a floating nesting area is included in the conceptual design of the storage ponds. The floating structure would be 40 feet by 60 feet in size and would be constructed of a wood frame with a rigid Styrofoam interior to maintain the structure's buoyancy. It would have a plywood top to provide a suitable surface for the waterfowl. The foam would be held inside the frame by wire mesh placed over the bottom of the floating structure. A concrete block on the bottom of the storage pond would securely anchor the structure by an attached cable. One habitat structure per pond is suggested. However, the costs for these features were not determined by the time the study was concluded. These habitat features would environmentally enhance the Socorro Ponds site. They would allow each pond's level to fluctuate as needed, yet keep the waterfowl's habitat close to the water's edge.

Rio Bosque Wetlands Park - Environmental Enhancement and Storage

Conceptual Storage Pond

Inside the Rio Bosque Wetlands Park, two options could provide either 600 or 750 acre-ft additional water storage. Both options and their relation to the Socorro Ponds and the Riverside Canal are shown in Figure 5. CERM provided the footprint of each option. The footprints are compatible with the conceptual designs for the wetlands park. In a letter dated September 2, 1999, CERM identified Rio Bosque Option A as the preferred storage pond location within the park.

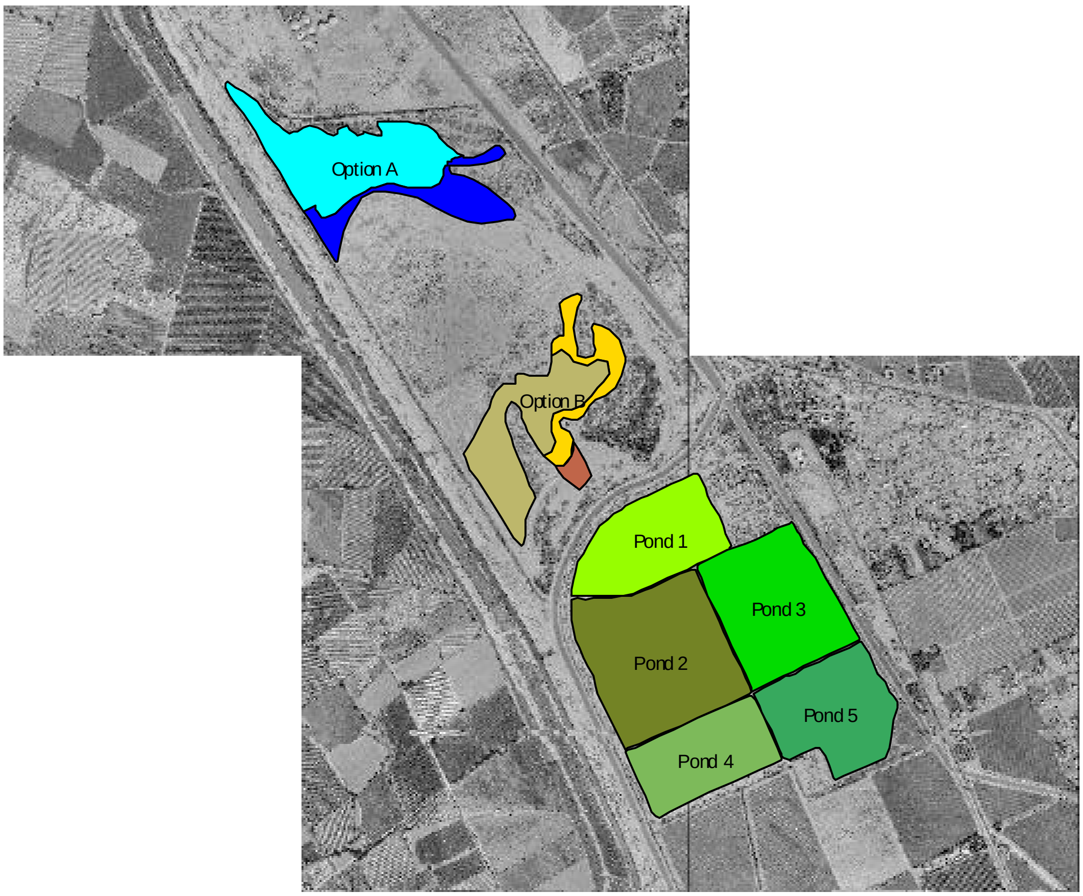

Figure 5. Rio Bosque Wetlands Park Storage Pond Options.

The maximum depth of each storage pond option is based on the depth to ground water. The ground water depth was established from the Salinity Assessment of the Rio Bosque Wetland Park, written and provided by CERM (Hendrickx, et al, 1998). The depth to ground water and the elevation of the ground surface recorded within the report were determined prior to the modifications completed during 1997 within the Rio Bosque Wetlands Park. No additional information on ground surface elevation or water table elevation was available during the investigation of the park for a storage pond.

Rio Bosque Option A pond would be located in the northern most area of the park. The pond would cover approximately 68 acres. The conceptual design provides a volume of approximately 750 acre-ft of water storage based on four feet of above-ground embankment and 15 feet of below ground excavation. The ground water is approximately 18 feet below the ground surface at the highest surface elevation at the pond location. In other areas of the storage pond's footprint, where the ground elevation is lower, the ground water can be as close to the surface as 14 feet. However, in these areas the pond design still maintains the approximate three feet of separation. This allows for significant storage without intercepting the ground water. Figure 6 shows a site plan for the Rio Bosque Option A.

