TRANS-TEXAS WATER PROGRAM

West Central Study Area

**Phase II Report
Letter of Intent
Analysis**

San Antonio River Authority

San Antonio Water System

Edwards Underground Water District

Guadalupe-Blanco River Authority

Lower Colorado River Authority

Bexar Metropolitan Water District

Nueces River Authority

Texas Water Development Board

October, 1996

HDR

HDR Engineering, Inc.

in association with
Paul Price Associates, Inc.

TRANS-TEXAS WATER PROGRAM
WEST CENTRAL STUDY AREA

PHASE II REPORT
LETTER OF INTENT
ANALYSIS

Prepared for

San Antonio River Authority
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Nueces River Authority
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TRANS-TEXAS WATER PROGRAM
WEST CENTRAL STUDY AREA
PHASE II - LETTER OF INTENT ANALYSIS

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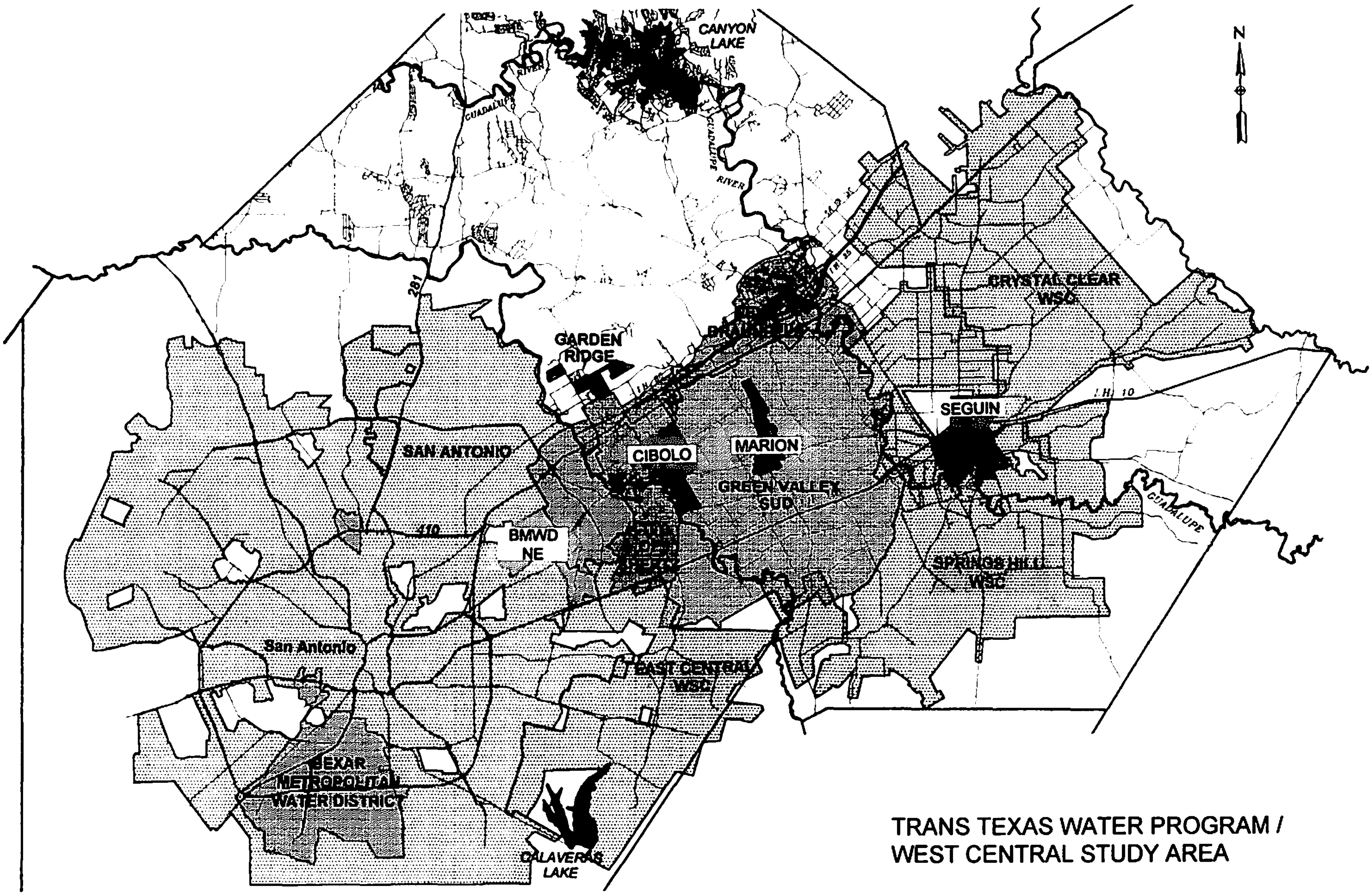
EXECUTIVE SUMMARY

In March, 1995, six water resource agencies[1] entered into a Letter of Intent (LOI) which provides the framework by which the Guadalupe-Blanco River Authority can potentially provide Guadalupe River water to the San Antonio metropolitan area as a first step to meet potential shortages. Under the Letter of Intent, GBRA will supply raw water for treatment and use in Bexar County. Treated surface water would be distributed on an equitable basis by the San Antonio River Authority to the San Antonio Water System, Bexar Metropolitan Water District and other Bexar County water purveyors. The LOI also includes provisions whereby the Guadalupe-Blanco River Authority (GBRA) will provide water to entities in its statutory district within the Guadalupe River Basin.

Under the Trans-Texas Water Program, the six participants in the LOI, the Texas Water Development Board, and the other members of the West Central Study Area have sponsored this study of water supply options outlined in the LOI. The purposes of the study are: (1) to present water demand and supply information for entities of Bexar and neighboring areas of Comal and Guadalupe counties; (2) to present water demand and water adequacy of supply information for entities in the Guadalupe River Basin; (3) to present information about the water supplies of the Guadalupe River Basin and the effect of providing water to the San Antonio metropolitan area; (4) to estimate the costs to divert, transfer, and treat various quantities of water from four locations in the Guadalupe River Basin (Canyon Lake, New Braunfels, Lake Dunlap, and Gonzales); and, (5) to present information on project implementation, including permitting issues, institutional requirements, and scheduling. The area to which this study pertains is Bexar County and neighboring areas of Comal and Guadalupe Counties of the San Antonio River Basin and the Guadalupe River Basin (Figure ES-1).

[1] The six participants in the Letter of Intent are: San Antonio River Authority, San Antonio Water System, Guadalupe-Blanco River Authority, Canyon Regional Water Authority, New Braunfels Utilities, and Bexar Metropolitan Water District.



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WATER SUPPLY AREAS

FIGURE ES-1

SUMMARY OF FINDINGS

- Present surface and ground water supplies are sufficient to meet projected demands in the Kendall, Comal, Hays, Guadalupe, and Caldwell counties areas of the Guadalupe River Basin beyond year 2020. However, surface water treatment and distribution facilities will have to be constructed in order to deliver available surface water supplies.

- Present water supplies are sufficient to meet projected demands in Guadalupe River Basin areas downstream of Guadalupe and Caldwell counties until year 2020.

- Upon implementation of Edwards Aquifer pumping limits (i.e., Senate Bill 1477 or comparable pumping regulation), water supply to areas dependent on the Edwards Aquifer, including the Mid-Cities along IH-35 between New Braunfels and Bexar County, would be limited to less than current demand.

- Several alternatives identified by the Letter of Intent increase water availability by conjunctive use of multiple water sources, including innovative use (i.e. "banked storage") of Canyon Lake. Maximizing the use of existing water sources should expedite permitting efforts as outlined in the Texas Natural Resource Conservation Commission's Regulatory Guidance Manual.

- Substantial quantities of water could be diverted from Lake Dunlap (up to 50,000 acft/yr) and/or from Gonzales (up to 75,000 acft/yr) without interruption through a recurrence of the drought of record. Diversion permits for these quantities of water would be subject to approval by the TNRCC, particularly with respect to conjunctive management of multiple water sources and applicable environmental criteria.

- Canyon Lake yield constitutes about 22,000 of 50,000 acft/yr diversion at Lake Dunlap during drought.

- Canyon Lake yield constitutes about 24,000 of 75,000 acft/yr diversion of Gonzales during drought.

- Diversions greater than 50,000 acft/yr at Dunlap and 75,000 acft/yr at Gonzales can be obtained with additional Canyon Lake yield combined with other water sources.

- Diversion of 50,000 acft/yr at Lake Dunlap with delivery of treated water at a uniform annual rate resulted in the lowest cost alternative. The average cost of water for this alternative is $268 per acft/yr ($0.82 per 1,000 gal). For the summer peaking delivery alternative, the resulting cost for the same annual quantity would be $403 per acft/yr ($1.24 per 1,000 gal).

- Diversion of 75,000 acft/yr at Gonzales with delivery of treated water at a uniform annual rate resulted in an average cost of $372 per acft/yr ($1.14 per 1,000 gal). For the summer peaking delivery alternative, the resulting cost for the same annual quantity would be $517 per acft/yr ($1.59 per 1,000 gal).

- Uniform diversion alternatives provide lowest unit cost water and most efficient use of Canyon Lake yield.

- Summer peaking diversion alternatives provide 100 percent increase in ability to respond to seasonal reductions in aquifer pumpage at an increase in unit cost of between 39 percent and 50 percent.

- Diversion at Gonzales provides 50 percent more water than Dunlap at an increase in unit cost of between 28 percent and 39 percent.

- Pumping costs represent between 10 percent and 20 percent of annual water cost.

- Delivery of water could occur in year 2000, if no permitting delays occur.

WATER DEMAND AND SUPPLY PROJECTIONS

Population, water demand, and supply projections have been tabulated for the Guadalupe River and San Antonio River basin areas as follows:

Guadalupe River Basin

- Parts of each of the 20 counties of the Guadalupe River Basin;
- All of the 10 counties of the Guadalupe-Blanco River Authority's statutory district;
- Comal and Guadalupe Counties and each city and unincorporated areas of each county;
- Mid-Cities Area of Comal and Guadalupe Counties.

San Antonio River Basin

- Bexar County and each city and unincorporated areas of the county;
- Comal County and each city and unincorporated areas of the county;
- Guadalupe County and each city and unincorporated areas of the county.

GUADALUPE RIVER BASIN

Guadalupe-Blanco River Authority Area

The population of the GBRA statutory district[2] was 360,735 in 1990 and is projected to increase to 670,358 in 2020, and to 1,040,987 in 2050. About 50 percent of this population was located in the Comal, Guadalupe, and Hays counties area in 1990. In 2050, the projections indicate that 75 percent of the population will be in the mid-basin counties.

[2] The GBRA statutory district includes all of 10 counties: Caldwell, Calhoun, Comal, DeWitt, Gonzales, Guadalupe, Hays, Kendall, Refugio, and Victoria.

In 1990, total water use in the GBRA 10-county statutory district was 187,570 acft/yr, with projected demands in 2020 of 288,258 acft/yr and in 2050 of 372,090 acft/yr. Of total water use in 1990, 60 percent was industrial use in the coastal counties.

Guadalupe River Basin

In 1990, the population of the Guadalupe River Basin was 302,409, and is projected to increase to 544,025 in 2020, and to 812,109 in 2050. The largest proportion of the population is now, and is projected to be, in the Comal, Guadalupe, and Hays counties area, with about 58 percent of the total in 1990 and 75 percent of the total in 2050.

Guadalupe-Blanco River Authority Statutory District/Guadalupe River Basin Water Demand and Supply Comparisons

Projected Demands

The Guadalupe River Basin water demand area includes all of the 10 counties of the Guadalupe-Blanco River Authority district, plus the in-basin parts of those 10 other counties which lie partially within the Basin. In 1990, total water use for the Guadalupe River Basin/GBRA Statutory districts was 208,913 acft/yr, with 128,484 acft (61 percent) in the lower basin counties of Goliad, Refugio, Victoria, and Calhoun (Table ES-1). In the following discussion, Guadalupe Basin projected demands are compared to projected supplies for the purpose of providing information for use in the cost analyses of this study. Projected water demand in the Guadalupe Basin/GBRA Statutory district is projected to be 365,775 acft/yr in 2020 and to be 415,801 acft/yr in 2050 (Table ES-1).

Projected Supplies

The quantities of groundwater available in the Guadalupe River Basin district are estimated at 182,606 acft/yr beginning in 2008 (Table ES-1).[3] In the "High Basin" counties (Kerr, Gillespie, Bandera, and Blanco) groundwater plus Guadalupe River rights appear to be adequate to meet most of the projected demands at both 2020 and 2050 (Table ES-1 and Figure ES-2). However, in the "Upper Basin" area (Kendall, Comal, Hays, Guadalupe, Caldwell,

[3] Unpublished planning data, Texas Water Development Board, 1992. Groundwater from the Edwards Aquifer is based upon the assumption that pumpage will be limited to 400,000 acft/yr and that users will be allocated their 1990 prorata share of this quantity.

Table ES-1 Water Demand and Water Supply Comparisons Guadalupe River Basin/Guadalupe-Blanco River Authority Statutory District Trans-Texas Water Program							
Area	Water Use In 1990 (acft)	Projected Water Demands 2020 (acft)	Projected Water Demands 2050 (acft)	Ground Water Supply Annually 2008 and Later* (acft)	Projected Surface Water Supplies: Run-of-the-River Rights (acft)	Projected Surface Water Supplies: Canyon Lake Contracts 1996[6] (acft)	Total Annual Supply Available (acft)
High Basin[1]	7,638	9,978	10,484	9,201	10,664	0	19,865
Upper Basin[2]	53,557	101,184	150,660	50,471	50,861	26,499	127,651
Middle Basin[3]	19,234	18,814	18,858	68,518	18,742	5	87,265
Lower Basin[4,5]	128,484	235,799	235,799	54,416	290,305	6,000	350,721
TOTAL**	208,913	365,775	415,801	182,606	370,572	32,504	585,502

* Source: Groundwater Availability Data for Texas Counties; Unpublished Planning Data; Texas Water Development Board; 1993. Groundwater from Edwards Aquifer is based on the assumption of pumpage limits of 400,000 acft/yr.

** Guadalupe-Blanco River Authority statutory counties (data for whole county); For all other counties, data for only that part of county located in Guadalupe Basin.

(1) High Basin = Parts of Kerr, Gillespie, Bandera, and Blanco Counties located in the Guadalupe Basin.

(2) Upper Basin = All of Kendall, Comal, Hays, Guadalupe, and Caldwell Counties, and those parts of Bastrop and Travis Counties that are located in the Guadalupe Basin.

(3) Middle Basin = All of Gonzales and DeWitt Counties, and parts of Wilson, Karnes, Fayette, and Lavaca Counties located in the Guadalupe Basin.

(4) Lower Basin = All of Victoria, Refugio, and Calhoun Counties.

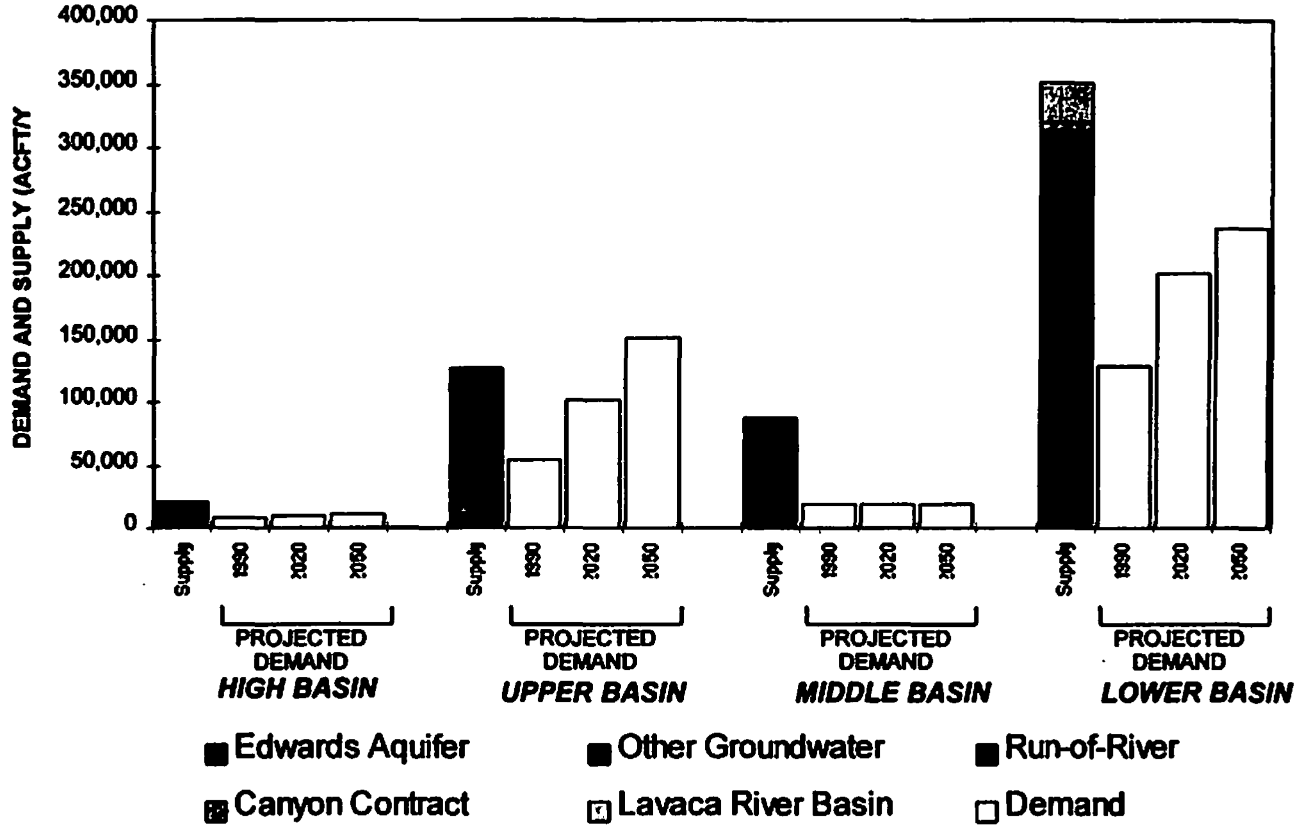
(5) 32,000 acft of firm supply is obtained from Lake Texana of the Lavaca Basin. Demand includes 11,000 acft of canal conveyance losses.

(6) Additional supply available from Canyon Lake is not included here.

Bastrop and Travis Counties), projected available ground water of 50,471 acft/yr is not adequate to meet projected demands beginning in the immediate future (Figure ES-2). Present plus potential run-of-river rights in this part of the basin are about 50,681 acft/yr, which with existing contracts for Canyon Lake water of 26,499 acft/yr, would meet projected needs in 2020, but would not meet projected needs in 2050. Surpluses shown in the Upper Basin in 2020 are largely groundwater supplies in Kendall, Caldwell, and Bastrop Counties.

The "Middle Basin" area (Gonzales, DeWitt, Wilson, Karnes, Fayette, and Lavaca Counties) has significant quantities of Carrizo Aquifer water (68,518 acft/yr), which is greater than projected demands in 2020 and 2050 (Figure ES-2). However, it is anticipated that the cities of Gonzales and Cuero, both located along the Guadalupe River, may find it advantageous to shift more of their future demands to surface water.

In the "Lower Basin" counties (Victoria, Refugio, and Calhoun), present uses and projected demands exceed the 54,416 acft/yr of available groundwater supplies. However, water



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DEMAND AND SUPPLY COMPARISONS - GUADALUPE RIVER BASIN SERVICE AREA

FIGURE ES-2

users of these counties hold run-of-river rights to Guadalupe River water, plus contracts for 32,000 acft of Lake Texana water in the neighboring Lavaca Basin that would more than meet projected needs in 2020 and 2050 (Figure ES-2). It is estimated, however, that for uses in Victoria and Calhoun Counties, some additional, dependable or firm supplies of surface water may be needed to firm up run-of-river rights.

Mid-Cities Area

The population and water demand and supply projections for fourteen entities (five major water supply corporations, eight cities, and one military installation) of eastern Bexar County, southwestern Comal County, and most of Guadalupe County, who are participants in (or affected by) the Letter of Intent are tabulated in order to provide information needed for the location and costing of water supply facilities to serve these entities[4].

In 1990, the total population of the 14 Mid-Cities entities was 106,099 and is projected to increase to 224,427 in 2020 and to 364,358 in 2050. About 58 percent of the population is projected to be in eastern Bexar County, about 18 percent in the areas where Bexar, Comal and Guadalupe Counties join, and about 24 percent is projected to be in Guadalupe County.

In 1990, total water use by the Mid-Cities entities was reported to be 17,958 acft/yr, of which 17,074 was obtained from the Edwards Aquifer. Projected water demands in 2020 are 34,153 acft/yr and in 2050 are 54,252 acft/yr.

A comparison of supplies and demand indicates shortages for the Mid-Cities entities beginning in 2000. In 2020, the projected shortage is 17,360 acft/yr and in 2050 it is projected to be 37,459 acft/yr.

SAN ANTONIO RIVER BASIN

The population of the Bexar/Comal/Guadalupe Counties area of the San Antonio River Basin was 1,208,017 in 1990 and is projected to increase to 2,193,014 in 2020 and to 3,204,738 in 2050. Of these totals, in 1990 the Bexar County part was about 98 percent.

In 1990, total water use in the Bexar, Comal, and Guadalupe County areas of the San Antonio River Basin was 281,186 acft/yr. Projected total water demands in 2020 are 450,278 acft/yr, and in 2050 are 616,148 acft/yr.

[4] These Mid-Cities entities are also included in their respective river basin tabulations where they are located.

The quantity of Edwards Aquifer water used for municipal and industrial purposes in Bexar/Comal/Guadalupe Counties within the San Antonio River Basin in 1990 was reported to be 239,658 acft. Thus, based on the provisions of SB 1477[5], the supply of Edwards Aquifer water available for this area would be 179,744 acft/yr in 2008 and later years. Supply to this area from other aquifers and surface water is about 23,500 acft/yr. The projected total municipal and industrial water shortages for the three counties (Bexar/Comal/Guadalupe, within the San Antonio River Basin) are projected to be 99,103 acft/yr in 2000, 208,999 acft/yr in 2020, and 377,929 acft/yr in 2050. It should be recognized, however, that these comparisons and projected shortages are based upon the provisions of SB 1477 that could limit pumping of the Edwards Aquifer. The quantities of Edwards Aquifer supplies calculated for these analyses are greater than would be expected to be available during severe droughts. Thus, during severe droughts, with SB 1477 in effect, the shortages could be significantly greater than shown here.

WATER SUPPLY ALTERNATIVES

A total of 11 water supply alternatives were studied at four potential points of diversion on the Guadalupe River as summarized in Table ES-2. Two types of monthly water delivery patterns were analyzed for each alternative. These included a uniform monthly delivery pattern and a summer peaking delivery pattern with the maximum months (July and August) having a delivery rate of 2.0 times the average monthly volume.

The Phase I study[6] of the Trans-Texas Water Program considered a broad array of water supply alternatives for the West Central Study Area other than those considered in the Letter of Intent. Further work in Phase II may require more detailed study of alternatives identified in Phase I and the LOI study in order to develop an integrated water supply program to meet the needs of the region.

WATER AVAILABILITY

Numerous factors other than the rainfall/runoff process affect water availability in the Guadalupe River Basin. For example, water availability will depend greatly on the management

[5] Senate Bill 1477, 1993 Texas Legislature, as amended.
[6] "Trans-Texas Water Program, West Central Study Area, Phase I Interim Report", Vols. 1 through 4, HDR Engineering, Inc., prepared for San Antonio River Authority, Texas Water Development Board, et al, 1994 and 1995.

Table ES-2 Summary of Water Supply Alternatives				
Alternative No.	**Diversion Location**	**Annual Diversion (acft/yr)**	**Treated Water Delivery Rate**	**Delivery Location[3]**
G-34A G-34B G-34C G-34D	Canyon Lake	5,000 5,000 8,000 8,000	Uniform Summer Peak Uniform Summer Peak	Canyon Lake WSC, Bulverde, and SAWS
G-35A G-35B	New Braunfels	15,000 15,000	Uniform Summer Peak	Mid-Cities and SAWS
G-36A G-36B G-36C G-36D	Lake Dunlap to CRWA WTP	5,000 5,000 15,000 15,000	Uniform Summer Peak Uniform Summer Peak	Mid-Cities, CRWA, and SAWS
G-37A G-37B G-37C G-37D	Lake Dunlap to Regional WTP	15,000 15,000 50,000 50,000	Uniform Summer Peak Uniform Summer Peak	Mid-Cities, CRWA, and SAWS
G-38A G-38B G-38C G-38D	Guadalupe River near Gonzales	40,000 40,000 75,000 75,000	Uniform Summer Peak Uniform Summer Peak	Mid-Cities, CRWA, and SAWS
G-39A G-39B G-39C G-39D	Lake Dunlap and Guadalupe River near Gonzales	40,000(1) 40,000(1) 75,000(2) 75,000(2)	Uniform Summer Peak Uniform Summer Peak	Mid-Cities, CRWA, and SAWS

(1) 40,000 acft/yr annual diversion is sum of 5,000 acft/yr diverted at Lake Dunlap and 35,000 acft/yr diverted at Gonzales.
(2) 75,000 acft/yr annual diversion is sum of 15,000 acft/yr diverted at Lake Dunlap and 60,000 acft/yr diverted at Gonzales.
(3) SAWS: San Antonio Water System; Mid-Cities: Municipalities in western Guadalupe County, i.e., Marion, Cibolo, Schertz, and Garden Ridge; CRWA: Member entities of Canyon Regional Water Authority in Guadalupe County, i.e., Green Valley SUD, Springs Hill WSC, and Crystal Clear WSC.

plan ultimately adopted for the Edwards Aquifer since aquifer pumpage affects springflow which, in turn, affects streamflow. In addition, application of environmental flow criteria could significantly affect estimated quantities of water available for diversion depending on whether the criteria ultimately adopted are more or less severe than the criteria used in this study (refer to Appendix C for description of environmental flow criteria applied). Other key factors include the degree to which hydropower rights are subordinated to Canyon Lake, assumed quantities of return flow, seasonal pattern for water demand, and maximum diversion rate associated with selected pump station and transmission pipeline capacity.

Alternatives G-34, G-35, G-36, G-37A, and G-37B consider the purchase of uncommitted stored water in Canyon Lake. The annual volume considered for diversion under each alternative is listed in Table ES-2.

Under alternatives G-37C, G-37D, G-38, and G-39, water potentially available for diversion would be obtained from the following sources: 1) enhanced springflow resulting from a theoretical reduction in overall Edwards Aquifer pumpage from that observed in calendar year 1989 (543,677 acft) to 400,000 acft/yr; 2) flow permitted to large existing water rights (permitted, but projected to be underutilized in calendar year 2020); 3) unappropriated streamflow; and 4) stored water delivered from Canyon Lake. The term "enhanced springflow" as used throughout this study is defined to be the estimated increase in discharge primarily from Comal and San Marcos Springs into the Guadalupe and San Marcos Rivers which, theoretically, would occur if Edwards Aquifer pumpage were reduced from an annual volume of 543,677 acft to an annual volume of 400,000 acft. For the purposes of this study, it was assumed that this water would first be dedicated to existing water rights (including Canyon Lake) with the remainder available for diversion from the Guadalupe River at Lake Dunlap and/or Gonzales. The procedures and assumptions pertinent to the computation of water potentially available from each of the four sources identified above are described in Appendix C.

Water availability analyses conclude that substantial quantities of water could be diverted from Lake Dunlap and/or Gonzales without interruption through the historical drought of record subject to either a uniform monthly diversion pattern or a peaked summer diversion pattern. Table ES-3 summarizes estimates of water available from each source during drought after meeting water rights. For the uniform monthly diversion pattern of 50,000 acft/yr at Lake Dunlap (Alt G-37C), analyses indicate that a drought average of 22,580 acft/yr could be obtained from enhanced springflow and 11,130 acft/yr obtained by purchase or lease of existing water rights projected to be underutilized in 2020. In addition, an average of 18,830 acft/yr would need to be purchased from the yield of Canyon Lake (of which about 2,580 acft/yr is needed to offset increased evaporation from banked storage as described in Appendix C) to ensure availability of 50,000 acft/yr at Lake Dunlap. For the peaked summer diversion pattern of 50,000 acft/yr at Lake Dunlap (Alt G-37D), analyses indicate that a drought average of 18,670 acft/yr could be

Table ES-3 Water Sources for Diversion at Lake Dunlap and Gonzales During Drought [1]					
Alternative No. and Diversion Location	**Annual Diversion (acft/yr)**	**Uniform Annual Diversion Pattern**		**Summer Peak Diversion Pattern**	
		Run-of-the-River Sources[2]	**Canyon Firm Yield[3]**	**Run-of-the-River Sources[2]**	**Canyon Firm Yield[3]**
G-37 Lake Dunlap	50,000	33,750	18,830	30,710	21,700
G-38 Gonzales	40,000	33,070	8,090	31,970	9,280
G-38 Gonzales	75,000	56,150	21,930	53,960	24,060
G-39 Lake Dunlap: Gonzales:	 5,000 35,000	 0 28,890	 5,000 7,140	 0 27,870	 5,000 8,240
G-39 Lake Dunlap: Gonzales:	 15,000 60,000	 0 44,910	 15,000 17,600	 0 43,010	 15,000 19,490

(1) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(2) Includes availability from enhanced springflow, unappropriated streamflow, and utilization of significant water rights projected to be underutilized in year 2020.
(3) Includes increased evaporation resulting from banked storage.

obtained from enhanced springflow and 11,980 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 21,700 acft/yr would need to be purchased from the firm yield of Canyon Lake (of which about 2,400 acft/yr is needed to offset increased evaporation from banked storage) to ensure availability of 50,000 acft/yr at Lake Dunlap. Analyses indicate that diversion of enhanced springflow would be significantly greater over the long-term than during drought, while utilization of water purchased from the yield of Canyon Lake would be significantly less.

For the uniform monthly diversion pattern of 75,000 acft/yr from the combined Lake Dunlap and Gonzales diversions (Alt G-39C), analyses indicate that a drought average of 28,840 acft/yr could be obtained from enhanced springflow and 15,280 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 32,600 acft/yr would need to be purchased from the yield of Canyon Lake (of which about 2,510 acft/yr is needed to offset increased evaporation from banked storage as described in Appendix C) to ensure availability of 75,000 acft/yr. For the peaked summer diversion pattern of 75,000 acft/yr from the combined Lake Dunlap and Gonzales diversions (Alt G-39D), analyses indicate that a drought average of 26,730 acft/yr could be obtained from enhanced springflow and 15,330 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 34,490 acft/yr would need to be purchased from the firm yield of Canyon Lake (of which about 2,500 acft/yr is needed to offset increased evaporation from banked storage) to ensure availability of 75,000 acft/yr. Analyses indicate that diversion of enhanced springflow would be significantly greater over the long-term than during drought, while utilization of water purchased from the yield of Canyon Lake would be significantly less.

COST ESTIMATES

Table ES-4 summarizes the annual unit cost ($ per acft/yr and $ per 1,000 gallons) for uniform annual deliveries for each of the supply alternatives. Table ES-5 contains a similar summary for a summer peak delivery pattern.

The top portion of Figure ES-3 contains a bar chart plot of the unit costs for uniform delivery of treated water to the SAWS' Stahl Pump Station for each of the potential diversion points and diversion rates. Delivery costs for uniform annual delivery into the San Antonio metro area at the Stahl Pump Station varied from a high of $455 per acft/yr ($1.40 per 1000 gal) for Alternative G-36C (i.e., diversion of 15,000 acft/yr at Lake Dunlap through the CRWA water treatment plant) to a low of $268 per acft/yr ($0.82 per 1000 gal) for Alternative G-37C (i.e., diversion of 50,000 acft/yr at Lake Dunlap treated at a potential regional water treatment plant near Marion). Alternative G-37C is indicated in Figure ES-3 by the highlighted bar. With implementation of Alternative G-37C, the unit costs to the other participants range from $227 per acft/yr ($0.70 per 1,000 gal) for the water supply corporations near the water treatment plant to $574 per acft/yr ($1.76 per 1,000 gal) for the City of Marion. The unit costs to the other potential participants for delivery of water under Alternative G-37C are plotted on the lower half of Figure ES-3. The unit cost to Marion ($574 per acft/yr) is somewhat higher than for the other entities because the small amount of water delivered does not fully utilize the delivery pipeline, even though the pipeline is sized at a minimum 4-inch diameter. The diversion location, potential pipeline routes, and delivery locations for Alternatives G-37 (i.e., lowest unit cost alternative) are shown on Figure ES-4.

Table ES-4
Summary of Annual Unit Costs[1] for Water Supply Alternatives with Uniform Delivery
($ per acft/yr; values in ( ) are $/1,000 gallons per year)
(1st Quarter - 1996 Dollars)

Diversion Point	Alt. No.	Annual Volume (acft)	Point of Delivery: CLWSC -Triple Peak	CLWSC -Rolling Hills	Bulverde	SH WSC (2)	CC WSC (2)	GV SUD (2)	Marion	Cibolo	Schertz	Garden Ridge	SAWS Marshall	SAWS -Stahl
Canyon	G-34A	5,000	$315 ($0.97)	$504 ($1.55)	$760 ($2.33)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$730 ($2.24)	n/a
Lake	G-34C	8,000	$278 ($0.85)	$454 ($1.39)	$585 ($1.80)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$510 ($1.57)	n/a
New Braunfels	G-35A	15,000	n/a	n/a	n/a	n/a	n/a	n/a	$538 ($1.65)	$430 ($1.32)	$355 ($1.09)	$352 ($1.08)	n/a	$416 ($1.28)
Lake Dunlap	G-36A	5,000	n/a	n/a	n/a	$297 ($0.91)	$297 ($0.91)	$374 ($1.15)	$701 ($2.15)	$463 ($1.42)	$425 ($1.30)	$425[4] ($1.30)	n/a	n/a
(CRWA WTP)	G-36C	15,000	n/a	n/a	n/a	$252[3] ($0.77)	$252[3] ($0.77)	$298 ($0.91)	$483 ($1.48)	$356 ($1.09)	$334 ($1.03)	$383 ($1.18)	n/a	$455 ($1.40)
Lake Dunlap	G-37A	15,000	n/a	n/a	n/a	$300[3] ($0.92)	$300[3] ($0.92)	$300 ($0.92)	$494 ($1.52)	$357 ($1.10)	$338 ($1.04)	$362 ($1.11)	n/a	$433 ($1.33)
(Regional WTP)	G-37C	50,000	n/a	n/a	n/a	$227[3] ($0.70)	$227[3] ($0.70)	$227 ($0.70)	$574 ($1.76)	$275 ($0.84)	$257 ($0.79)	$261 ($0.80)	n/a	$268 ($0.82)
Gonzales	G-38A	40,000	n/a	n/a	n/a	$391[3] ($1.20)	$391[3] ($1.20)	$391 ($1.20)	$747 ($2.29)	$438 ($1.34)	$421 ($1.29)	$428 ($1.31)	n/a	$438 ($1.34)
	G-38C	75,000	n/a	n/a	n/a	$349[3] ($1.07)	$349[3] ($1.07)	$349 ($1.07)	$701 ($2.15)	$400 ($1.23)	$378 ($1.16)	$381 ($1.17)	n/a	$381 ($1.17)
Dunlap	G-39A	40,000	n/a	n/a	n/a	$392[3] ($1.20)	$392[3] ($1.20)	$392 ($1.20)	$747 ($2.29)	$444 ($1.36)	$421 ($1.29)	$428 ($1.31)	n/a	$439 ($1.35)
Combined w/Gonzales	G-39C	75,000	n/a	n/a	n/a	$338[3] ($1.04)	$338[3] ($1.04)	$338 ($1.04)	$691 ($2.12)	$387 ($1.19)	$367 ($1.13)	$371 ($1.14)	n/a	$372 ($1.14)

(1) Cost of treated water delivered on a wholesale basis and does not include operating costs of the participant's distribution system. Included in the purchase price is stored water from GBRA and purchase of underutilized water rights at a cost of $53 per acft/yr. Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water, and the cost to bring the water, may occur before year 2020.
(2) SH WSC: Springs Hill Water Supply Corporation; CC WSC: Crystal Clear Water Supply Corporation; GV SUD: Green Valley Special Utility District.
(3) Springs Hill and Crystal Clear WSCs will potentially receive allocation of new water supplies through a trade with Green Valley SUD. Unit cost to SHWSC and CCWSC will be the same as delivery to Green Valley SUD.
(4) Garden Ridge delivery is combined at Schertz delivery point and Garden Ridge will potentially receive water through Schertz' distribution system.
n/a means Not Applicable; i.e. no potential water delivery for the diversion/delivery combination was evaluated.