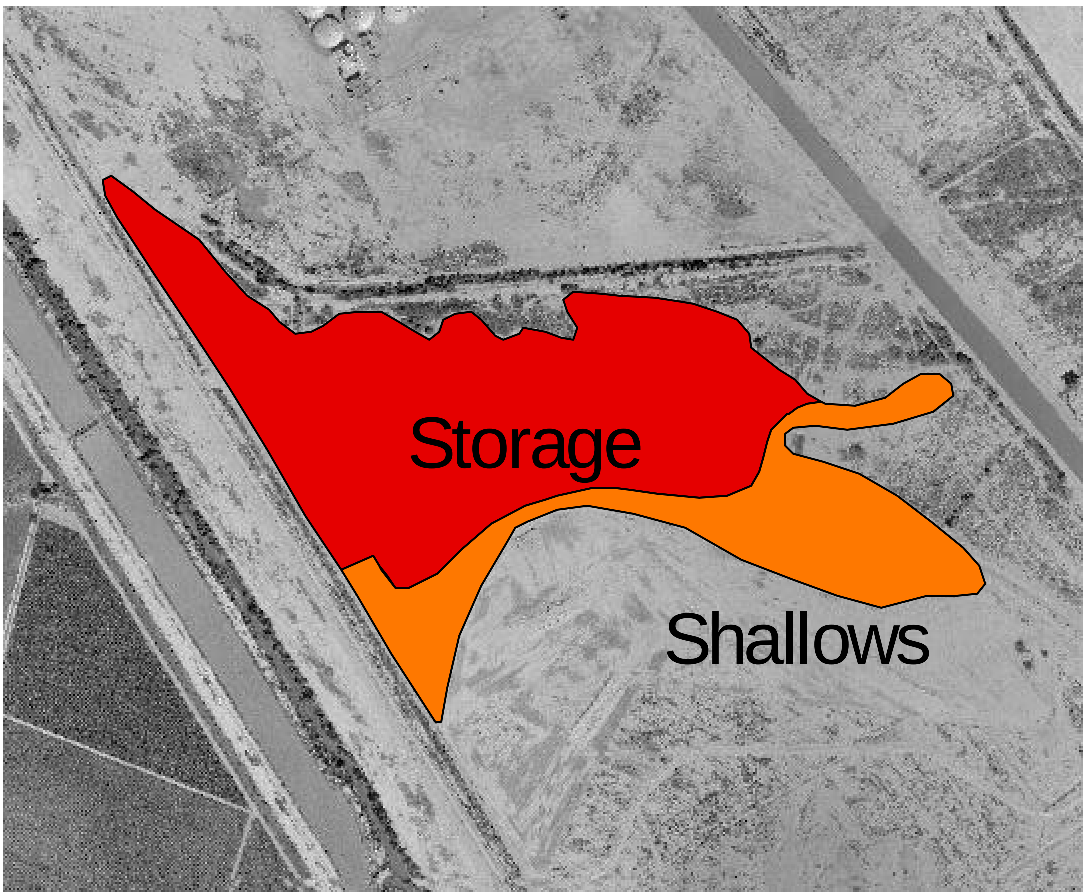

Figure 6. Rio Bosque Option A.

However, Rio Bosque Option A displaces the ditch used to receive effluent from the RBWWTP during the non-irrigation season. This ditch would have to be realigned along the northern boundary of the storage pond. This study did not determine the relocation costs associated with moving the ditch when it was concluded.

The conceptual design for Option A, using the available pond footprint, would provide the maximum water storage while still adhering to the park's purpose of providing wetland and riparian wildlife habitat. A typical schematic of the pond cross section is shown in Figure 7.

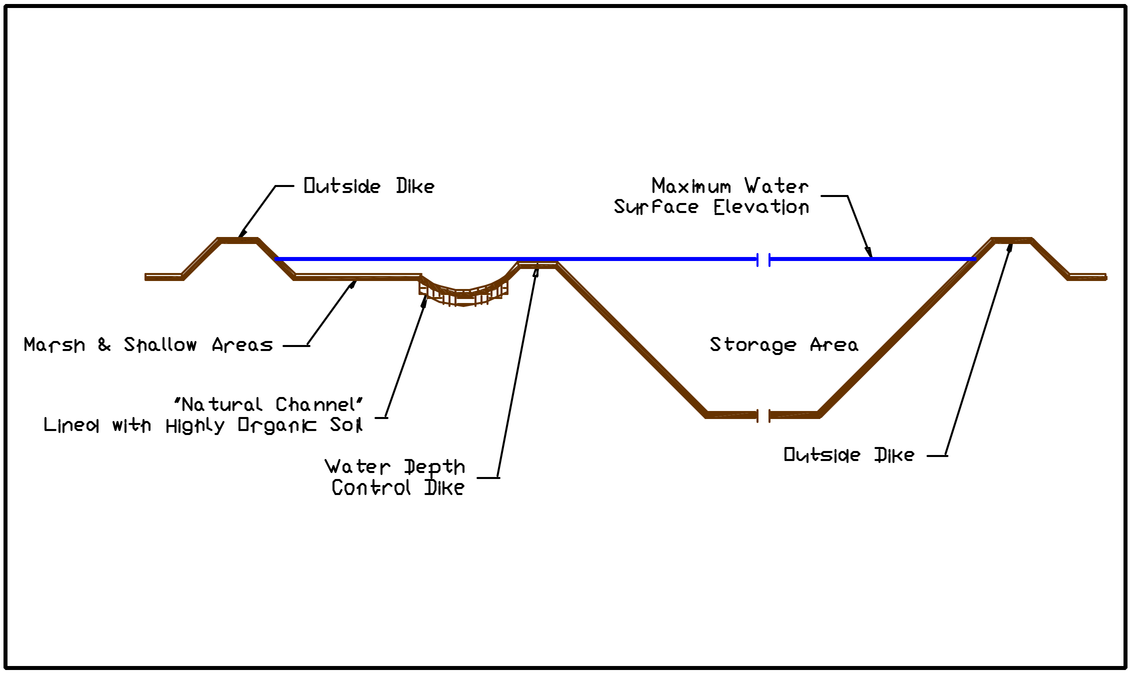

Figure 7. Typical Profile of each of the Rio Bosque Storage Pond Options.

Wetland Improvement

The wetland and riparian habitat improvements could be accomplished by creating a second dike within the pond's footprint following the outside dike. Between these two dikes a natural looking channel, wetland area, and riparian habitat would be created on approximately 15 acres. The elevation of the area within this enclosed portion of the pond would be varied to provide variation in the types of habitat. The conceptual design for the channel provides the capacity to deliver the pond's influent from Riverside Canal by meandering to the southwest end along a route nearly 1,300 feet long. This channel is described as the "natural channel" in Figure 7. The three-foot-deep channel would be lined with minimal gravel in the bottom to control erosion while allowing vegetation to grow within its banks. At the end of the meandering channel would be a weir to control the water depth in the natural channel, marsh, and shallow areas. The weir would be set at an elevation to back up the water to flood the area outside the channel within the shallow wetland area. The marsh area outside the channel would have a varied water depth of up to three feet. Adjacent to the depth control weir would be a channel gate. The gate would allow CERM to regulate the depth in the shallow area and allow the wetland area to be drained. This ability would simulate periodic flooding of a natural stream onto its flood plain.

The purpose of the depth control dike is to create wetlands on the southern edge of the pond site. Once this wetland area has sufficient water to maintain the shallow habitat area, the continuing water flow is directed to the main storage area of the pond. The main storage area of the pond provides the water to be delivered to the JRWTP. Because of the design of the depth control dike, the water would flow from the shallow wetlands and into the main storage area before it is available for pumping to the treatment plant. Only the water in the storage area would be pumped to the treatment plant. The pumping of the storage pond would not effect the depth of water in the wetland area. Except for evapotranspiration and seepage losses in the wetland system, all of the influent to the wetland area of the storage pond would reach the storage area.

Rio Bosque Option A results in approximately 15 acres of wetland. The target wetland system would be a willow—cottonwood—cattail complex. The dominant species in this complex would be coyote willow, Goodding willow, Rio Grande cottonwood, and southern cattail.

The wetland component of the storage pond would be lined with up to three feet of water retaining, highly organic soil. This liner would retain water and limit the infiltration losses. An additional benefit would be to retain water in the soil profile when water is not available to divert into the storage pond thus prolonging the vegetation's life until water can be diverted again. The provided cost estimate does not include the cost of this lining because the study was concluded before the material availability was determined.

CERM also requested in the letter dated September 2, 1999 that the inside slope of the berms and the pond bottom elevation be varied to provide a more natural appearing storage area. This level of detail was left for the final design.

Rio Bosque Option B pond would be located near the southern edge of the park boundary. This pond option would cover approximately 53 acres and provide approximately 600 acre-ft of water storage. It has a concept design similar to Rio Bosque Option A. Rio Bosque Option B was also designed with the water depth control dikes to provide shallow wetlands and a main water storage area. At this location in the park, the ground water is not as deep as it is for either the Socorro site or Rio Bosque Option A. For Rio Bosque Option B, the ground water is only 10-12 feet below the ground surface. The shallowness of the ground water restricts the depth of the pond, reducing its total volume. The maximum height of the embankments above the ground is approximately 11 feet. Figure 8 shows the Rio Bosque Option B storage pond layout. Rio Bosque Option B results in nearly 12 acres of wetland. Similar to Option A, the RBWWTP effluent ditch would need to be relocated to continue to supply water. The cost of this improvement had not been determined at the conclusion of this study.