Table ES-5
Summary of Annual Unit Costs[1] for Water Supply Alternatives with Summer Peak Delivery
($ per acft/yr; values in ( ) are $/1,000 gallons per year)
(1st Quarter - 1996 Dollars)

Diversion Point	Alt. No.	Annual Volume (acft)	Point of Delivery: CLWSC -Triple Peak	CLWSC -Rolling Hills	Bulverde	SH WSC[2]	CC WSC[2]	GV SUD[2]	Marion	Cibolo	Schertz	Garden Ridge	SAWS Marshall	SAWS-Stahl
Canyon	G-34B	5,000	$491 ($1.51)	$695 ($2.13)	$1,003 ($3.08)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$982 ($3.01)	n/a
Lake	G-34D	8,000	$429 ($1.32)	$619 ($1.90)	$799 ($2.45)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	$730 ($2.24)	n/a
New Braunfels	G-35B	15,000	n/a	n/a	n/a	n/a	n/a	n/a	$708 ($2.17)	$640 ($1.96)	$561 (1.72)	$554 ($1.70)	n/a	$632 ($1.94)
Lake Dunlap	G-36B	5,000	n/a	n/a	n/a	$469 ($1.44)	$469 ($1.44)	$567 ($1.74)	$897 ($2.75)	$699 ($2.15)	$637 ($1.95)	$637[4] ($1.95)	n/a	n/a
(CRWA WTP)	G-36D	15,000	n/a	n/a	n/a	$389[3] ($1.19)	$389[3] ($1.19)	$452 ($1.39)	$637 ($1.95)	$515 ($1.58)	$503 ($1.54)	$573 ($1.76)	n/a	$660 ($2.03)
Lake Dunlap	G-37B	15,000	n/a	n/a	n/a	$458[3] ($1.41)	$458[3] ($1.41)	$458 ($1.41)	$647 ($1.99)	$523 ($1.61)	$511 ($1.57)	$541 ($1.66)	n/a	$625 ($1.92)
(Regional WTP)	G-37D	50,000	n/a	n/a	n/a	$341[3] ($1.05)	$341[3] ($1.05)	$341 ($1.05)	$690 ($2.12)	$394 ($1.21)	$384 ($1.18)	$391 ($1.20)	n/a	$403 ($1.24)
Gonzales	G-38B	40,000	n/a	n/a	n/a	$517[3] ($1.59)	$517[3] ($1.59)	$517 ($1.59)	$874 ($2.68)	$575 ($1.76)	$561 ($1.72)	$570 ($1.75)	n/a	$586 ($1.80)
	G-38D	75,000	n/a	n/a	n/a	$473[3] ($1.45)	$473[3] ($1.45)	$473 ($1.45)	$827 ($2.54)	$525 ($1.61)	$515 ($1.58)	$519 ($1.59)	n/a	$519 ($1.59)
Dunlap	G-39B	40,000	n/a	n/a	n/a	$512[3] ($1.57)	$512[3] ($1.57)	$512 ($1.57)	$862 ($2.65)	$569 ($1.75)	$557 ($1.71)	$565 ($1.73)	n/a	$583 ($1.79)
Combined w/Gonzales	G-39D	75,000	n/a	n/a	n/a	$471[3] ($1.45)	$471[3] ($1.45)	$471 ($1.45)	$828 ($2.54)	$525 ($1.61)	$512 ($1.57)	$516 ($1.58)	n/a	$517 ($1.59)

(1) Cost of treated water delivered on a wholesale basis and does not include operating costs of the participant's distribution system. Included in the purchase price is stored water from GBRA and purchase of underutilized water rights at a cost of $53 per acft/yr. Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water, and the cost to bring the water, may occur before year 2020.

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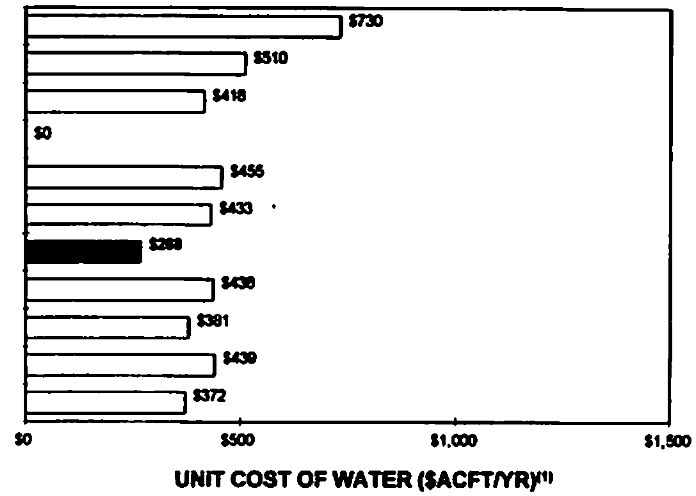
(3) Springs Hill and Crystal Clear WSCs will potentially receive allocation of new water supplies through a trade with Green Valley SUD. Unit cost to SHWSC and CCWSC will be the same as delivery to Green Valley SUD.

(4) Garden Ridge delivery is combined at Schertz delivery point and Garden Ridge will potentially receive water through Schertz' distribution system.

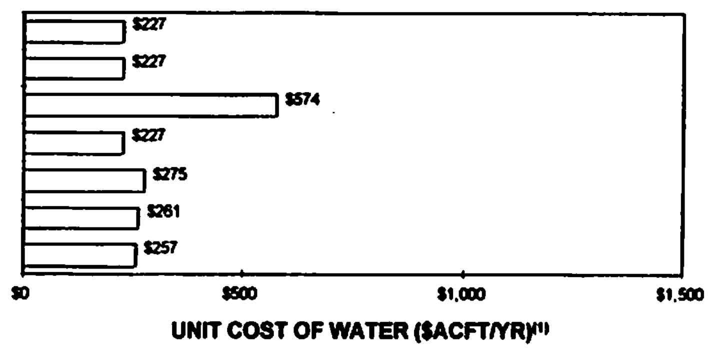
n/a means Not Applicable; i.e. no potential water delivery for the diversion/delivery combination was evaluated.

	Delivery Point	Diversion Location	Alternative	Annual Quantity (Year 2020) (acft/yr)
SAWS		Canyon Lake	G-34A	2,404
		Canyon Lake	G-34C	5,404
		NBU	G-35A	11,571
		Dunlap-CRWA	G-36A	n/a
		Dunlap-CRWA	G-36C	9,348
		Dunlap-Regional	G-37A	9,348
		Dunlap-Regional	G-37C	44,348
		Gonzales	G-38A	34,348
		Gonzales	G-38C	69,348
		Gonzales/Dunlap	G-39A	34,348
		Gonzales/Dunlap	G-39C	69,348



Costs by Delivery Location for Alternative G-37C

	Diversion Location	Alternative	Annual Quantity (Year 2020) (acft/yr)
Springs Hill WSC[2]	Dunlap-Regional	G-37C	123
Crystal Clear WSC[2]	Dunlap-Regional	G-37C	476
Marion	Dunlap-Regional	G-37C	87
Green Valley SUD	Dunlap-Regional	G-37C	1,624
Cibolo	Dunlap-Regional	G-37C	160
Garden Ridge	Dunlap-Regional	G-37C	570
Schertz	Dunlap-Regional	G-37C	2,612



(1) Cost of treated water delivered on a wholesale basis and does not include operating costs of the participant's distribution system. Included in the purchase price of stored water from GBRA or purchase of unutilized rights is $53 per acft/yr. Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water, and the cost to bring the water, may occur before year 2020.

(2) Springs Hill and Crystal Clear WSCs will potentially receive allocation of new water supplies through a trade with Green Valley SUD. Unit cost to SHWSC and CCWSC will be the same as delivery to Green Valley SUD.

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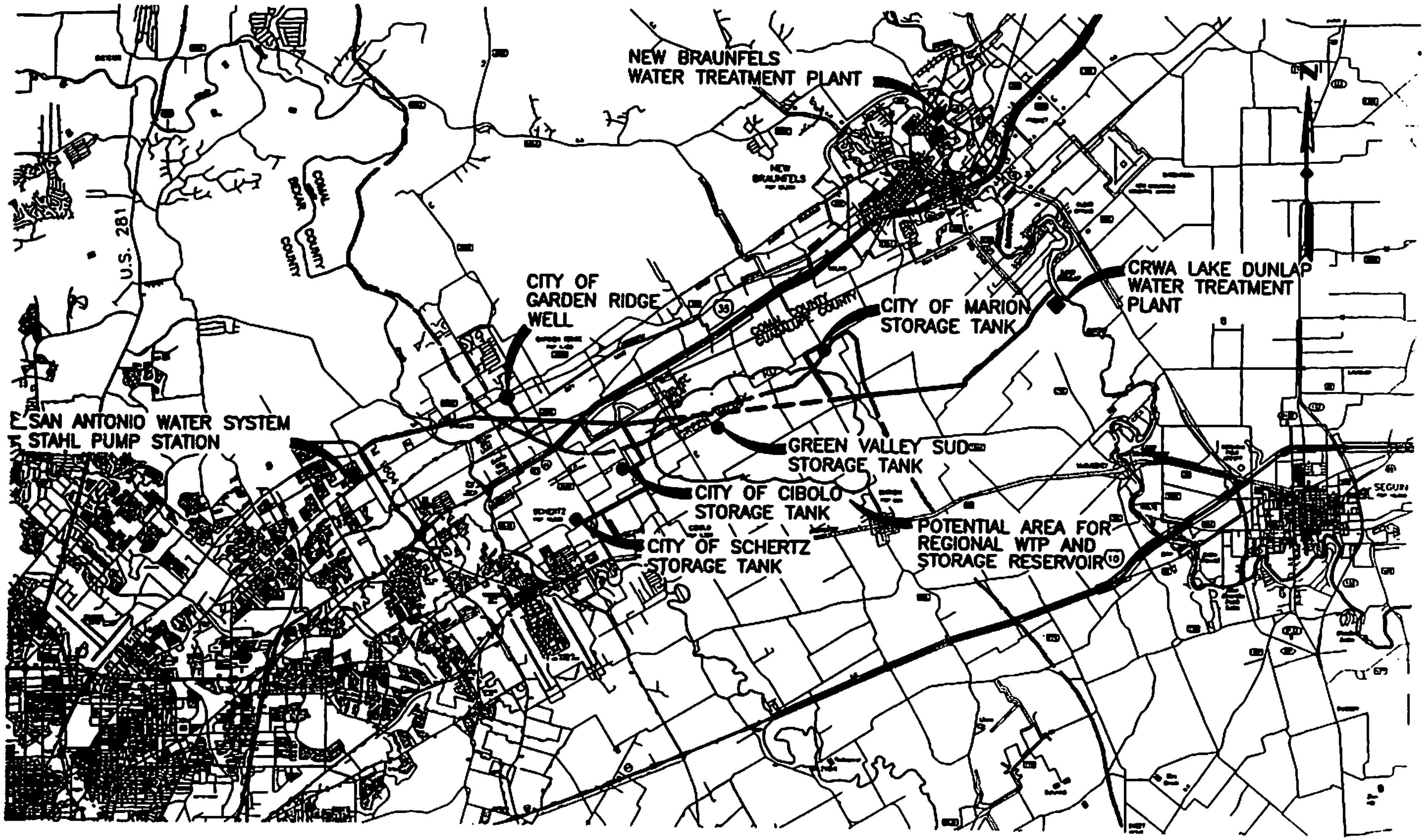
UNIT COSTS FOR UNIFORM ANNUAL DELIVERY

FIGURE ES-3



Legend

- Water Treatment Plant
- Connection Point to Existing Distribution System
- Potential Water Transmission Pipeline
- Basin Boundary

2 0 2 4 6

Approximate Scale in Miles

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GUADALUPE RIVER DIVERSION AT LAKE DUNLAP DELIVERED TO REGIONAL WTP, ALTERNATIVE G-37

FIGURE ES-4

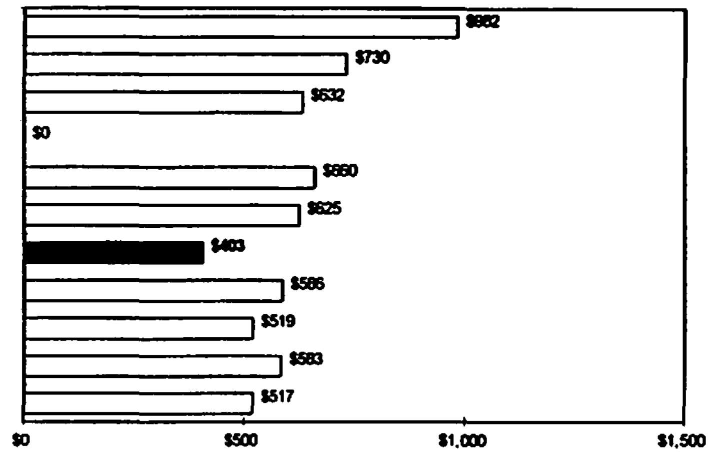
The second lowest cost alternative based on a uniform delivery rate is for Alternative G-39C (i.e., diversion of 15,000 acft at Lake Dunlap and 60,000 acft at Gonzales) as shown on the top portion of Figure ES-3. This alternative provides a significantly greater supply (i.e., 50 percent increase) of treated water supply over the most economical alternative (i.e., G-37C) at a unit cost of $372 per acft/yr ($1.14 per 1,000 gallons) which represents a 36% increase in unit cost.

The top portion of Figure ES-5 contains a bar chart plot of the unit costs for delivery of treated water based on a summer peaking rate to the SAWS' Stahl Pump Station for each of the potential diversion points and diversion rates. Delivery costs for summer peak delivery pattern into the San Antonio metro area at the Stahl Pump Station varied from $660 per acft/yr ($2.03 per 1,000 gal) for diversion of 15,000 acft/yr at Lake Dunlap through the CRWA water treatment plant to $403 per acft/yr ($1.24 per 1,000 gal) for diversion of 50,000 acft/yr at Lake Dunlap treated at a potential regional water treatment plant near Marion. Alternative G-37D is indicated in Figure ES-5 by the highlighted bar. With implementation of Alternative G-37D, the unit costs to the other participants range from $341 per acft/yr ($1.05 per 1,000 gal) for the water supply corporations near the plant to $690 per acft/yr ($2.12 per 1,000 gal) for Marion. The unit costs to the other potential participants for delivery of water under Alternative G-37D are plotted on the lower half of Figure ES-5.

The second lowest cost alternative based on a summer peaking delivery rate is for Alternative G-39D (i.e., diversion of 15,000 acft at Lake Dunlap and 60,000 acft at Gonzales) as shown on the top portion of Figure ES-5. This alternative provides a 50 percent increase in water supply over the most economical alternative (i.e., G-37D) at a unit cost of $517 per acft/yr ($1.59 per 1,000 gal) which represents a 25% increase in unit cost.

For the most economical alternative (Alt G-37C, Lake Dunlap diversion of 50,000 acft/yr to regional WTP), the unit cost differential between the uniform annual delivery pattern and the summer peak delivery pattern is an increase of $135 per acft/yr ($0.41 per 1,000 gal) or a 50 percent increase in unit cost. For the second most economical alternative (Alt G-39D) the unit cost differential between alternative delivery patterns is $145 acft/yr ($0.45 per 1,000 gal) or a 39 percent increase in unit cost. Implementation of the summer peak delivery capability offers the following advantages:

Delivery Point	Diversion Location	Alternative	Annual Quantity (Year 2020) (acft/yr)
SAWS	Canyon Lake	G-34B	2,404
	Canyon Lake	G-34D	5,404
	NBU	G-35B	11,571
	Dunlap-CRWA	G-36B	n/a
	Dunlap-CRWA	G-36D	9,348
	Dunlap-Regional	G-37B	9,348
	Dunlap-Regional	**G-37D**	**44,348**
	Gonzales	G-38B	34,348
	Gonzales	G-38D	69,348
	Gonzales/Dunlap	G-39B	34,348
	Gonzales/Dunlap	G-39D	69,348



Costs by Delivery Location for Alternative G-37D

Delivery Point	Diversion Location	Alternative	Annual Quantity (Year 2020) (acft/yr)
Springs Hill WSC[2]	Dunlap-Regional	G-37D	123
Crystal Clear WSC[2]	Dunlap-Regional	G-37D	476
Marion	Dunlap-Regional	G-37D	87
Green Valley SUD	Dunlap-Regional	G-37D	1,624
Cibolo	Dunlap-Regional	G-37D	160
Garden Ridge	Dunlap-Regional	G-37D	570
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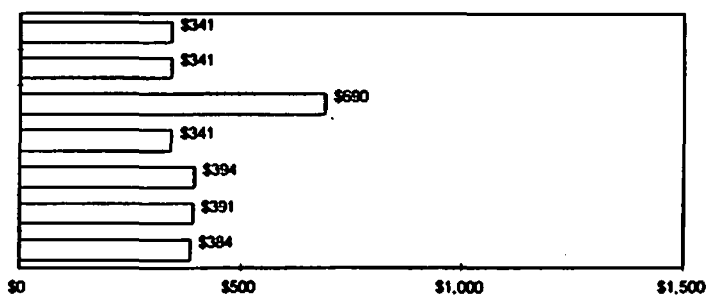

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(2) Springs Hill and Crystal Clear WSCs will potentially receive allocation of new water supplies through a trade with Green Valley SUD. Unit cost to SHWSC and CCWSC will be the same as delivery to Green Valley SUD.

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UNIT COSTS FOR SUMMER PEAKING DELIVERY

FIGURE ES-5

- Provides the greatest flexibility to meet municipal demands
- Provides much higher ability to meet the metro area's needs when aquifer regulation (by the courts or SB 1477) reduces peak summer pumping of the aquifer
- Provides for excess non-summer capacity to treat water potentially available from other sources, thereby further reducing annual demand on the aquifer.

IMPLEMENTATION

Implementation steps include:

- Commitment of project participants
- Phasing of project elements
- Negotiating water purchase and operating contracts with GBRA and other existing water rights owners
- Financing
- Permitting
- Engineering
- Construction
- Start-up
- Operations and Maintenance

Permit Requirements

<u>Lake Dunlap Intake</u>

It will be necessary to obtain these permits:

1. a. TNRCC Water Right permit.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the intake.
   c. GLO Easement for use of state-owned land.
   d. Coastal Coordinating Council review.
   e. GBRA modification or construction permit.
2. Permitting, at a minimum, will require these studies:
   a. Environmental studies.
   b. Cultural resource studies.
3. Land will need to be acquired through either negotiations or condemnation.

<u>Requirements Specific to Diversion of Water from Guadalupe River</u>

Need For Additional In-Stream Flow Studies

To obtain more realistic values of surface water availability, additional in-depth studies of environmental water needs should be performed for affected reaches of the Guadalupe and San

Antonio Rivers. These studies are consistent with the Environmental Water Needs Criteria of the Consensus Planning Process which allows the substitution of alternative flow minimums based on stream-specific studies considering indigenous species, habitat, recreational utilization, water quality, and assimilative capacity of individual stream segments.

1. Necessary permits:
   a. One, or possibly more, existing water rights permit will need to be amended to allow for an additional point of diversion at either Lake Dunlap and/or Gonzales.
   b. TNRCC permit to divert water.
   c. TNRCC Interbasin Transfer Approval.
2. Permitting will require these studies:
   a. Water availability analyses.
   b. Instream flow issues and impact.
   c. Environmental studies.
   d. Bay and estuary inflow impact.
3. Agreements with water right permit owners including GBRA for use and payment for water diverted under existing permits and for water released from Canyon Lake.

Requirements Specific to Pipelines

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel and Marl Removal permits.
   d. Coastal Coordinating Council review may be required.
2. Right-of-way and easement acquisition.
3. Crossings.
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

Requirements Specific to Amending the Canyon Lake Permit

1. Alternatives G-37C, G-37D, G-38 and G-39 will likely require exceeding the current permitted annual diversion from Canyon Lake of 50,000 acft, and a permit amendment will require:
   a. Hydrologic studies substantiating requested firm yield.
   b. Environmental studies of in-stream flow and bay/estuary effects.
   c. Subordination of hydropower rights.
   d. Future management of Edwards Aquifer by a regional agency to achieve the modeled aquifer pumpage/springflow scenario.
   e. Application to the TNRCC.

Requirements Specific to Transfer of Underutilized Water Rights

Existing diversion permits would need to be amended on a temporary basis to change the point of diversion. Potential significant water rights holders which may have under-utilized diversion rights in year 2020 include GBRA, E.I. Dupont de Nemours, City of San Marcos, and City of Victoria.

Requirements Specific to Treatment and Distribution

A detailed study is needed of the cost of pumping and transmission pipeline improvements necessary to effectively integrate the new supply into SAWS water distribution system.

Off-Channel Reservoir (when implemented)

1. It will be necessary to obtain these permits for the off-channel storage reservoir.
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer Approval.
   c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. GLO Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordinating Council review.
   g. TPWD Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Bay and estuary inflow impact.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired either through negotiations or condemnation.
4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Other utilities.

Engineering

Engineering services will need to be procured for:

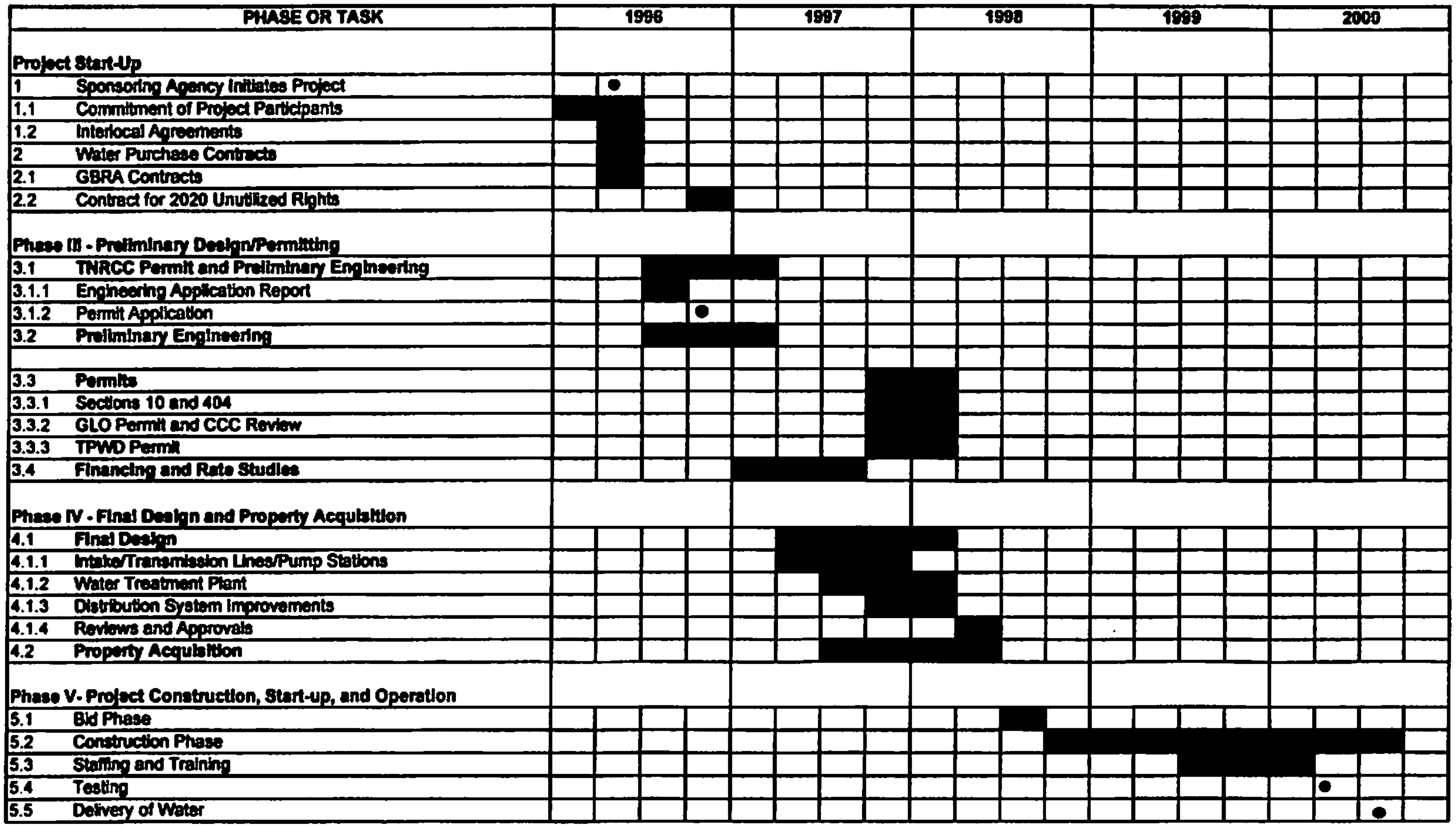
1. Development of TNRCC permit application and Preliminary Engineering Report
2. Design Services for:
   a. Pipelines.
   b. Intake, pump stations, and channel dam.
   c. Water treatment plant.
   d. Distribution system improvements.

Schedule

A list of tasks and schedule has been developed for implementation of one of the larger projects, (e.g., G-37C or G-37D, G-38, or G-39). Implementation of a smaller project, utilizing only stored water in Canyon Lake would require proportionately less study and less time than indicated in the schedule. The implementation schedule is contained in Figure ES-6. The Trans-Texas Water Program defines the following project phases and these designations are used in the implementation schedule contained in Figure ES-6.

Phase I:	Program Initiation/Conceptual Planning (Phase I has been completed)
Phase II:	Feasibility Studies (This report, when finalized, will conclude the Phase II work)
Phase III:	Preliminary Project Design/State and Federal Permitting
Phase IV:	Property Acquisition/Final Design
Phase V:	Project Construction, Start-up, and Operation

IMPLEMENTATION SCHEDULE



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POTENTIAL IMPLEMENTATION SCHEDULE

FIGURE ES-6

TRANS-TEXAS WATER PROGRAM
WEST CENTRAL STUDY AREA
PHASE II REPORT - LETTER OF INTENT ANALYSIS

1.0 INTRODUCTION

1.1 Trans-Texas Water Program

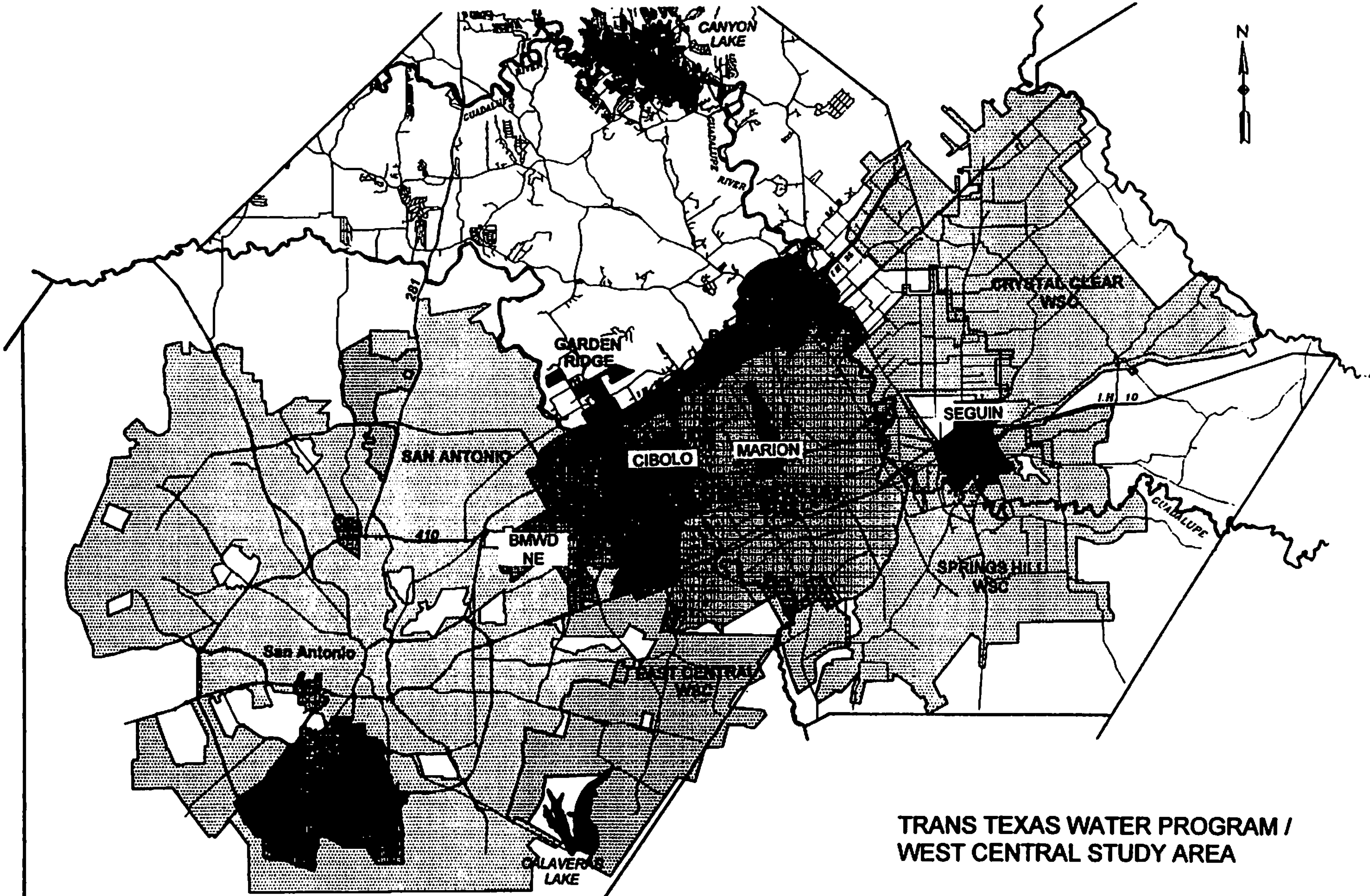
In 1992, under the leadership of the Texas Water Development Board, the Trans-Texas Water Program was organized in cooperation with local water agencies to address the water supply needs of the metropolitan areas of South East, South Central, and West Central Texas. The West Central Study area of the Trans-Texas Water Program includes all of the San Antonio and Guadalupe River Basins, parts of the Nueces, Colorado and Brazos River Basins, and parts of the San Antonio-Nueces, Lavaca-Navidad, and Brazos-Colorado Coastal Basins. The area has a total of 33 counties.

The Trans-Texas Water Program has multiple phases, beginning with Phase I planning studies to determine projected water demands and supplies for the period 1990 through 2050, and to identify potential water supply alternatives to meet future needs. Phase I planning studies for West Central Study Area were begun in September of 1993 and were completed in December of 1995.

Within the West Central study area, slightly more than one-half of the area's 2.7 million people depend upon the Edwards Aquifer for their municipal, industrial, irrigation, and other water supplies. The current dependence on this single water source, coupled with the projected growth of the area from 1.36 million people in 1990 to 3.7 million in 2050, necessitates the development of additional water supplies to meet growth demands and to maintain significant ecosystems at Comal and San Marcos Springs; i.e., present levels of pumpage are near to, or greater than, average annual recharge, and during droughts there is a threat that those springs would go dry.

1.2 Study Area

The area to which this study pertains is Bexar County and neighboring areas of Comal and Guadalupe Counties of the San Antonio River Basin and the Guadalupe River Basin (Figure 1).



TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

WATER SUPPLY AREAS

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FIGURE 1 -1

1.3 Letter of Intent to Bring Surface Water Supplies to the Study Area

In March of 1995, the Canyon Regional Water Authority, New Braunfels Utilities, Bexar Metropolitan Water District, San Antonio Water System, San Antonio River Authority, and Guadalupe-Blanco River Authority entered into a "Letter of Intent" which provides the framework by which Guadalupe-Blanco River Authority could provide temporary Guadalupe River treated water to the San Antonio River Authority who will, in turn, provide water to the San Antonio Water System and other Bexar County water purveyors on an equitable basis. This letter is an important first step for bringing a surface water source to the San Antonio metro area. The letter also includes provisions whereby Guadalupe-Blanco River Authority will provide treated water to entities of the Guadalupe Basin (Figure 1).[1] This is a Trans-Texas Phase II study to provide an analysis of the specific water supply options of the Letter of Intent. The Phase I study[2] of the Trans-Texas Water Program considered a broad array water supply alternatives for the West Central Study Area other than those considered in the Letter of Intent. Further work in Phase II may require more detailed study of alternatives identified in Phase I and the LOI study in order to develop an integrated water supply program to meet the needs of the region.

1.4 Study Objectives

The objectives of this Trans-Texas Phase II study are to:

1. Present water demand and water supply projections for entities of Bexar and neighboring Mid-Cities areas of Comal and Guadalupe Counties of the San Antonio River Basin;
2. Present water demand and water supply projections for entities of the Guadalupe Basin;
3. Present information about the water supplies of the Guadalupe Basin and the effect of providing water on temporary basis to the Bexar, Comal, and Guadalupe county areas of the San Antonio River Basin;
4. Estimate costs to divert, transfer, and treat various quantities of water from three locations in the Guadalupe Basin (Canyon Lake to Bulverde and North Bexar County, Lake Dunlap to the Mid-Cities and Bexar County areas, and Gonzales to the Mid-Cities and Bexar County areas; and
5. Present a schedule and engineering requirements for permitting, design, construction, and delivery of water.

---

[1] In Cause No. MO-91-CA-069 (Sierra Club vs. Babbitt) in the United States District Court for the Western District of Texas, 1993, 1994, and 1995, the court strongly urged the San Antonio Water System, the Guadalupe-Blanco River Authority, and the Lower Colorado River Authority to enter into appropriate written agreements to actually get at least 150,000 acft/yr of treated water from other sources flowing in Bexar County at the earliest practicable date.

[2] "Trans-Texas Water Program, West Central Study Area, Phase I Interim Report", Vols. 1 through 4, HDR Engineering, Inc., prepared for San Antonio River Authority, Texas Water Development Board, et al, 1994 and 1995.

2.0 POPULATION, WATER DEMAND, AND WATER SUPPLY PROJECTIONS

The Texas Water Development Board's (TWDB) Consensus Population and Water Demand Projections[1] have been tabulated for San Antonio and Guadalupe River Basin areas, as follows:

San Antonio River Basin

- Bexar County and each city and unincorporated areas of the county;
- Comal County and each city and unincorporated areas of the county;
- Guadalupe County and each city and unincorporated areas of the county;

Guadalupe River Basin

- Comal and Guadalupe Counties and each city and unincorporated areas of the county;
- All or parts of each of the 28 counties of the Guadalupe River Basin; and,
- Each of the 10 counties of the Guadalupe-Blanco River Authority's statutory district.

The population and water demand projections are shown for the years 2000, 2010, 2020, 2030, 2040, and 2050, with projections of water demand for each purpose of water use for the following TWDB projections cases:

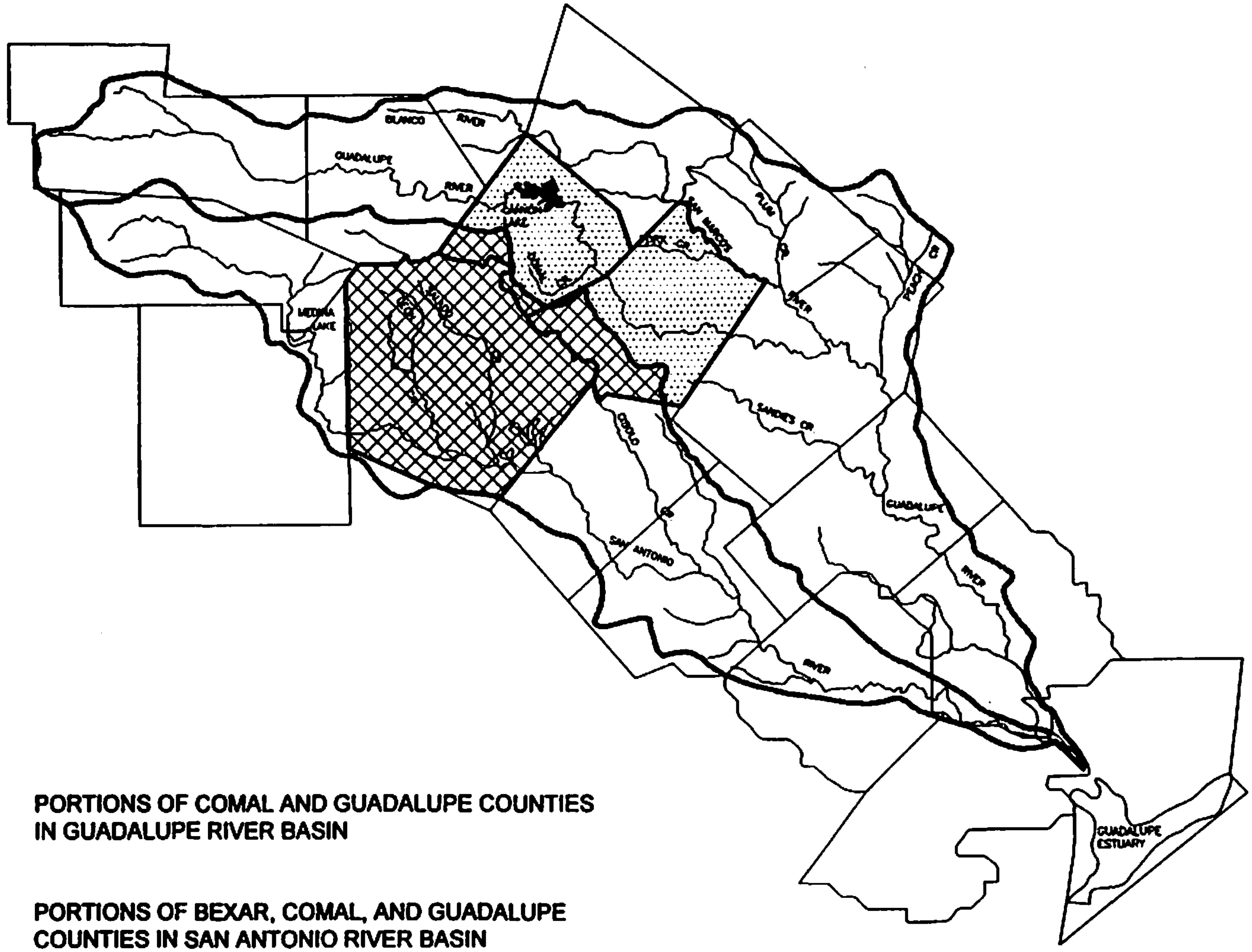
- Most likely population;
- Most likely municipal water demand for below normal precipitation and advanced conservation;
- Industrial water demand, with conservation and base oil prices ($17.00 to $23.00 per bbl for West Texas Crude Oil);
- Steam-electric power generation water demand -- high series;
- Irrigation water demand for aggressive adoption of irrigation technology and a reduction in Federal Farm Programs by one-half; and,
- Livestock water demand -- TWDB only series.