In the letter dated September 2, 1999, CERM indicated that it prefers the storage pond location of Rio Bosque Option A. The pond layout and location in a remote area of the park will best serve the rest of the park's design and public usage requirements.

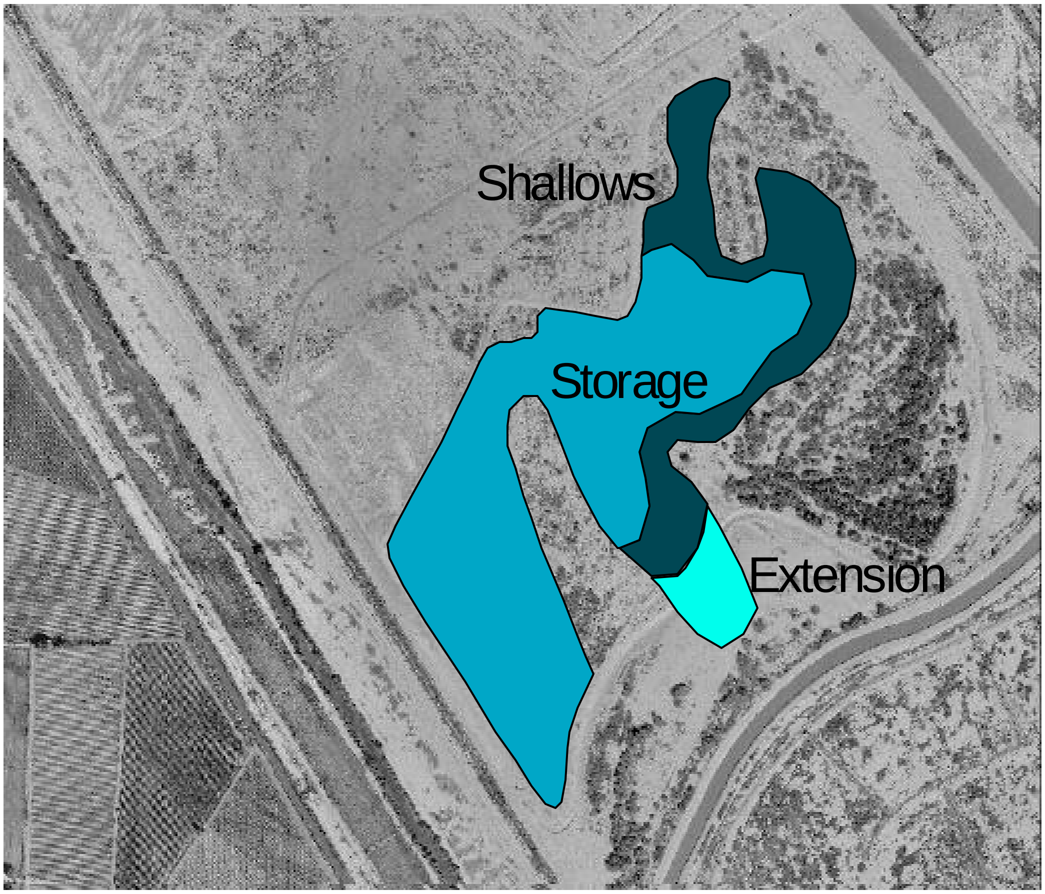

Figure 8. Rio Bosque Option B.

Requested Flow Rates for Non-storage Water Uses in Rio Bosque Park

There is an existing agreement with El Paso Water Utilities (EPWU) to allow effluent water from the Roberto Bustamonte Wastewater Treatment Plant (RBWWTP) to be released to the Rio Bosque Park during the non-irrigation season. The effluent is channeled through the park in a canal with several turnouts to provide water to the indigenous plant life and wildlife.

A proposal made to CERM by EPWU is to release from the RBWWTP to the park the volume of water during the irrigation season that the park stores for the JRWTP. For example, if Option A pond were used, RBWWTP would release 750 acre-ft of water to the Rio Bosque Wetlands Park during the irrigation season which lasts approximately eight months. This water would not be stored in any reservoir but would flow through the channels and into the wetland system for the park.

The park area remaining after the construction of the pond would be approximately 300 acres. The water released to the park from the wastewater treatment plant would be nearly 2.5 acre-ft per acre of water during the irrigation season (assumed to be eight months). This is equivalent to 1.5 cfs continuous flow and equal to over 2.3 gallons per minute per acre in the park. This flow rate is based on the entire area within Rio Bosque Wetlands Park. Since the entire park area will not be flood irrigated, the areas receiving the water would receive more. Also, it would be more appropriate to release a higher flow rate at given time intervals to better assist with the park management and the flushing of salts from the soil. This water would be available when the park needs it most, during the hot, dry summer. CERM identified the lack of a year-round water supply as the major hindrance in the re-vegetation effort in the park.

Additional benefits to the park would be the infiltration of the storage pond into the ground and the movement of water through the park. This may help to reduce salinity in the soil and help restore the necessary soil conditions to grow indigenous plant species, such as cottonwood trees.

In the letter received from CERM dated September 2, 1999, a continuous flow of 8.6 cfs during the irrigation season was requested. By receiving some of the effluent of RBWWTP during the irrigation season, the Rio Bosque Park would obtain year-round water flow through the park's main channel. Year-round flow was identified as a priority by CERM for the Rio Bosque Wetlands Park. This estimated flow rate would be directed through the park and released back into the Rio Grande River. Also, CERM would like to flood irrigate three wetland cells that have been created within the park. CERM estimates it would take an additional 13.2 cfs for the duration of a week for each period of flooding. This flooding would occur about every three weeks during the spring and summer months. CERM has stated that the area for which they would use the requested flow is 180 acres.

Since receipt of the letter from CERM, additional study by CERM has resulted in recognition that the requested flow may be more than needed, particularly if the flow through water is captured before it leaves the park and is introduced into the wetland cells. Parsons estimates that four or five acre-feet of water per acre would be sufficient to maintain a wetland. At 4.5 acre-feet per acre for 180 acres, this equates to approximately 810 acre-feet during the irrigation season. Essentially, the amount of total water needed for maintenance of wetlands and the storage volume for Option A are not vastly different.

A preliminary design for environmental enhancement without a storage pond within the park is referred to as Rio Bosque Option C. This design would capture all the water released to the park and reintroduce it into the wetland cells. This option includes the installation of a pump station at the end of the ditch from the RBWWTP. A flashboard check structure would divert the water from the ditch to the pump for delivery back into the park. The pump station would feed a 22-inch HDPE pipe that would have the capacity to carry the full ditch flow, 8.6 cfs (3,860 gpm), back to the flood irrigated area within the park. CERM has created three wetland cells within the park to flood irrigate during the spring and summer months. The pipeline would be able to feed each of these by having a delivery valve at each cells' location. This option would allow for better wetland development by being able to fully utilize the available water within the park. This would also allow the ditch to be used continuously throughout its length, flush salts from the soil, and keep its vegetation alive. The effect of such a re-circulating water system on the soil salinity in the park would need to be evaluated if this option were pursued further. By including the pump station within the Rio Bosque Park, it would provide environmental enhancement to the park without building a storage pond.