In addition to the population and water demand projections mentioned above, water supplies and water needs of each area are shown.

2.1 San Antonio River Basin Area

The area to which this analysis pertains is those parts of Bexar, Comal, and Guadalupe Counties that are located in the San Antonio River Basin (Figure 2.1-1).

[1] "Consensus Texas Water Plan Projections of Population and Water Use," Texas Water Development Board, Austin, Texas, February 1995 (see Appendix E for population and water demand projection methods).



PORTIONS OF COMAL AND GUADALUPE COUNTIES IN GUADALUPE RIVER BASIN

PORTIONS OF BEXAR, COMAL, AND GUADALUPE COUNTIES IN SAN ANTONIO RIVER BASIN

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

RIVER BASIN AREAS

HDR Engineering, Inc.

FIGURE 2.1-1

2.1.1 Population Projections

The population of the Bexar/Comal/Guadalupe Counties area of the San Antonio River Basin was 1,208,017 in 1990 and is projected to increase to 2,193,014 in 2020 and to 3,204,738 in 2050 (Table 2.1-1). Of these totals, in 1990 the Bexar County part was 1,182,643 (97.9%), the Comal County part was 6,314 (0.5%), and the Guadalupe County part was 19,060 (1.6%). The Bexar County population of the San Antonio Basin is projected to increase to 2,124,142 (96.9%) in 2020; the Comal County population of the San Antonio Basin is projected to increase to 20,529 (0.9%) in 2020; and the Guadalupe County population of the San Antonio Basin is projected to increase to 48,343 (2.2%) in 2020. For 2050, the population projections for Bexar, Comal, and Guadalupe Counties of the San Antonio River Basin area are 3,072,461 (95.9%), 40,844 (1.3%), and 91,433 (2.8%), respectively (Table 2.1-1 and Figure 2.1-2).

2.1.2 Water Demand Projections

In this section, the Texas Water Development Board's Consensus planning projections of municipal, industrial, steam-electric power, irrigation, mining, livestock, and total water demands are tabulated for those parts of Bexar, Comal, and Guadalupe Counties located in the San Antonio River Basin. Water use in 1990 is shown in the tabulations, along with projections for years 2000, 2010, 2020, 2030, 2040, and 2050.

<u>Municipal Water Demand</u>

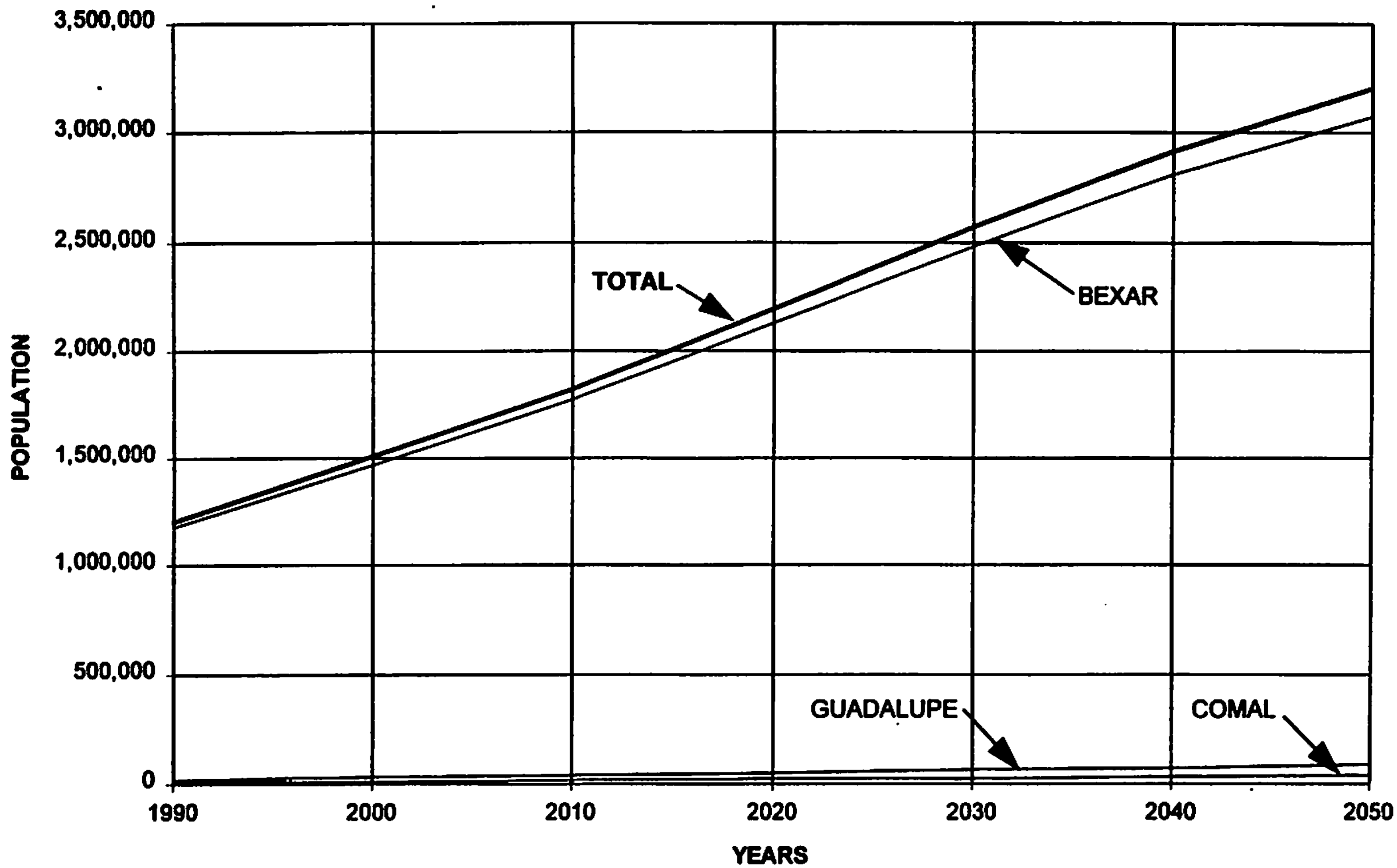
In 1990, municipal water use in the Bexar/Comal/Guadalupe Counties area of the San Antonio Basin was 229,707 acft, of which 225,295 acft (98.1%) was in Bexar County, 1,756 acft (0.7%) was in Comal County, and 2,656 acft (1.2%) was in Guadalupe County (Table 2.1-2). In 1990, there were more than 100 public water systems in Bexar County, more than 10 systems in Comal County, and more than 8 systems in Guadalupe County. The list of water supply utilities, together with the quantity of water used by each in 1990 is shown in Appendix A, Table 1.

Projected municipal water demands to year 2020 for those parts of Bexar, Comal, and Guadalupe Counties that are located in the San Antonio Basin is 389,800 acft of which 379,564 acft is in Bexar County, 3,409 acft is in Comal County, and 6,827 acft is in Guadalupe County (Table 2.1-2). Projected municipal water demands for these same counties in 2050 are 549,404

Table 2.1-1 Population Projections Bexar, Comal, and Guadalupe Counties San Antonio River Basin Trans-Texas Water Program							
County/Water Utility	Total in 1990	Projections					
		2000	2010	2020	2030	2040	2050
BEXAR COUNTY							
San Antonio*	935,933	1,137,369	1,360,669	1,621,857	1,886,190	2,125,314	2,394,753
Balcones Heights*	3,022	3,437	3,791	4,182	4,455	4,734	5,030
Terrell Hills*	4,592	5,120	5,417	5,810	5,970	5,969	5,968
Olmos Park*	2,161	2,438	2,669	2,920	3,086	3,253	3,429
Helotes*	1,535	2,045	2,600	3,251	3,937	4,295	4,686
Leon Valley*	9,581	12,455	12,704	12,577	12,748	12,919	13,694
Alamo Heights*	6,502	7,039	7,391	7,759	7,868	7,959	8,051
Converse*	8,887	13,658	20,424	27,634	35,537	42,763	51,458
FairOaks Ranch*	1,640	2,318	3,070	3,952	4,899	5,762	6,777
Kirby*	8,326	10,039	11,992	14,276	16,584	18,672	21,023
Live Oak Water Public Utility*	10,023	12,439	15,199	18,430	21,756	24,774	28,211
Schertz (Part) *	414	607	807	951	1,021	1,176	1,417
Schertz (Outside City) Estimated*	3,165	4,111	5,026	6,383	7,767	8,926	10,330
Shavano Park*	1,708	2,097	2,425	2,687	2,784	2,917	3,056
St. Hedwig*	1,443	1,843	2,425	3,107	3,837	4,503	5,285
Universal City*	13,057	15,992	19,452	23,502	27,658	31,426	35,707
Windcrest (WC&ID No. 10)*	5,331	5,818	6,160	6,520	6,665	6,796	6,930
Castle Hills(BMWD)*	4,198	4,967	5,328	5,667	5,778	5,742	5,706
Somerset(BMWD)*	1,144	1,251	1,314	1,361	1,321	1,280	1,240
Hill Country(BMWD)*	1,038	1,289	1,556	1,874	2,170	2,531	2,952
BMWD(Subdvisions) Estimated	108,988	125,751	167,041	207,920	245,492	284,585	307,993
Unincorporated	49,955	98,339	114,237	141,522	175,607	201,870	148,765
Total	1,182,643	1,470,422	1,771,697	2,124,142	2,483,130	2,808,166	3,072,461

Table 2.1-1 continued							
County/Water Utility	Total in 1990	Projections					
		2000	2010	2020	2030	2040	2050
COMAL COUNTY							
FairOaks Ranch*	51	88	127	180	241	294	359
Schertz * (Part)	129	210	325	484	627	891	1,187
Unincorporated	6,134	10,259	14,086	19,865	26,013	32,544	39,298
Total	6,314	10,557	14,538	20,529	26,881	33,729	40,844
GUADALUPE COUNTY							
Cibolo*	1,757	3,840	4,490	5,830	6,710	7,780	8,420
Schertz* (Part)	10,747	12,894	18,720	24,890	32,574	42,421	55,231
Unincorporated	6,556	11,659	14,562	17,623	22,270	24,744	27,782
Total	19,060	28,393	37,772	48,343	61,554	74,945	91,433
TOTAL	1,208,017	1,509,372	1,824,007	2,193,014	2,571,565	2,916,840	3,204,738

Source: Texas Water Development Board, 1996 Concensus Water Plan Projections, Most Likely Case.
* Cities for which TWDB has made projections.



TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

HDR Engineering, Inc.

POPULATION PROJECTIONS BEXAR, COMAL, AND GUADALUPE COUNTIES SAN ANTONIO RIVER BASIN

FIGURE 2.1-2

Table 2.1-2 Municipal Water Demand Projections Bexar, Comal, and Guadalupe Counties San Antonio River Basin Trans-Texas Water Program							
County/Water Utility	Total Use 1990 (acft)	Projections					
		2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
BEXAR COUNTY							
San Antonio*	166,616	220,405	242,339	272,507	312,695	349,957	391,640
Balcones Heights*	538	731	739	759	798	843	885
Terrell Hills*	817	1,090	1,056	1,054	1,070	1,063	1,050
Olmos Park*	385	519	520	530	553	579	603
Helotes*	310	360	387	415	494	534	577
Leon Valley*	1,715	2,288	2,135	1,958	1,956	1,954	2,040
Alamo Heights*	2,210	2,799	2,732	2,686	2,706	2,728	2,742
Converse*	1,213	2,127	2,837	3,529	4,498	5,365	6,456
FairOaks Ranch*	617	774	894	1,005	1,240	1,452	1,700
Kirby*	1,080	1,586	1,693	1,839	2,099	2,343	2,614
Live Oak Water Public Utility*	1,221	1,101	1,141	1,389	1,554	1,738	2,200
Schertz (Part) *	60	116	140	152	162	186	222
Schertz (Outside City) * (estimated)	607	819	1,031	1,243	1,455	1,667	1,880
Shavano Park*	840	1,088	1,163	1,192	1,232	1,284	1,342
City of St. Hedwig*	187	200	215	230	275	318	367
Universal City*	2,323	3,386	3,748	4,186	4,864	5,491	6,200
Windcrest (WC&ID No. 10)*	1,329	1,675	1,663	1,665	1,687	1,713	1,731
Castle Hills(BMWD)*	1,311	1,714	1,743	1,765	1,786	1,769	1,751
Somerset(BMWD)*	215	220	225	230	235	237	240
Hill Country(BMWD) *	460	510	542	575	661	768	893
BMWD (Subdivisions)	20,741	27,999	34,024	39,841	46,235	52,910	56,821
Unincorporated	20,500	33,526	36,432	40,814	49,734	56,749	45,887
Subtotal	225,295	305,033	337,399	379,564	437,989	491,648	529,841

Table 2.1-2 continued							
County/Water Utility	Total Use 1990 (acft)	Projections					
		2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
COMAL COUNTY							
FairOaks Ranch*	19	29	37	46	61	74	90
Schertz * (Part)	19	40	56	78	100	141	186
Unincorporated	1,718	2,036	2,520	3,285	4,226	5,235	6,310
Subtotal	1,756	2,105	2,613	3,409	4,387	5,450	6,586
GUADALUPE COUNTY							
Cibolo*	198	308	307	313	346	392	424
Schertz* (Part)	1,437	2,680	3,217	3,851	5,016	6,490	8,411
Unincorporated	1,021	1,807	2,268	2,663	3,308	3,675	4,140
Subtotal	2,656	4,795	5,792	6,827	8,670	10,557	12,975
TOTAL	229,707	311,933	345,804	389,800	451,046	507,655	549,402

Source: Texas Water Development Board , 1996 Concensus Water Plan Projections, Most Likely Demand/Below Normal Precipitation/Advanced Conservation.

* Cities for which TWDB has made projections.

acft, with 529,841 acft in Bexar County, 6,586 acft in Comal County, and 12,975 acft in Guadalupe County (Table 2.1-2 and Figure 2.1-3).

Industrial Water Demand

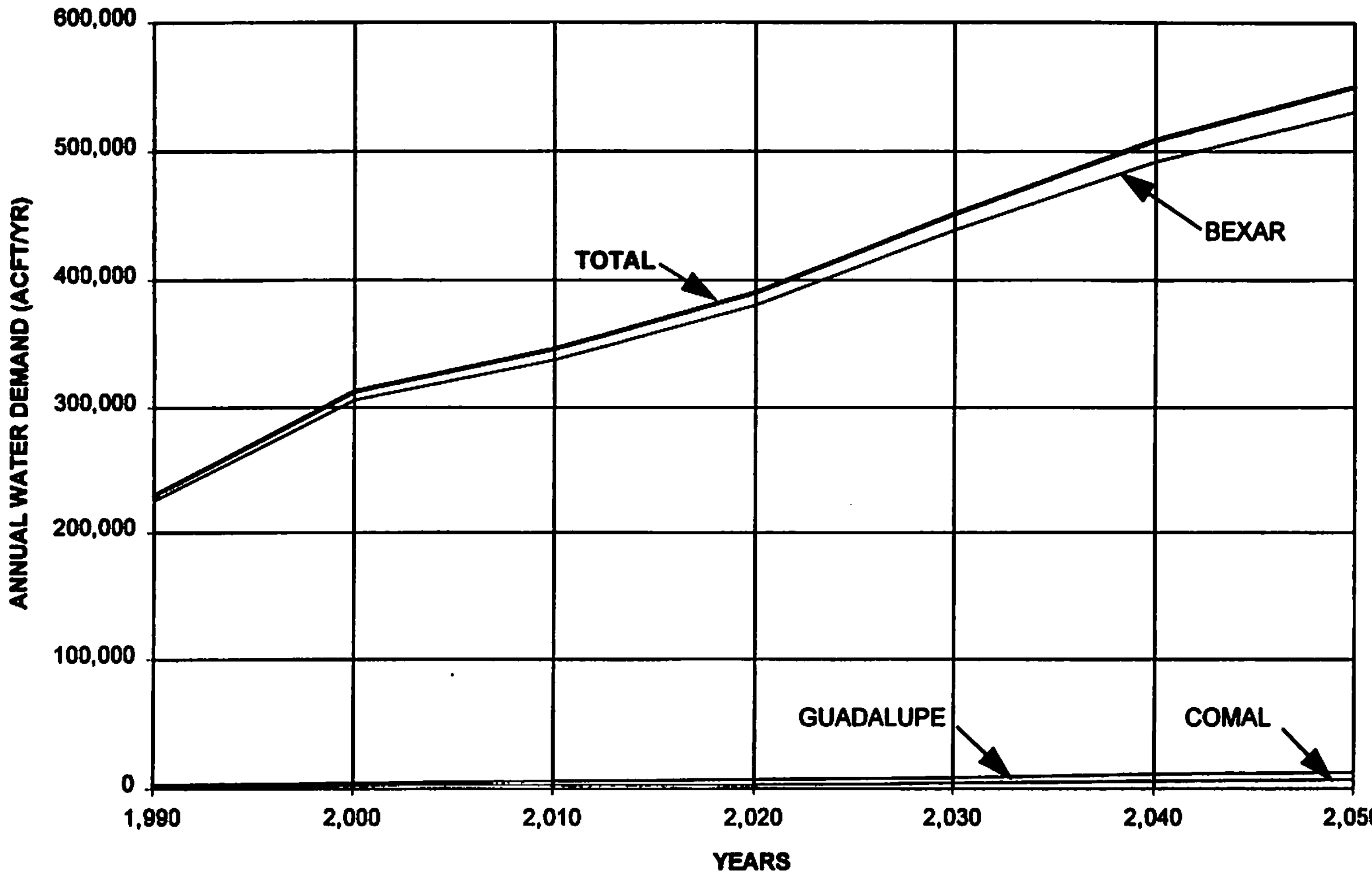
In 1990, ninety-two major industrial water users in Bexar County reported 14,049 acft of industrial water use, however, there were no reports of industrial water use in those parts of Comal and Guadalupe Counties that are located in the San Antonio Basin (Appendix A, Table 2). Of the total industrial water use in Bexar County, 6,066 acft was reported to have been obtained from the San Antonio Water System (SAWS), 6,447 acft was obtained from industries' own wells, 1,132 acft was obtained from SAWS and own wells combined, and 404 acft was obtained from other suppliers (Bexar Metropolitan Water District, Converse, and East Central Water Supply Corporation). Projected industrial water demand for the Bexar County area of the San Antonio River Basin is 16,805 acft in year 2000, 22,359 acft in year 2020, and 31,697 acft in 2050 (Table 2.1-3).

Steam-Electric Power Water Demand

In 1990, steam-electric power water use in Bexar County was reported at 31,089 acft, with no use in Comal and Guadalupe County areas of the San Antonio River Basin (Appendix A, Table 3). Projected steam-electric power water demands are 36,000 acft in year 2000, 40,000 acft per year in 2020, and 56,000 acft per year in 2050 (Appendix A, Table 3). However, since steam-electric power generation is done with reclaimed wastewater, of which adequate quantities are anticipated to be available, these projections are not included in the total water demands for Bexar County.

Irrigation Water Demand

In 1990, irrigation water use in the parts of Bexar, Comal, and Guadalupe Counties located in the San Antonio River Basin was estimated at 34,051 acft, with 33,638 acft in Bexar County (Table 2.1-2). Projected irrigation water demands decline to 31,296 acft/yr in 2020 and to 27,481 acft/yr in 2050 (Table 2.1-3). These projections are based upon the assumption there will be an aggressive rate of adoption of irrigation technology, and that Federal Farm Programs will be reduced to one-half of their 1990 levels.



TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

HDR Engineering, Inc.

MUNICIPAL WATER DEMAND PROJECTIONS - BEXAR, COMAL, AND GUADALUPE COUNTIES SAN ANTONIO RIVER BASIN

FIGURE 2.1-3

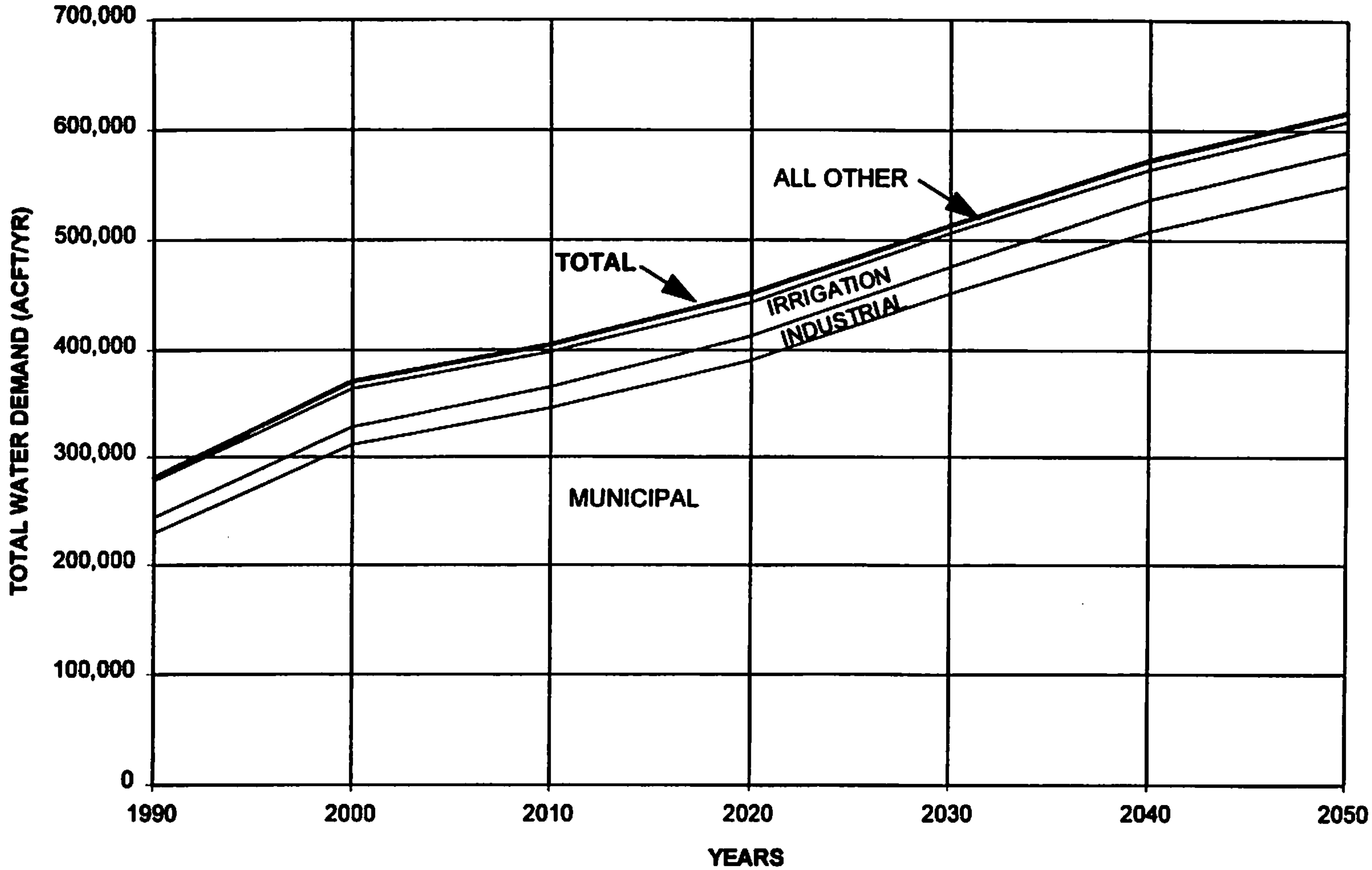
Table 2.1-3 Total Water Demand Projections Bexar, Comal, and Guadalupe Counties San Antonio River Basin Trans-Texas Water Program							
County	Use in 1990 (acft)	Projections					
		2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
Bexar*							
Municipal	225,295	305,033	337,399	379,564	437,989	491,648	529,841
Industrial	14,049	16,805	19,682	22,359	24,935	28,264	31,697
Irrigation	33,638	35,080	32,313	30,946	29,638	28,385	27,184
Mining	1,715	4,781	4,758	5,018	5,217	5,451	5,763
Livestock	1,353	1,461	1,461	1,461	1,461	1,461	1,461
Total	276,050	363,160	395,613	439,348	499,240	555,209	595,946
Comal							
Municipal	1,756	2,105	2,613	3,409	4,387	5,450	6,586
Irrigation	70	66	63	61	58	56	53
Livestock	45	50	50	50	50	50	50
Total	1,871	2,221	2,726	3,520	4,495	5,556	6,689
Guadalupe							
Municipal	2,656	4,795	5,792	6,827	8,670	10,557	12,975
Irrigation	343	324	306	289	273	258	244
Mining	8	8	10	10	10	10	10
Livestock	258	284	284	284	284	284	284
Total	3,265	5,411	6,392	7,410	9,237	11,109	13,513
Total Area							
Municipal	229,707	311,933	345,804	389,800	451,046	507,655	549,402
Industrial	14,049	16,805	19,682	22,359	24,935	28,264	31,697
Irrigation	34,051	35,470	32,682	31,296	29,969	28,699	27,481
Mining	1,723	4,789	4,768	5,028	5,227	5,461	5,773
Livestock	1,656	1,795	1,795	1,795	1,795	1,795	1,795
Total	281,186	370,792	404,731	450,278	512,972	571,874	616,148

Source: Texas Water Development Board 1996 Consensus Water Plan Projections.

* Steam-Electric Power generation water demands of Appendix A:Table 3 are not included, since most of these demands are met with reclaimed wastewater.

Mining Water Demands

In 1990, mining water use by 5 establishments in the Bexar and Guadalupe County areas located in the San Antonio River Basin was 1,723 acft, with no mining water use in that part of Comal County located in the San Antonio Basin (Appendix A, Table 5). Projected mining water demands are 4,789 acft/yr in 2000, 5,028 acft/yr in 2020, and 5,773 acft/yr in 2050 (Table 2.1-3).



TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

HDR Engineering, Inc.

PROJECTED TOTAL WATER DEMANDS - BEXAR, COMAL, AND GUADALUPE COUNTIES SAN ANTONIO RIVER BASIN

FIGURE 2.1-4

Livestock Water Demand

In 1990, livestock water use in Bexar, Comal, and Guadalupe County areas of the San Antonio River Basin was estimated at 1,656 acft per year, with projected demands for the year 2000 through 2050 at 1,795 acft/yr (Table 2.1-3). These projections are based upon the estimated maximum numbers of livestock that can be grazed in each area, with 81 percent of the use and demands located in Bexar County.

Total Water Demand

In 1990, total water use in the Bexar, Comal, and Guadalupe County areas of the San Antonio River Basin was 281,186 acft/yr. Projected total water demands in 2000 are 370,792 acft/yr, in 2020 are 450,278 acft/yr, and in 2050 are 616,148 acft/yr (Table 2.1-3 and Figure 2.1-4). Of these totals, approximately 97 percent are for Bexar County, with 2 percent for Guadalupe County, and 1 percent for Comal County (Table 2.1-3).

2.1.3 Water Demand and Supply Comparisons

Water demand projections of Section 2.1.2 are summarized for each of Bexar, Comal, and Guadalupe County areas of the San Antonio River Basin, for purposes of comparing projected water demands with projected water supplies and calculating projected shortages at each decadal projection point. In the following discussion, attention is focused upon the municipal and industrial demands, however, in Appendix A, Table 7, total demands for all purposes (municipal, industrial, steam-electric power generation, irrigation, mining, and livestock) are tabulated and compared with projected supplies.

Water supply information for each county is as follows. For the Edwards Aquifer, it is assumed that pumping limits as set forth in Senate Bill 1477 would apply.[2] Senate Bill 1477 provides that through year 2007, pumpage from the Edwards Aquifer can be no more than 450,000 acft/yr, and 400,000 acft/yr thereafter, with further provision that plans be developed to insure that Comal and San Marcos Springs will not go dry during a repeat of the drought of record. SB 1477 generally provides that pumping permits are to be issued to entities and individuals who have a history of use of water from the Edwards Aquifer, and that the basis for establishing the individual permit quantities is a 1990 prorata share of maximum pumpage

[2] Senate Bill 1477, 1993 Texas Legislature, as amended.

allowed. Thus, for year 2000, the quantity of Edwards Aquifer water available to cities and industries of the study area would be approximately 86 percent of the quantity obtained from the Edwards Aquifer in 1990 (450,000 divided by 519,796) and for year 2010 would be approximately 75 percent of the quantity obtained in 1990 (400,000 divided by 519,796).[3]

The quantity of Edwards Aquifer water used for municipal and industrial purposes in Bexar County in the San Antonio River Basin in 1990 was reported at 236,882 acft.[4] For the purposes of this study, based on the provisions of SB 1477, the supply of Edwards Aquifer water available for municipal and industrial purposes in Bexar County in the San Antonio River Basin is estimated to be 203,719 acft/yr in the year 2000, and 177,662 acft/yr beginning in year 2008 (Table 2.1-4). The Edwards Aquifer supply for municipal purposes in Comal County in the San Antonio River Basin in 2000 would be 290 acft/yr and 253 acft/yr beginning in year 2008 (Table 2.1-4). For Guadalupe County in the San Antonio River Basin, the Edwards Aquifer supply for municipal purposes would be 2,098 acft/yr in 2000 and 1,829 acft/yr in 2008 and later (Table 2.1-4). The total Edwards Aquifer supply for the three county area is computed at 206,106 acft/yr in 2000, and 179,744 acft/yr beginning in 2008 (Table 2.1-4).

The projected water supply for Bexar, Comal, and Guadalupe Counties from other aquifers (Trinity and Carrizo) is the quantity of groundwater that is estimated to be available on a continuous, annual basis without mining these aquifers.[5] For Bexar County, this quantity is 19,125 acft/yr; for Comal County, the quantity is 270 acft/yr; and for Guadalupe County is 2,516 acft/yr (Table 2.1-4). Note: In Comal County, the quantity of water withdrawn from the Trinity Aquifer (other Aquifer) for municipal type users in 1990 was reported at 1,419 acft/yr, which is much greater than the estimated long term available supply. For example, the Trinity Aquifer in Comal County is being mined and water suppliers are shifting to surface water in some parts of the county, i.e., around Canyon Lake. In other parts of the county, well yields are declining and local users are experiencing water shortages. Use from the Carrizo Aquifer in both Bexar and Guadalupe Counties is much less than the estimated available supply (Table 2.1-4). In Guadalupe County, the Carrizo Aquifer is being used for local area water supplies as demands

[3] Estimated total quantity pumped from the Edwards Aquifer in 1990 was approximately 519,796 acft, according to water use reports and estimates by the Texas Water Development Board.
[4] Water use reports by public water suppliers and industries to the TWDB.
[5] Unpublished planning data, Texas Water Development Board, 1992.

are increasing, however, in southern Bexar County, Carrizo Aquifer water quality is poor and may not be usable for municipal supply without expensive treatment.

The presently available quantity of surface water for municipal and industrial purposes in the study area is relatively low (424 acft/yr in Bexar County; and 1,176 acft/yr in Guadalupe County (Table 2.1-4). Practically all of this surface water supply is obtained from the Guadalupe River through contracts between the Guadalupe-Blanco River Authority and the water supply corporations that serve the areas, and can be increased to the extent that such water is available from the Guadalupe River.

A comparison between water supplies available for municipal and industrial purposes with projected municipal and industrial water demands shows shortages of 98,570 acft/yr in Bexar County in year 2000, 204,713 acft/yr in 2020, and 364,327 acft/yr in 2050 (Table 2.1-4). The projected shortage in that part of Comal County located in the San Antonio River Basin is 1,527 acft/yr in 2000, grows to 2,979 acft/yr in 2020, and is 6,148 acft/yr in 2050 (Table 2.1-4). For Guadalupe County areas of the San Antonio River Basin there is a surplus of municipal and industrial water of 995 acft/yr in 2000, but shortages are projected to occur shortly thereafter. The projected shortages in Guadalupe County in 2020 are 1,307 acft/yr and in 2050 are 7,454 acft/yr (Table 2.1-4).

The projected total municipal and industrial water shortages for the three counties (Bexar, Comal, and Guadalupe) are 99,103 acft/yr in 2000, 208,999 acft/yr in 2020, and 377,929 acft/yr in 2050 (Table 2.1-4). It should be recognized, however, that these comparisons and projected shortages are based upon the provisions of SB 1477 that would limit pumping of the Edwards Aquifer in order to protect flows at Comal and San Marcos Springs. The quantities of Edwards Aquifer supplies calculated for these analyses are greater during wet periods. Likewise, during severe droughts, with SB 1477 in effect, the shortages could be significantly greater than shown here.[6]

2.2 Mid-Cities Area

In this section, the population and municipal water demand projections and water supplies for five major water supply corporations, eight cities, and one military installation of

[6] See Appendix A, Table 7, for a comparison of total water demand to available supplies. The main difference between the analysis here for municipal and industrial demands is that irrigation agriculture demands and prorata share of Edwards Aquifer supply is included in Appendix A, Table 7.

Table 2.1-4
Municipal and Industrial Water Demand and Supply Projections
Bexar, Comal, and Guadalupe Counties, San Antonio River Basin
Trans-Texas Water Program

County	Use in 1990 (acft)	Projections 2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
Bexar*							
Demand	239,344	321,838	357,081	401,923	462,924	519,912	561,538
Supply							
Edwards Aquifer**	236,882	203,719	177,662	177,662	177,662	177,662	177,662
Other Aquifers	2,338	19,125	19,125	19,125	19,125	19,125	19,125
Surface Sources[1]	124	424	424	424	424	424	424
Total Supply	239,344	223,268	197,211	197,211	197,211	197,211	197,211
Shortage	0	98,570	159,871	204,713	265,713	322,701	364,327
Comal							
Demand	1,756	2,105	2,726	3,520	4,495	5,556	6,689
Supply							
Edwards Aquifer**	337	290	253	253	253	253	253
Other Aquifers[2]	1,419	270	270	270	270	270	270
Surface Sources[3]	0	18	18	18	18	18	18
Total Supply	1,756	578	541	541	541	541	541
Shortage	0	1,527	2,185	2,979	3,954	5,015	6,148
Guadalupe							
Demand	2,656	4,795	5,792	6,828	8,670	10,557	12,975
Supply							
Edwards Aquifer**	2,439	2,098	1,829	1,829	1,829	1,829	1,829
Other Aquifers[4]	46	2,516	2,516	2,516	2,516	2,516	2,516
Surface Sources[5]	171	1,176	1,176	1,176	1,176	1,176	1,176
Total Supply	2,656	5,790	5,521	5,521	5,521	5,521	5,521
Shortage	0	-995	271	1,307	3,149	5,036	7,454
TOTAL							
Demand	243,756	328,738	365,599	412,271	476,089	536,025	581,202
Supply							
Edwards Aquifer**	239,658	206,106	179,744	179,744	179,744	179,744	179,744
Other Aquifers	3,803	21,911	21,911	21,911	21,911	21,911	21,911
Surface Sources	295	1,618	1,618	1,618	1,618	1,618	1,618
Total Supply	243,756	229,635	203,273	203,273	203,273	203,273	203,273
Shortage	0	99,103	162,326	208,999	272,816	332,752	377,929

Source: Texas Water Development Board 1996 Concensus Water Plan Projections.