Delivery System to Jonathan Rogers Water Treatment Plant

The Jonathan Rogers Water Treatment Plant (JRWTP) is located to the north of both the Socorro Ponds site and of the Rio Bosque Wetlands Park. The northern border of the Rio Bosque site is the RBWWTP. The JRWTP is to the north of RBWWTP. The distance from the Socorro site to the JRWTP raw water reservoirs is two miles.

Figure 9 shows the locations of each of the conceptual pump stations at the Socorro Ponds site and each of the Rio Bosque pond options. This figure also shows the conceptual alignment of the gravity pipelines and the pressurized delivery pipeline.

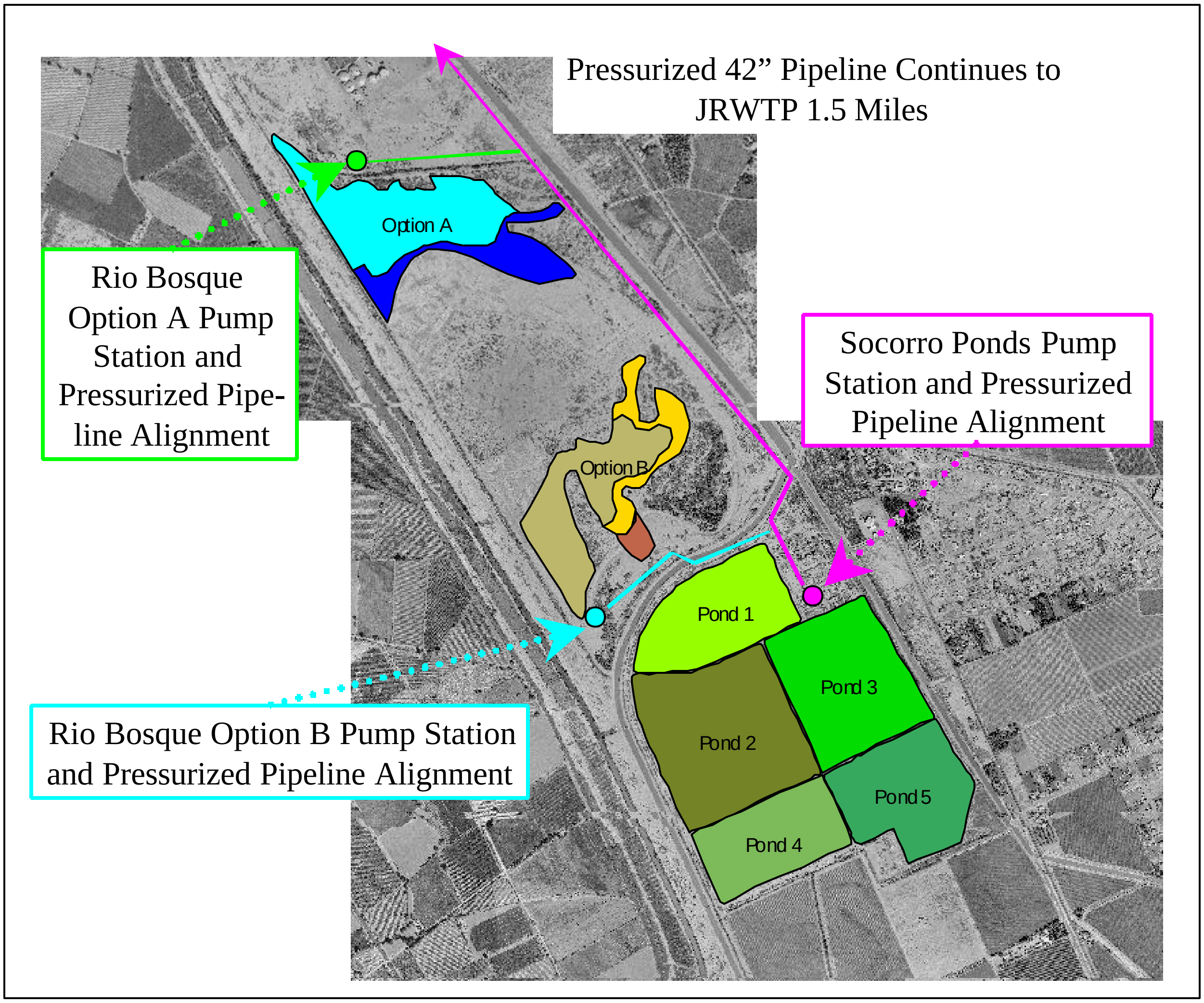

Figure 9. Location of each Pump Station and the Alignment of each Pipeline for the Socorro Ponds Site and the Rio Bosque Ponds Options.

From each pond on the Socorro Ponds site, a gravity pipe would feed a pump station located in the northern third of the site. At this point the water would be pumped through a pressurized pipeline to supply the JRWTP by discharging into the plant's raw water reservoirs. Each pond would be drained in the reverse order of filling. By doing this, the Socorro Ponds would provide the most stable environmental enhancement features by maintaining some ponds at full depth for longer periods.

The alignment of the pipeline to convey water from the pump station to the water treatment plant would closely follow Riverside Canal. The design flow for the pipeline is 50 cfs. At this flow rate, it would take approximately 40 days to drain all of the storage ponds on the Socorro site, assuming no infiltration or evaporation. Both single pipe and two pipe alternatives were considered. However, only the single pipe alternative is included in the Appendices and the cost estimates. The hydraulic calculations for the pipeline are shown on Table A.5 in the Appendix.

To deliver water from either of the Rio Bosque Park Options, an additional pump station would need to be built. The pump for Rio Bosque Option A would be located on the northern edge of the storage pond site in the park. The pressurized pipeline would connect to the Socorro Ponds pipeline at the conceptual alignment near the Riverside Canal. For Rio Bosque Option B, a pump station similar to the one described for Option A would be constructed on the south edge of the pond and would deliver to the pressurized pipeline from the Socorro Ponds site. For each of the two options, a conceptual design flow of 10 cfs was used in the calculation to size the pipeline and the pump. With this flow rate, it would require approximately 38 days to empty Rio Bosque Option A storage pond and nearly 30 days for Rio Bosque Option B storage pond, assuming no infiltration or evaporation. The hydraulic calculations are shown on Table A.5 in the Appendix. To size the delivery pump, it was assumed that only one site at a time, either the Socorro Ponds site or the selected Rio Bosque pond option, would feed the JRWTP.

Cost Estimates

Socorro Ponds Site

The cost of improvement to the Socorro site is shown in Table 1. The amount of excavation (cut) shown in the table includes the removal of unnecessary dikes within the existing treatment ponds. The lowering of the bottom of each pond to the conceptual design elevation and the removal of the material where the canal and pond structures are existing are necessary to accommodate the maximum storage volume. Such improvements include overflow weirs, delivery channels through the storage pond system, and the pump station. The materials needed

Table 1. Cost Estimate for the Improvements to the Socorro Ponds Site.

Item	Quantity	Unit	Materials & Installation Unit Cost ($)	Total Cost
Excavation (Cut)	3,722,729	CY	2.00	$ 7,445,458
Pond Embankment (Fill)	157,593	CY	4.76	$ 750,143
Hauling excess soil from site	3,565,136	CY	4.80	$ 17,112,653
Pipeline - 60" dia RCP	3,100	LF	165.74	$ 513,794
Pipeline - 42" dia HDPE	13,825	LF	104.04	$ 1,438,353
Structural Concrete - Weirs, canal lining, misc., etc.	2,806	CY	361.00	$ 1,012,966
Riprap - erosion control gravel	4,158	CY	30.57	$ 127,110
Riverside Canal Check Station	1	LS	84,400	$ 84,400
Pump Station	1	LS	468,000	$ 468,000
Fencing	16,320	LF	11.62	$ 189,638
Fencing Gates	5	LS	832.05	$ 4,160
			Subtotal	$ 29,146,700
			Contingencies (15%)	$ 4,372,000
			Construction Subtotal	$ 33,518,700
			Engineering Design (6%)	$ 2,011,100
			Engineering Construction Services (6%)	$ 2,011,100
			Administration & Legal Services (1%)	$ 335,200
			Total	**$ 37,876,100**
			Total per acre-ft	$ 9,242
Operation & Maintenance of the Socorro Ponds Site				
Yearly O&M - 1% of capital cost				$ 378,800
Pumping Cost - Total storage volume operation cycle				$ 15,500
			Total	**$ 394,300**

to enlarge the existing dikes at the site will be provided from the excavated materials. This embankment construction volume is shown as “Pond Embankment (Fill)” in the table. One of the most expensive components of the storage pond design is the hauling of excess materials off the Socorro Ponds site. This cost element is also shown in Table 1. The estimated cost of the delivery pipelines for both the gravity and pressure systems includes the pipe cost, delivery, and installation. The concrete shown is necessary to construct the channel and pond structures including weirs to the channels located between each of the ponds and the collection system to the pump station. As shown, it would cost approximately $9,200 per acre-ft of storage capacity. The total cost of improvements to the Socorro site is roughly $37.9 million to store approximately 4,100 acre-ft of water. The capital construction cost estimate does not include the cost of delivery through the Riverside Canal, cost to obtain any water rights, or any other cost not directly associated with the improvements of the existing Socorro treatment ponds.

Rio Bosque Wetlands Park

Table 2 shows the cost estimated for Rio Bosque Option A Pond. The table is very similar to Table 1. For Rio Bosque Option A Pond, the Riverside Canal structure is not needed due to the lower designed flow rate into the storage pond. Also, Riverside is checked by the Franklin Feeder Canal check structure. The conceptual turnout will be located on Riverside Canal and

Table 2. Cost Estimation of Rio Bosque Option A.

Item	Quantity	Unit	Materials & Installation Unit Cost ($)	Total Cost
Excavation (Cut)	1,009,294	CY	2.00	$ 2,018,588
Pond Embankment (Fill)	14,840	CY	4.76	$ 70,638
Hauling excess soil from site	994,454	CY	4.80	$ 4,773,379
Pipeline - 60" dia RCP	120	LF	165.74	$ 19,889
Pipeline - 22" dia HDPE	2,185	LF	64.74	$ 141,457
Structural Concrete - Weirs, canal lining, misc., etc.	176	CY	361.00	$ 63,536
Riprap - erosion control gravel	4,000	CY	30.57	$ 122,280
Riverside Canal Turnout	1	LS	15,000	$ 15,000
Pump Station	1	LS	48,000	$ 48,000
			Subtotal	$ 7,272,800
			Contingencies (15%)	$ 1,090,900
			Construction Subtotal	$ 8,363,700
			Engineering Design (6%)	$ 501,800
			Engineering Construction Services (6%)	$ 501,800
			Administration & Legal Services (1%)	$ 83,600
			Total	**$ 9,450,900**
			Total per acre-ft	$ 12,601
Operation & Maintenance of the Rio Bosque Option A				
Yearly O&M - 1% of capital cost				$ 94,500
Pumping Cost - Total storage volume operation cycle				$ 1,400
			Total	**$ 95,900**

will be sufficient to deliver to the pond. The cost per acre-foot of storage is approximately $12,600. This cost is due to the unique shape of the storage pond's footprint, the wetland habitat created within the storage pond, and the irregular dikes. Also, this option is a single storage pond without the advantage of common dikes found between multiple storage ponds such as with the Socorro Ponds. This cost estimate also includes the necessary concrete to build the flow control weirs to maintain the wetlands within the storage ponds footprint and other canal and storage pond structures. However, the cost estimate does not include relocating the displaced canal that currently receives effluent water from the RBWWTP. The total cost estimate for Rio Bosque Option A is nearly $9.4 million to store approximately 750 acre-ft of water.

Rio Bosque Option B cost estimate is shown in Table 3. The cost estimate for this option is approximately $5.3 million. Due to the higher water table at the location of Rio Bosque Option B Pond, the conceptual design includes less excavation and higher embankments resulting in a lower cost. The check structure for the Socorro Ponds could be shared by the Rio Bosque Option B Pond. The Riverside Canal structure shown in Table 3 is to modify the check structure used to divert water into the Socorro Ponds site to also allow diversion into the Rio Bosque Option B Pond. The cost of construction of this option is approximately $8,800 per acre-ft. The conceptual total storage capacity of Rio Bosque Option B is 600 acre-ft.

Table 3. Cost Estimation of Rio Bosque Option B.

Item	Quantity	Unit	Materials & Installation Unit Cost ($)	Total Cost
Excavation (Cut)	541,941	CY	2.00	$ 1,083,882
Pond Embankment (Fill)	36,992	CY	4.76	$ 176,082
Hauling excess soil from site	504,949	CY	4.80	$ 2,423,755
Pipeline - 60" dia RCP	120	LF	165.74	$ 19,889
Pipeline - 22" dia HDPE	2,425	LF	64.74	$ 156,995
Structural Concrete - Weirs, canal lining, misc., etc.	176	CY	361.00	$ 63,536
Riprap - erosion control gravel	4,000	CY	30.57	$ 122,280
Riverside Canal Structure	1	LS	15,000	$ 15,000
Pump Station	1	LS	54,000	$ 54,000
			Subtotal	$ 4,115,400
			Contingencies (15%)	$ 617,300
			Construction Subtotal	$ 4,732,700
			Engineering Design (6%)	$ 284,000
			Engineering Construction Services (6%)	$ 284,000
			Administration & Legal Services (1%)	$ 47,300
			Total	**$ 5,348,000**
			Total per acre-ft	$ 8,796
Operation & Maintenance of the Rio Bosque Option B				
Yearly O&M - 1% of capital cost				$ 53,500
Pumping Cost - Total storage volume operation cycle				$ 1,300
			Total	**$ 54,800**

Rio Bosque Option C cost estimate is shown in Table 4. To add the pump and the distribution line it would cost approximately $424,000. Based on one percent of the capital cost per year for operation and management expenses and pumping 750 acre-ft of water to recirculate through the park, the yearly cost would be $5,100.

Table 4. Cost Estimation of Rio Bosque Option C.