* Steam-Electric Power generation water demands of Appendix A:Table 3 are not included, since most of this demand is met with reclaimed wastewater.

** Projections are estimated based upon provisions of SB 1477, 1993 Texas Legislature, as amended.

[1] Includes 124 acft of local surface water and 300 acft of Guadalupe River Water (East Central WSC).

[2] Projected supplies include 15% of county's annually available groundwater, as reported by TWDB (percent of county located within San Antonio River Basin) (see text for further explanation).

[3] Includes 18 acft of Guadalupe River Water (Green Valley WSC).

[4] Includes 46 acft of local groundwater and 210 acft of Carrizo Aquifer Water (Springs Hill WSC @ 30% of present Carrizo Aquifer Supply for 1990. Projected @ 20% of County's annually available Groundwater, as reported by TWDB (percent of Carrizo Aquifer of county located within San Antonio River Basin).

[5] Includes Guadalupe River Water through Green Valley and Springs Hill WSCs @ 40% of 2,940 acft of present supply available.

eastern Bexar County, southwestern Comal County, and most of Guadalupe County, who are participants in the Letter of Intent water supply project are tabulated in order to provide information needed for the location and costing of water supply facilities to serve these entities.[7] The locations of the Mid-Cities entities are shown on Figure 1.1-1. The projections are presented below.

2.2.1 Population Projections

For the cities of the group of Mid-Cities entities, the TWDB consensus water plan population projections are used. For the water supply corporations, the number of connections, the trend in connections for each corporation during the last five years, and an average number of people per connection were used to make population projections. The rate of growth in number of connections ranged from average annual growth rates of 2.3 percent for Crystal Clear to 3.5 percent for Springs Hill, Green Valley, and East Central Water Supply Corporations. The number of persons per connections ranged from 2.5 to 3.0.

In 1990, the total population of the 14 Mid-Cities entities was 106,099 (Table 2.2-1), with 27,610 in the three water supply corporation service areas located mostly in Guadalupe County, 64,286 in the seven service areas located in eastern Bexar County, and 14,203 in the 4 cities (Marion, Cibolo, Schertz, and Garden Ridge) located in the Comal, Guadalupe, Bexar County bordering areas (Table 2.2-1). The population of the service areas of the 14 Mid-Cities entities is projected to increase to 224,427 in 2020 and to 364,358 in 2050 (Table 2.2-1). About 58 percent of the population is projected to be in the eastern Bexar County area, about 18 percent in the areas where Bexar, Comal and Guadalupe Counties join, and about 24 percent is projected to be in the Guadalupe County area. Water demand and supply projections for each entity are presented below in Section 2.2.2.

2.2.2 Water Demand and Supply Comparisons

For the cities of the Mid-Cities group, the TWDB most likely municipal water demand projections (dry weather with advanced water conservation case) were used. For the water

[7] These Mid-Cities entities are also included in the San Antonio and Guadalupe River Basin Counties where they are located, respectively, and their data are tabulated in Sections 2.1, 2.3, and 2.4, as appropriate.

Table 2.2-1 Population Projections Mid-Cities Area Trans-Texas Water Program							
		Projections					
Entity	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
GUADALUPE							
Crystal Clear WSC[1]	6,639	8,165	9,691	11,217	12,743	14,269	15,795
Springs Hill WSC[1]	9,466	12,779	16,092	19,405	22,718	26,031	29,344
Green Valley WSC[2]	11,505	15,531	19,557	23,583	27,609	31,635	35,661
Subtotal	27,610	36,475	45,340	54,205	63,070	71,935	80,800
COMAL/ GUADALUPE/BEXAR							
Marion[3]	984	1,082	1,180	1,278	1,376	1,474	1,572
Cibolo[3]	1,757	3,940	4,640	5,830	6,710	7,780	8,420
Schertz[4]	10,012	14,183	19,118	24,890	32,574	42,421	55,231
Garden Ridge[5]	1,450	2,503	3,619	4,732	5,686	6,903	8,380
Subtotal	14,203	21,708	28,557	36,730	46,346	58,578	73,603
EAST BEXAR							
BMWD Northeast[6]	20,593	29,024	36,543	44,043	51,581	59,100	66,620
East Central WSC[6]	7,206	9,728	12,250	14,772	17,294	19,816	22,338
Selma[6]	520	712	912	1,111	1,303	1,468	1,621
Universal City[6]	13,057	15,992	19,452	23,502	27,658	31,426	35,707
Live Oak PUD[6]	10,023	12,439	15,199	18,430	21,756	24,774	28,211
Converse[6]	8,887	13,658	20,424	27,634	35,537	42,763	51,458
Randolph AFB[6]	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Subtotal	64,286	85,553	108,780	133,492	159,129	183,347	209,955
TOTAL	106,099	143,736	182,677	224,427	268,545	313,860	364,358

(1) Located primarily in Guadalupe County in the Guadalupe River Basin.
(2) Located primarily in Guadalupe County, but serves areas in Comal and Bexar Counties and is in both the San Antonio and Guadalupe River Basins.
(3) Located in Guadalupe County in the San Antonio River Basin.
(4) Located in Bexar County in the San Antonio River Basin.
(5) Located in Comal County in the Guadalupe River Basin.
(6) Located in Bexar County in the San Antonio River Basin with a small area as East Central WSC service area in Guadalupe County (San Antonio Basin).

supply corporations, water demand projections were computed at a water use rate of 140 gallons per person per day for the population projections shown in Table 2.2-1. Reported 1990 water use and projected demands for each entity are shown in Table 2.2-2.

In 1990, total water use by the Mid-Cities entities was reported at 17,958 acft/yr, of which 17,074 acft was obtained from the Edwards Aquifer (Table 2.2-2). Projected water demands in 2020 are 34,434 acft/yr, with projections in 2050 of 54,639 acft/yr (Table 2.2-2)

Table 2.2-2
Municipal Water Demand and Supply Projections
Mid-Cities Area
Trans-Texas Water Program

Entity	Use in 1990 (acft)	Projections 2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
GUADALUPE							
Crystal Clear WSC	1,042	1,280	1,519	1,758	1,998	2,237	2,476
Springs Hill WSC*	1,486	2,003	2,523	3,043	3,562	4,082	4,601
Green Valley WSC	1,804	2,435	3,066	3,697	4,329	4,960	5,592
Total Demand	4,332	5,718	7,108	8,498	9,889	11,279	12,669
Edwards Supply*	3,448	2,447	2,134	2,134	2,134	2,134	2,134
Other Supply**	884*	4,140	4,140	4,140	4,140	4,140	4,140
Shortage		-869	834	2,224	3,615	5,005	6,395
COMAL/ GUADALUPE/BEXAR							
Marion	150	169	185	200	216	231	246
Cibolo	204	481	520	594	669	758	811
Schertz	2,140	2,873	3,515	4,217	5,443	7,027	9,069
Garden Ridge	397	613	770	868	1,038	1,253	1,511
Total Demand	2,891	4,136	4,990	5,879	7,366	9,269	11,637
	2,891	2,486	2,168	2,168	2,168	2,168	2,168
Shortage		1,650	2,822	3,711	5,198	7,101	9,469
EAST BEXAR							
BMWD Northeast	3,229	4,551	5,730	6,906	8,088	9,267	10,446
East Central WSC	1,130	1,528	1,920	2,316	2,712	3,107	3,502
Selma	125	156	182	244	286	322	356
Universal City	2,323	3,386	3,748	4,186	4,864	5,491	6,200
Live Oak PUD	1,221	1,101	1,141	1,218	1,389	1,554	1,738
Converse	1,213	2,127	2,837	3,529	4,498	5,365	6,456
Randolph AFB	1,494	1,877	1,761	1,658	1,649	1,644	1,635
Total Demand	10,735	14,726	17,319	20,057	23,486	26,750	30,333
Edwards Supply	10,735	9,232	8,051	8,051	8,051	8,051	8,051
Other Supply***		300	300	300	300	300	300
Shortage		5,194	8,968	11,706	15,135	18,399	21,982
Total Demand	17,958	24,580	29,417	34,434	40,741	47,298	54,639
Edwards Supply*	17,074	14,165	12,353	12,353	12,353	12,353	12,353
Other Supply/*****	884*	4,440	4,440	4,440	4,440	4,440	4,440
Shortage		5,975	12,624	17,641	23,948	30,505	37,846

* In 1990, Springs Hill WSC obtained 602 acft from Edwards Aquifer(New Braunfels Utilities), and 884 acft from Guadalupe River sources; however Springs Hill WSC has no Edwards Aquifer supply after August, 1994. Future supply computed without the 602 acft of 1990 Edwards use by Springs Hill WSC.

** Projections include 700 acft of Carrizo Aquifer water and 3,440 acft of Guadalupe River water.

*** Includes 300 acft of Guadalupe River Water.

approximately 24 percent of projected demands are in the Guadalupe County area, 16 percent are in the areas near the points where Bexar, Comal, and Guadalupe Counties join, and the remaining 60 percent is in eastern Bexar County (Table 2.2-2).

The principal source of water supply for the Mid-Cities entities in 1990 was the Edwards Aquifer, with only 4.9 percent obtained from the Guadalupe River. Projected supplies from the Edwards Aquifer for year 2000 through 2050 are based upon provisions of SB 1477 (see Section 2.1.3 for explanation of concept and assumptions), and for the area are 14,165 acft/yr in 2000 and 12,353 acft/yr beginning in year 2008 (Table 2.2-2). At the present time, other water supplies (Carrizo Aquifer and Guadalupe River sources through contracts with the Guadalupe-Blanco River Authority) for the Mid-Cities area are 4,440 acft/yr (Table 2.2-2).

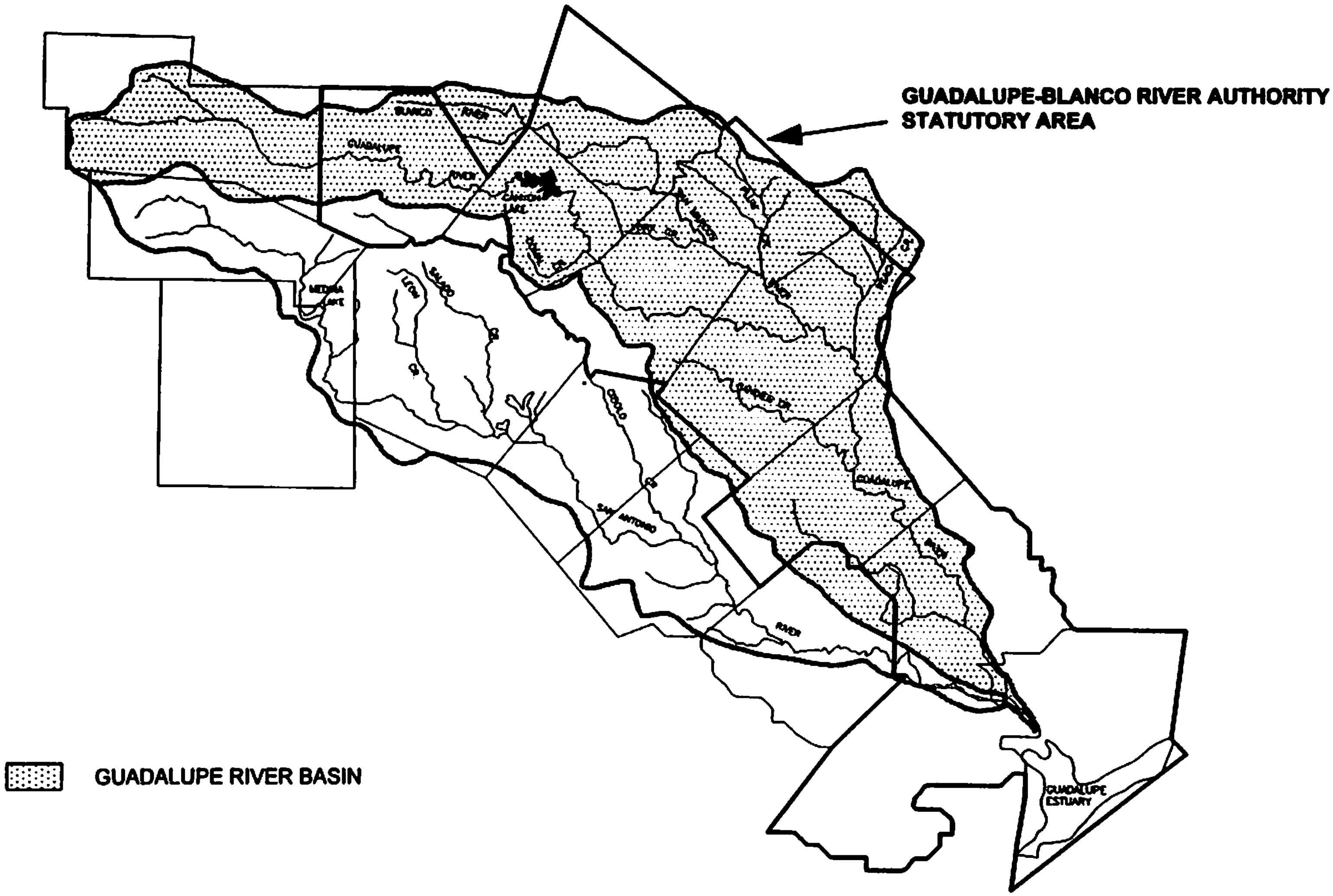
A comparison of supplies and demands shows shortages for the entities located in eastern Bexar, southwestern Comal, and northwestern Guadalupe Counties areas in year 2000, with shortages in all parts of the Mid-Cities areas in 2010 and later (Table 2.2-2). In 2020, the shortages are 17,641 acft/yr and in 2050 are 37,846 acft/yr (Table 2.2-2). In 2020, the projected shortages for Mid-Cities entities of Guadalupe County are 2,224 acft/yr, and in 2050 are 6,395 acft/yr (Table 2.2-2). For the northwestern Bexar County/southwestern Comal County/ northwestern Guadalupe County area entities, the shortages in 2020 are 3,711 acft/yr with shortages of 9,469 acft/yr in 2050 (Table 2.2-2). For the eastern Bexar County entities, the shortages in 2020 are 11,706 acft/yr and in 2050 are 21,982 acft/yr (Table 2.2-2).

2.3 Guadalupe River Basin Areas

The Guadalupe River Basin includes parts of the following 20 counties, as listed in upstream to downstream order of location:

Kerr	Comal	Travis	Fayette
Gillespie	Hays	Gonzales	Lavaca
Bandera	Guadalupe	DeWitt	Goliad
Blanco	Caldwell	Wilson	Victoria
Kendall	Bastrop	Karnes	Calhoun

with no individual county lying wholly within the Basin (Figure 2.3-1). However, the Guadalupe-Blanco River Authority's statutory district includes the entire areas of nine counties through which the Guadalupe and Blanco Rivers flow, plus neighboring Refugio County (Figure



NOTE:

THE GBRA STATUTORY AREA INCLUDES THESE 10 COUNTIES:

CALDWELL	GUADALUPE
CALHOUN	HAYS
COMAL	KENDALL
DeWITT	REFUGIO
GONZALES	VICTORIA

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GUADALUPE RIVER BASIN AND GBRA STATUTORY AREA

FIGURE 2.3-1

2.3-1). The 10 counties of the Guadalupe-Blanco River Authority statutory district, listed in alphabetical order are as follows:

Caldwell	Guadalupe
Calhoun	Hays
Comal	Kendall
DeWitt	Refugio
Gonzales	Victoria

For purposes of this study, information is needed about projected water demands and supplies of the following areas of the Guadalupe Basin: 1.) Comal and Guadalupe Counties; 2.) The Guadalupe-Blanco River Authority's 10-county statutory district; and, 3.) The entire Guadalupe Basin. In order to supply this information, tabulations of population and water demands are presented for the following areas: 1.) Comal and Guadalupe Counties areas located within the Guadalupe River Basin; 2.) The Guadalupe-Blanco River Authority 10-county area; and 3.) The Guadalupe-Blanco River Basin area, which includes parts of 20 counties.[8] A water demand and water supply comparison which applies to all three sub-areas is presented in Section 2.3.4 below.