Item	Quantity	Unit	Materials & Installation Unit Cost ($)	Total Cost
Pipeline - 22" dia HDPE	4,600	LF	64.74	$ 297,804
Structural Concrete - canal diversion, canal lining, misc., etc.	10	CY	361.00	$ 3,610
Riprap - erosion control gravel	50	CY	30.57	$ 1,529
Pump Station	1	LS	26,000	$ 26,000
			Subtotal	$ 328,900
			Contingencies (15%)	$ 49,300
			Construction Subtotal	$ 378,200
			Engineering Design (6%)	$ 22,700
			Engineering Construction Services (6%)	$ 22,700
			Total	**$ 423,600**
Operation & Maintenance of the Rio Bosque Option C				
Yearly O&M - 1% of capital cost				$ 4,200
Pumping Cost - Total 750 acre-ft				$ 900
			Total	**$ 5,100**

Summary

It is possible to store over 4,100 acre-ft of water on the Socorro Ponds site with the conceptual design at a cost of $37.9 million. This water can be pumped back to the Jonathan Rogers Water Treatment Plant and/or delivered into the Riverside Canal. While the water is stored at the site, it will benefit waterfowl and wildlife in the area by addition of the floating habitat structures.

Using one of the options provided by the Center for Environmental Resource Management, UTEP, within the Rio Bosque Wetlands Park an additional 600 to 750 acre-ft of water storage could be added, while still adhering to the purpose of the wetland park. Rio Bosque Option A would provide 15 acres of wetland inside the footprint of the storage pond. This option is the preferred option of CERM and cost $9.4 million.

These conclusions represent the conceptual maximum storage capacity at the two sites provided for the study and their associated cost estimates. This storage volume may not be the most economical or practical depending on the available flow rate to divert into the storage ponds and the amount of time each year that excess water could be captured. Optimizing the storage based on the available flow rate was outside the scope of study.

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Appendix

Table A.1. Socorro Ponds and Rio Bosque Storage Pond Options Conceptual Design.

Note: * Elevations reconciled to USBR survey marker on the Franklin Feeder Check structure. (Elevation 3616.25)

Socorro Ponds

Conceptual Ponds	**One**	**Two**	**Three**	**Four**	**Five**		**Total water storage**
Volume (acre-ft)	681	1197	918	586	716		**4098 acre-ft**
Area (acres)	44.1	75.7	58.6	38.3	46.3		**263 acres**
Area (ft^2)	1,922,271	3,295,626	2,552,428	1,669,916	2,017,051		
Perimeter (ft)	5,649	7,269	6,390	5,386	5,790		
Top of Dike	3617.15	3617.15	3617.15	3617.15	3617.15	*	
High Water	3615.15	3615.15	3615.15	3615.15	3615.15	*	
Bottom of Pond	3598.15	3598.15	3598.15	3598.15	3598.15	*	

Rio Bosque Wetland Park

Possible Pond	**Option A**	**Option B**	
Volume (acre-ft)	750	608	
Area (acres)	50.1	42.0	
Area (ft^2)	2,182,340	1,830,675	
Perimeter (ft)	8,296	8,683	
Top of Dike	3619.00	3617.15	*
High Water	3617.00	3615.15	*
Bottom of Pond	3600.00	3598.15	*

Total water storage
Option A 750 acre-ft
Option B 608 acre-ft

Note: Areas shown represent the area covered by the stored water within the storage pond. The actual footprint of the storage pond is slightly larger.

Existing Ponds	One & Two	Three	Four	Five	Six	Seven		**Total**
Volume (acre-ft)	239.2	92.9	78.5	100.3	89.2	182.9		**783 acre-ft**
Area (acres)	45.0	19.4	16.5	19.2	18.7	37.9		**157 acres**
Area (ft^2)	1,958,368	847,232	719,110	834,919	814,881	1,649,919		
Perimeter (ft)	5705	3615	3360	3593	3583	5370		
Top of Dike	3615.65	3615.15	3615.15	3614.15	3614.15	3613.15	*	
High Water	3614.65	3614.15	3614.15	3613.15	3613.15	3612.15	*	
Bottom of Pond	3609.15	3609.15	3609.15	3607.65	3608.15	3607.15	*	

Table A.2. Pipeline Calculations for the Rio Bosque Option C.

Design Flow (cfs) **8.6**
(MGD) 5.56

Hazen -Williams Coefficient Ch = 155 HDPE Pipe

Pump from the End of the Ditch to the Wetland Cells in the Rio Bosque Wetlands Park
Pressure Pipeline

Per Pipe	Q (cfs)	I.D. (in)	L (ft)	V (ft/s)	Q (gpm)	Hf/L (ft/ft)	D (ft)	A (ft^2)	Rh
Option C HDPE -O.D. 22"	8.6	19.78	4600	4.03	3,860	0.0019584	1.65	2.13	0.412

Pump Size	TDH (ft)	whp (hp)	eff (pump)	eff (motor)	bhp (hp)	Static Head (ft)	Power (hp)
Option C	17.01	16.60	0.85	0.85	19.52	8	23.0

Table A.3. Weir Size and Channel Flow within the Storage Ponds.

Riverside Capacity (cfs)	1500	
Design Flow (cfs)	1500	Socorro
(MGD)	969	
Design Flow (cfs)	200	Rio Bosque Options
(MGD)	129	

Mannings Equation Socorro Ponds Site	Flow Q (cfs)	Base Width (ft)	Top Width (ft)	Mannings Coefficient n	Length L (ft)	Velocity V (ft/s)	Depth Y (ft)	Area A (ft^2)	Hydraulic Radius Rh	Friction Slope Hf/L (ft/ft)
Channel Flow	1500	148.0	152.0	0.016	135	5.00	2.00	300	1.952402	0.001181
Rectangular Weir Flow	1500	182.6	K =	0.8360			1.50	273.8		
Rio Bosque Options Site	Q (cfs)	Base Width (ft)	Top Width (ft)	n	L (ft)	V (ft/s)	Y (ft)	A (ft^2)	Rh	Hf/L (ft/ft)
Channel Flow	200	20.5	24.5	0.016	904	4.45	2.00	44.98	1.720264	0.001106
Rectangular Weir Flow	200	24.3	K =	0.8360			1.50	36.51		

Table A.4. Time to Fill Each Socorro Pond.

Design Flow (cfs)	1500	200
Time to fill Ponds	Time (hrs)	Time (hrs)
One	5.5	41.2
Two	9.7	72.4
Three	7.4	55.5
Four	4.7	35.4
Five	5.8	43.3
Total Time (hrs)	33	248

Table A.5. Pressurized Delivery Pipeline Calculations to the JRWTP.

Design Flow (cfs) **50**
(MGD) 32.32

Hazen-Williams Coefficients	Ch =	155	HDPE Pipe
	Ch =	120	RCP Pipe

Pump to Jonathan Rogers Water Treatment Plant (JRWTP)
Pressure Pipeline

	Q (cfs)	I.D. (in)	L (ft)	V (ft/s)	Q (gpm)	Hf/L (ft/ft)	D (ft)	A (ft^2)	Rh
HDPE -O.D. 42"	50.0	37.76	13825	6.43	22,442	0.00219	3.15	7.78	0.79

Pump Size	TDH (ft)	whp (hp)	eff (pump)	eff (motor)	bhp (hp)	Static Head (ft)	Power (hp)
	53.24	302.04	0.85	0.85	355.34	23	418.0

Gravity Pipe from each Pond to the Pump House
Gravity Pipeline

Per Pipe	Q (cfs)	I.D. (in)	L (ft)	V (ft/s)	Q (gpm)	Hf/L (ft/ft)	D (ft)	A (ft^2)	Rh
Pond One	50.0	60	120	2.55	22,442	0.000368	5.00	19.63	1.25
Pond Two [a]	50.0	60	200	2.55	22,442	0.000368	5.00	19.63	1.25
Pond Three	50.0	60	120	2.55	22,442	0.000368	5.00	19.63	1.25
Pond Four [a]	50.0	60	10	2.55	22,442	0.000368	5.00	19.63	1.25
Pond Five [a]	50.0	60	2650	2.55	22,442	0.000368	5.00	19.63	1.25

[a] Ponds Two, Four, and Five share part of the gravity pipe shown for Pond Five

Design Flow (cfs) **10**
(MGD) 6.46

Pump from Rio Bosque Options to Jonathan Rogers Water Treatment Plant (JRWTP)
Pressure Pipeline

Per Pipe	Q (cfs)	I.D. (in)	L (ft)	V (ft/s)	Q (gpm)	Hf/L (ft/ft)	D (ft)	A (ft^2)	Rh
Option A HDPE -O.D. 22"	10.0	19.78	2185	4.69	4,488	0.00259	1.65	2.13	0.41
Option A - Cont. [b]	10.0	37.76	5265	1.29	4,488	0.00011	3.15	7.78	0.79
Option B HDPE -O.D. 22"	10.0	19.78	2425	4.69	4,488	0.00259	1.65	2.13	0.41
Option B - Cont. [b]	10.0	37.76	11885	1.29	4,488	0.00011	3.15	7.78	0.79

Pump Size	TDH (ft)	whp (hp)	eff (pump)	eff (motor)	bhp (hp)	Static Head (ft)	Power (hp)
Option A [c]	27.24	30.91	0.85	0.85	36.36	21	42.8
Option B [c]	30.60	34.72	0.85	0.85	40.84	23	48.1

[b] The HDPE 22" pipe from the storage pond connects into the Socorro ponds' HDPE 42" pipe
[c] Equations based on delivery from each storage pond to the JRWTP

Gravity Pipe from each Pond to the Pump House
Gravity Pipeline

Per Pipe	Q (cfs)	I.D. (in)	L (ft)	V (ft/s)	Q (gpm)	Hf/L (ft/ft)	D (ft)	A (ft^2)	Rh
Option A	10.0	18	120	5.66	4,488	0.0040989	1.5	1.77	0.375
Option B	10.0	18	120	5.66	4,488	0.0040989	1.5	1.77	0.375

APPENDIX B

Responses to TWDB Comments

1. All Report Figures: In the final report, please consider reviewing all figure formatting and changing, where appropriate, so that all details will be distinguishable in a Black & White format. (especially Figures 2, 6, 14, 19-25, 34, 36-38)

The color figures are appropriate given the fact that most documents now are distributed and shared electronically. It would be a step backwards to convert all figures to black and white.

2. Page 1: Contract scope of work (SOW) deliverables state that the report will include an executive summary; and that the introduction section will include the purpose of the study, especially documenting *"how the study supports regional water planning"*. Please provide the executive summary and the purpose in the final report.

Executive Summary added. Purpose added in the Introduction (Page 10).

3. Sections 2.15 – 2.3 (pages 15-28): Please clarify whether the methodology used to calculate the various exceedance probabilities is based on the median ranking scheme for flow values, as would seem appropriate for percentile statistics. Please review and reconcile in the final report, if applicable.

The cumulative frequencies were developed by ranking the annual flow values and then assigning a probability based on a Weibull plotting position: m/(n+1). Text added to clarify.

4. Tables 4-8 and 11-14: In the final report, please provide units for these table values.

Units added

5. Page 7, paragraph 2 & page 34, paragraph 1: Please consider providing an actual estimate (AFY) of the treatment capacity under 'ideal conditions'. Based on information from other sections, 'ideal conditions' appears to be in reference to the 100 MGD combined WTP capacities, which the report translates to 307 AF/day; if so, this would be equivalent to ~112,000 AFY or ~70% more water treatment capacity than the existing surface water right can provide. Also, please consider documenting and discussing the reasons why Rio Grande surface water actually diverted by the EPWU has always been less than the full water right allocation.

This is beyond the intent of the report. Here, the objective is to conceptually present the limitations. Details of the limitations of the surface water treatment capacity as well as the details of the contractual issues are beyond the scope of this report.

6. Page 11, last paragraph: Please consider providing discussion of the value of including the extended tree-ring analysis data in Section 2 and please provide more discussion/clarity for the reason(s) this data set was not used in the report's analyses.

The extended record was used in the subsequent analyses.

7. Page 14, Section 2.1.2: Please consider explaining the choice of June 30th as the date used for data analyzed at Elephant Butte Reservoir.

Based on the end-of-month storage records from 1915 to 2007, June 30 has the highest average storage. Thus, it is the most conservative estimate to base the regression of annual evaporation.

8. Page 23, paragraph 2: In the final report, please consider documenting and discussing the concept of "annual yield" and the statistical relationship with monthly percentile flow projections (classify dependent and independent variables, etc).

The term annual yield is already defined (excess flow times the frequency).

9. Page 23, Table 7: It appears that the formula used for column 1 is incorrect. To be consistent with the formulas used for columns 2 & 3, the formula in column 1 would need to be *Exceedence Probability = (<u>0.2</u>) x (Table 4, 25% column value)*. [currently formula is = (<u>0.25</u>) x (Table 4, 25% column value)]. Also, it appears the single value for "July(0.05)" is incorrect. Please review and reconcile this data in the final report, if applicable.

Actually, it was columns 2 and 3 that contained errors. Columns 2 and 3 have been corrected.

10. Page 24, paragraphs 1-2: Contract SOW task 4 states that increased water availability estimates will be developed for irrigation and municipal surface water uses and decreased groundwater pumping for <u>each</u> alternative. The report's storage of excess Rio Grande flows (alternative #1) analysis seems to only address the volumes of excess water that could be available consistently for irrigation use. Please provide the rest of the analysis for municipal use, which could have a much different storage timing scenario than for irrigation given the conjunctive use abilities of the EPWU system. This municipal use analysis could include consideration of the system's infrastructure in terms of its ability to conjunctively utilize treated sources of surface water, fresh groundwater, and brackish groundwater and access to the proposed surface water storage facilities. Please include consideration of evaporative losses while the water is stored in the ponds. Also, please document and discuss how each of these use scenarios would allow for decreased groundwater pumpage.

The focus of this study was on conceptual alternatives. The comment would be appropriate if the analysis was far more detailed, and will be appropriate for further analysis if the Regional Planning Group and EPWU decide to proceed with one or more alternatives.

11. Page 24, paragraph 4 & page 27, paragraph 1: Please clarify which annual yield value is correct for a 4,000-AF storage facility (less than 1,500AFY or less than 1,000 AFY).

Less than 1,500 AFY is correct. Page 27 has been corrected.

12. Page 27, paragraph 1, last sentence: contract SOW task 2 states a conceptual evaluation of surface water storage will include operation and flow routing. Please provide conceptual discussion of the major diversion components that would be needed for these surface water storage facilities. For example, the pumps that would be required to move the peak flows to the storage facilities might need to be very large and such a significant cost would need to be considered in this discussion.

Some of this was covered in the previous study that is attached to this study. As already stated in the report, details covered in the comment are beyond the scope of this conceptual study.

13. Page 28, Table 10: Please clarify what percent availability was used to calculate the "excess daily flows" available for storage (as was done for the monthly flow analyses in Tables 4-6).

Text was added to state 25% availability.

14. Page 28, Section 2.4: Contract SOW task 5 states that all cost estimates developed for this study will follow the contract's Exhibit B Guidelines. These guidelines specify that all cost estimates are to be presented in 2007 dollars. Please provide all cost estimates in 2007 dollars in the final report.

It is reasonable to assume that costs in the Boyle report at the conceptual level are representative of 2007 dollars. Moreover, the emphasis is the comparison of costs between alternatives.

15. Pages 30 & 33, Figures 28 & 31, and associated text: In the final report, please clarify which probability scenario from Table 7 was used to calculate 'most' of the annual yields used in these figures. And please specify the source of the values that did not come from Table 7.

The comment mischaracterizes the statements in the report. In simplest terms, the x-axis range in Figures 28 and 31 were bounded by the analysis in Table 7

16. Page 32, last paragraph: Please clarify how construction cost estimates were derived for the Upper Valley Water Treatment Plant (WTP) ponds in the final report.

As already stated in the report, the 30% increase from the Socorro Ponds estimate reflects the estimated cost of creating ponds (recall that ponds already exist at the Socorro Ponds site).

17. Page 32, Figure 30 & last paragraph: Figure 30 shows the sum of the treatment plant property areas to be 203 acres; but the text states that this area is 303 acres. Please reconcile this information in the final report.

203 acres is correct and the text (including pond depths) has been corrected.

18. Page 34, Section 3.0: For storage of excess surface water in the Hueco Bolson Aquifer (alternative #2), please consider discussing the choice of percolation of water into this aquifer storage and recovery (ASR) system from an open basin over using an injection well(s).

EPWU's experience with injection wells in the Hueco Bolson has led to the shift to using spreading basins. The injection wells are expensive to construct and maintain, and have a relatively short life before replacement is required. To date, the spreading basins (which have been in operation since 2001) are proving to be a more effective and economical approach.

19. Page 34, Section 3.0: For alternative #2, please clarify the level of treatment that would be required at the Jonathan Rogers WTP before the Rio Grande source water is transferred to the open settling basin for percolation into the Hueco Bolson Aquifer.

The intent is to simply spread water from the distribution system in excess of demands. Therefore, the spread water would be drinking water quality, and no additional treatment would be required.

20. Page 34, Section 3.0, paragraph 2: Please review and revise alternative #2 methodology descriptions for determination of annual yield where appropriate in the final report as follows: (1) provide the formula that was chosen to estimate annual yield; (2) include consideration of evaporative losses while the water is stored in the spreading basin; (3) include spreading basin infiltration rate estimates and losses from percolation into and storage in the aquifer {100% recovery does not seem realistic using ASR processes}; (4) provide discussion on the capacity of the aquifer to be able to accept and hold additional water for storage; and (5) discuss if there would be potential impact of groundwater pumpage from the Mexican portion of the Hueco Bolson Aquifer.

1) Annual yield estimate method is already defined (80% of 5,000 AF/yr, based on frequency of drought).

2) Based on the rapid infiltration rates observed since 2001, evaporation losses are negligible.

3) This is not an ASR project where, as the comment correctly points out, 100% "recovery" is not realistic. This is simply spreading the water and letting the aquifer store and ultimately convey the water to existing wells. The benefit of this alternative is that groundwater levels will rise in the area and pumping wells further downgradient will benefit from higher groundwater levels.

4) The depth to water in the area is about 400 feet below ground surface. Thus, there is ample storage capacity.

5) This issue has been covered extensively in other studies and is beyond the scope of this study.

21. Page 36, paragraph 2 & page 41 text: Both well injection and percolation are inferred as methods for putting water into the aquifer for storage in alternative #3 (storage of local stormwater) using runoff from the northeast sector of El Paso. Please clarify which method was the primary choice used to develop the cost estimates. Also, please specify what aquifer is to be utilized in this ASR alternative and discuss the same methodology parameters listed in comment #20 above.

Lower capital costs in Figures 36-38 essentially are limited to spreading basins. Higher capital costs reflect injection wells.

22. Page 38-41, Tables 11-14, "Watershed 28,991 Acres Sub-table", row 1.00: Values appear to be incorrect and carry down through the rest of each of these sub-tables. [Scenario A example: equation should be (28,991 Ac)(1.68 in)(1 ft/12 in) = 4,058.74 ~ 4,059 AF] Please review and reconcile these table values, where appropriate, in the final report.

The values are correct. The result from the calculation in the comment (4059) needs to be multiplied by the return probability (0.2) as shown in the table to get the correct result.

23. Page 41-42: For storage of local stormwater (alternative #3), please provide cost estimates for pumping groundwater back out of the ASR well, as was done for the previous settling basin ASR analysis (page 35, paragraph 2).

Discussion on pumping costs added.

24. Page 42, paragraphs 1 & 2: Please clarify what the expected level of water treatment would be for stormwater runoff prior to aquifer storage and list all of the processes that are included in the "operating costs" presented.

Conceptually treatment could be as simple as settling of solid material or could include full surface water treatment. Given that EPWU surface water costs are about $300/AF and some of that is for payment of the water, the operating costs extend into full surface water treatment, even after accounting for the economy of scale issues. These costs were not intended to represent any particular level of treatment, but were intended to consider the potential wide range depending on the specific application that would be better considered at a feasibility level investigation.

25. Page 43: There are two figures labeled "Figure 37". Please reconcile in the final report.

The second Figure 37 is really Figure 38 as mentioned in the text. Correction was made.

26. Page 45, paragraph 3: Please consider providing an <u>actual</u> unit cost (vs. the "projected" cost stated in the text) for brackish groundwater desalination since the Kay Bailey Hutchison plant is completely operational or provide an explanation for only providing a projected cost.

The desalination plant is operational, but at less than full capacity. Therefore, actual costs at full capacity are not yet available.

APPENDIX B1

Responses to TWDB Comments

- **Please provide new set of hard copy reports printed in color (not black and white).**

Response: Hard copy reports provided to TWDB.

- **Please include missing pages 42-48 in revised final report.**

Response: Correction made to the report.

- **Please bind the hard copy revised final reports(example would be using GBC spiral binding).**

Response: Hard copy reports provided to TWDB.

- **Please correct Table of Contents pagination.**

Response: Correction made to the report.

- **Regarding Comment #7: Please include response in report text in Section 2.1.2 (page 14).**

Response: Correction made to the report.

- **Regarding Comment #8, Page 23, paragraph of text above Table 7. Please correct text to provide accurate description of methodology used in generating tables.**

Response: Tables 4, 5, 6, and 7 have been expanded with additional data and notes to describe table generation.

- **Regarding Comment #18: Please include response in report text in Section 3.0 (page 35).**

Response: Correction made to the report.

- **Regarding Comment #22: Tables 11, 12, 13, 14-Please correct Ft. Bliss Watershed Area value in heading (should be 28,891)**

Response: Correction made to the report.

- ***Regarding Comment #25: Please correct List of Figures for Figure 38.***

Response: Correction made to the report.