2.3.1 Comal and Guadalupe Counties

2.3.1.1 Population Projections

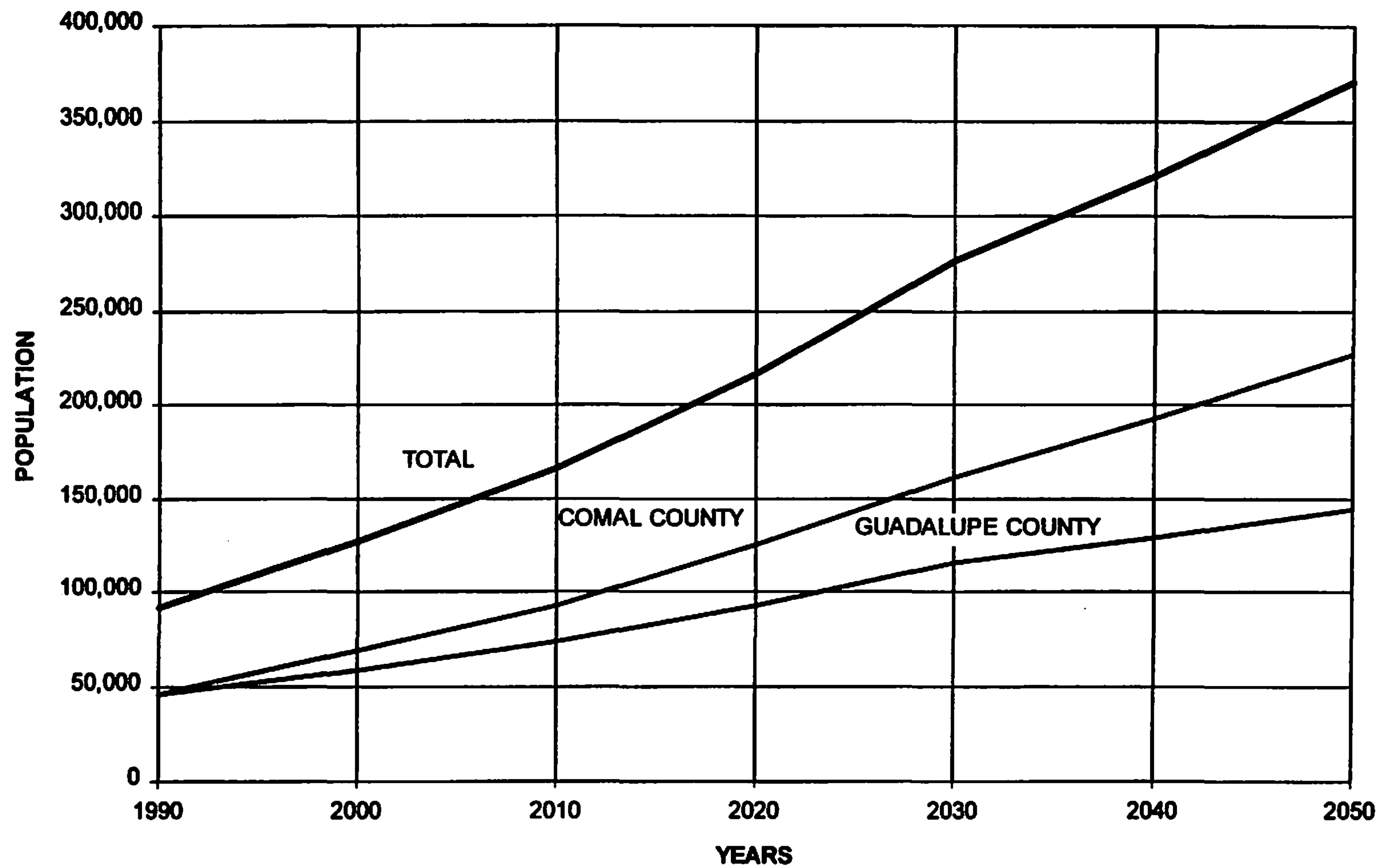
In 1990, the population of those parts of Comal and Guadalupe Counties that are located in the Guadalupe Basin was reported at 91,331, with 45,518 in Comal County and 45,813 in Guadalupe County (Table 2.3-1 and Figure 2.3-2). New Braunfels, the largest city in Comal County is projected to grow from 27,091 in 1990 to 65,003 in 2020, and 109,848 in 2050 (Table 2.3-1). Garden Ridge is projected to increase from 1,450 in 1990 to 4,732 in 2020 and 8,380 in 2050. The unincorporated areas of Comal County located in the Guadalupe Basin had a population of 16,977 in 1990, and are projected to increase to 54,605 in 2020 and 108,771 in 2050 (Table 2.3-1). There are more than 75 public water systems in Comal County in the Guadalupe Basin (Appendix A, Table 8).

[8] Tabulations for those parts of Comal and Guadalupe Counties that are located in the San Antonio Basin are shown in Section 2.1.

Table 2.3-1 Population Projections Comal and Guadalupe Counties Guadalupe River Basin Trans-Texas Water Program							
			Projections				
Water Supply Entity	1990 (acft)	2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
COMAL COUNTY							
Garden Ridge	1,450	2,503	3,619	4,732	5,686	6,903	8,380
New Braunfels	27,091	38,126	49,873	65,003	82,894	95,424	109,848
Unincorporated*	16,977	28,192	38,528	54,605	72,003	90,077	108,771
Total	45,518	68,821	92,020	124,340	160,583	192,404	226,999
GUADALUPE COUNTY							
New Braunfels	243	278	334	414	592	657	729
Seguin	18,853	20,364	21,983	27,040	33,125	36,934	41,181
Unincorporated	26,717	37,633	51,348	64,573	81,602	90,665	101,796
Total	45,813	58,275	73,665	92,027	115,319	128,256	143,706
TOTAL	91,331	127,096	165,685	216,367	275,902	320,660	370,705
Texas Water Development Board 1996 Consensus Water Plan Projections.							
* Unincorporated							
Canyon Lake (CLWSC)	9,161	14,935	19,551	22,982	25,324	27,629	29,940
Canyon Lake (Others)	4,974	8,107	12,241	16,036	19,404	21,344	23,479
Western Comal Co. **	685	1,370	2,397	3,596	5,393	6,742	8,427
Remainder of Comal Co.	2,157	3,780	4,339	11,991	21,882	34,362	46,925
Total	16,977	28,192	38,528	54,605	72,003	90,077	108,771
** Non-lake.							

Water use reports to the Texas Water Development Board, which include quantity of water and number of connections were used to make projections of population and water use for subdivisions located around Canyon Lake and in the remainder of Comal County.[9] The assumption underlying the projections for subdivisions located around Canyon Lake and in Western Comal County are as follows: 1.) The number of persons per connection is 2.6; 2.) The rate of development of undeveloped lots is 12.5% by 2,000, 33.75% by 2010, 60% by 2020, 70% by 2030, 80% by 2040, and 90% by 2050; and 3.) Per Capita water demand is 140 gallons per person per day. Based on these assumptions, the TWDB projections for unincorporated parts of Comal County of the Guadalupe Basin were divided among the Canyon Lake WSC (CLWSC) members, other subdivisions around and near Canyon Lake, and the remainder of the county.

[9] For members of the Canyon Lake Water Supply Corporation, the maximum number of building lots per subdivision was also used in making projections of growth.



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POPULATION PROJECTIONS COMAL AND GUADALUPE COUNTIES IN GUADALUPE RIVER BASIN

FIGURE 2.3-2

For example, the CLWSC members were estimated to have a population of 9,161 in 1990, with projections to 2020 of 22,982, and to 2050 of 29,940 (Table 2.3-1, footnote). Projections for others of this group are shown in Table 2.3-1, footnote.

Those parts of Guadalupe County that are located in the Guadalupe Basin had a population of 45,813 in 1990, and are projected to grow to 92,027 in 2020, and 143,706 in 2050 (Table 2.3-1). The major city of this area is Seguin with a population of 18,853 in 1990, and projections to 2020 and 2050 of 27,040 and 41,181 respectively (Table 2.3-1). There are more than ten public water systems in Guadalupe County within the Guadalupe River Basin (Appendix A: Table 8). The population of unincorporated areas of the county, within the Guadalupe Basin are projected to grow from 26,717 in 1990 to 64,573 in 2020 and to 101,796 in 2050 (Table 2.3-1).

2.3.1.2 Water Demand Projections

Municipal Water Demand

In 1990, total municipal water use in Comal County in the Guadalupe Basin was reported at 8,659 acft/yr, with 397 acft for Garden Ridge, 6,199 acft for New Braunfels, and 2,063 acft in the 75 unincorporated subdivisions and rural areas (Table 2.3-2 and Figure 2.3-3). Projected municipal water demand for the area in Comal County is 25,278 acft/yr in 2020 and 44,641 acft/yr in 2050 (Table 2.3-2 and Figure 2.3-3). Of these totals, 72 percent was used by New Braunfels in 1990, with New Braunfels share of the projected demands at 60 percent in 2020 and 56 percent in 2050.

In the Canyon Lake and neighboring areas of western Comal County, reported municipal water use in 1990 was 1,774 acft/yr, and is projected at 6,999 acft/yr in 2020, and 9,926 acft/yr in 2050 (Table 2.3-2, footnote). In 1990, all of this water was obtained from the Trinity Group Aquifer, which according to local experience and TWDB reports, is not capable of meeting the levels of demand projected for this area. Thus, if it is assumed that present levels of groundwater pumpage by subdivisions of the Canyon Lake Area of 1,774 acft/yr can be maintained, the shortage to be made up from Canyon Lake in 2020 is estimated at 5,225 acft/yr (Table 2.3-2, footnote).

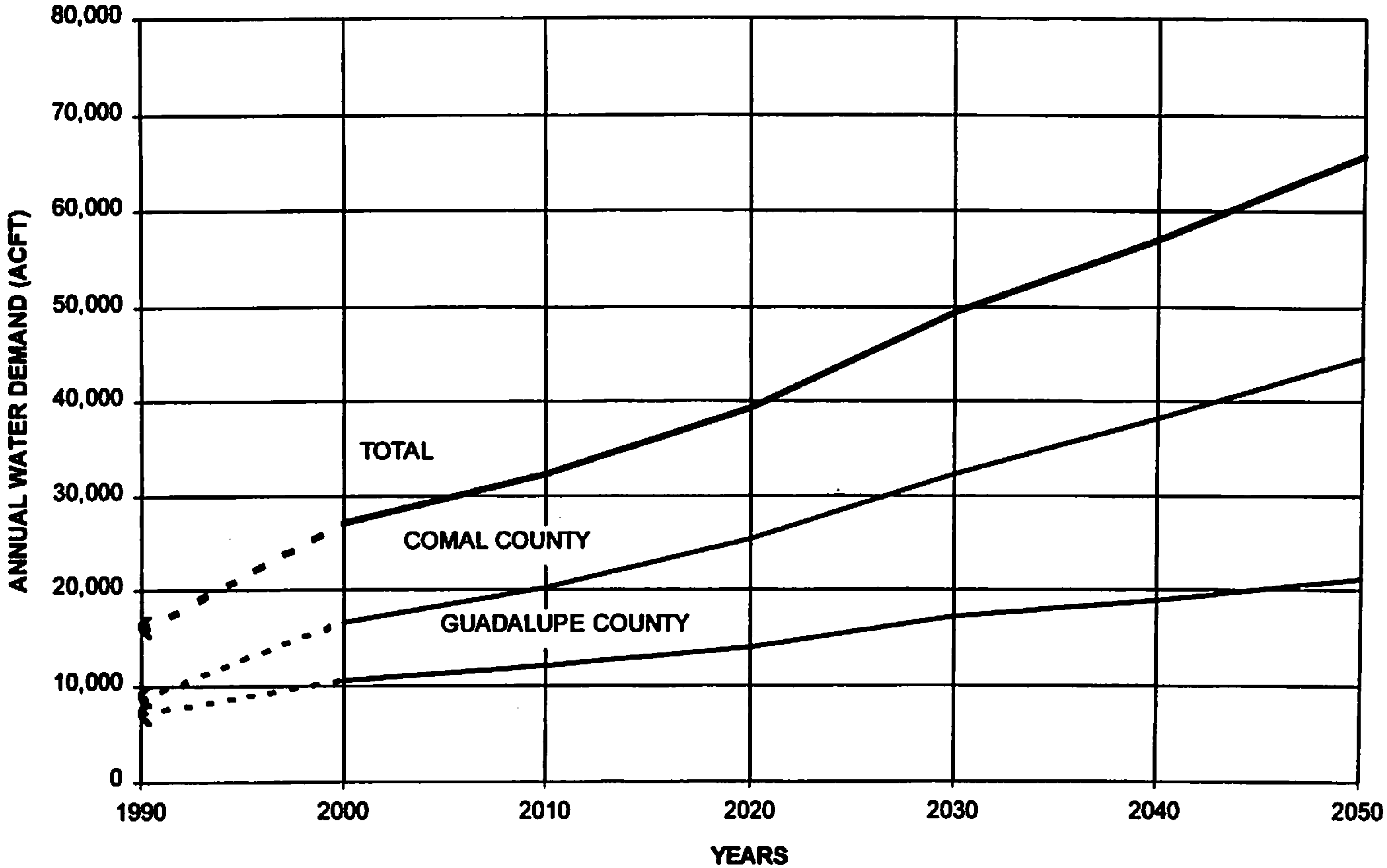
In 1990, municipal water use in Guadalupe County areas of the Guadalupe River Basin was 6,971 acft/yr, with projected demands in 2020 of 13,869 acft/yr and in 2050 of 21,113

Table 2.3-2 Municipal Water Demand Projections Comal and Guadalupe Counties Guadalupe River Basin Trans-Texas Water Program							
Water Supply Entity	Total Use in 1990 (acft)	Projections					
		2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
COMAL COUNTY							
Garden Ridge	397	613	770	868	1,038	1,253	1,511
New Braunfels	6,199	10,335	12,570	15,436	19,499	22,447	25,717
Unincorporated*	2,063	5,534	6,827	8,974	11,645	14,440	17,413
Total	8,659	16,482	20,167	25,278	32,182	38,140	44,641
GUADALUPE COUNTY							
New Braunfels	55	75	84	98	139	155	171
Seguin	3,604	4,037	3,989	4,513	5,454	6,040	6,689
Unincorporated	3,312	6,450	7,937	9,258	11,517	12,695	14,253
Total	6,971	10,562	12,010	13,869	17,110	18,890	21,113
TOTAL	15,630	27,044	32,177	39,147	49,292	57,030	65,754
*Texas Water Development Board 1996 Consensus Water Plan Projections.							
Unincorporated*							
Canyon Lake (CLWSC)	1,093	2,933	3,482	3,769	4,076	4,476	4,702
Canyon Lake (Others)	578	1,605	2,185	2,602	3,144	3,466	3,657
Western Comal Co. (Non Lake)	103	277	410	628	815	1,011	1,567
Remainder of Comal Co.	289	719	750	1,975	3,610	5,487	7,487
Total	2,063	5,534	6,827	8,974	11,645	14,440	17,413
Canyon Lake Sub-Area	1,774	4,815	6,077	6,999	8,035	8,953	9,926
Local Groundwater Supply	1,774	1,774	1,774	1,774	1,774	1,774	1,774
Projected Shortage	0	3,041	4,303	5,225	6,261	7,179	8,152

acft/yr (Table 2.3-2). In 1990, 52 percent of municipal water use in the Guadalupe County area was in Seguin, but the Seguin share of projected demand in 2020 and 2050 is about 32 percent of the total (Table 2.3-2). (See Section 2.3.4 for a water demand and supply comparison for counties of the Guadalupe Basin.)

Total Water Demand

Total water use in the Comal and Guadalupe counties area of the Guadalupe Basin in 1990 was 25,241 acft/yr with 13,533 acft/yr used in Comal County and 11,708 acft/yr used in Guadalupe County (Table 2.3-3 and Figure 2.3-4). Projected total demand in 2020 is 54,220



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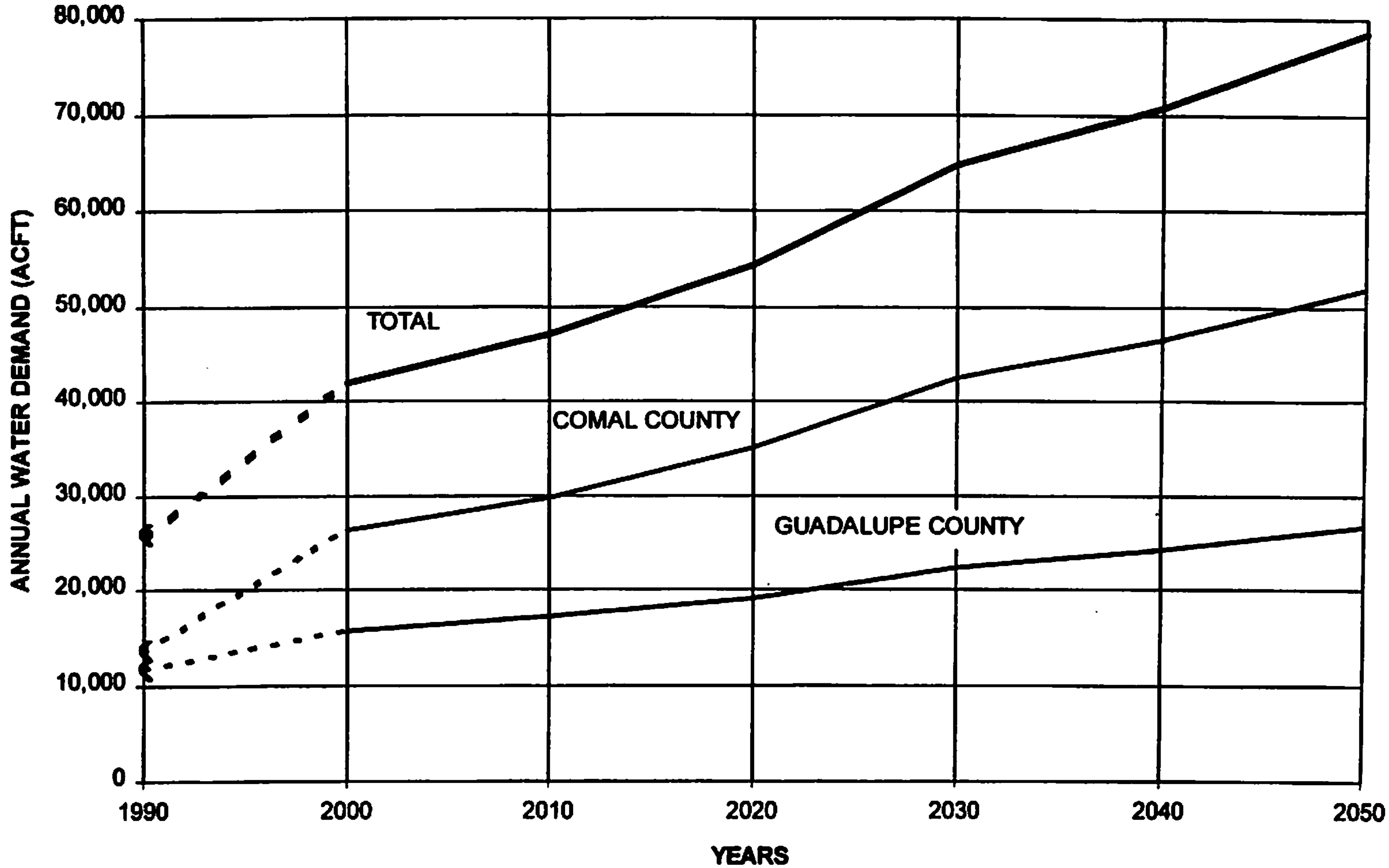
MUNICIPAL WATER DEMAND PROJECTIONS - COMAL AND GUADALUPE COUNTIES IN GUADALUPE RIVER BASIN

FIGURE 2.3-3

County and Type of Use	Total Use 1990 (acft)	Projections 2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
Table 2.3-3 Total Water Demand Projections Comal and Guadalupe Counties Guadalupe River Basin Trans Texas Water Program							
Municipal							
Comal	8,659	16,482	20,167	25,278	32,182	38,140	44,641
Guadalupe	6,971	10,562	12,010	13,869	17,110	18,890	21,113
Subtotal	15,630	27,044	32,177	39,147	49,292	57,030	65,754
Industrial							
Comal	3,248	3,450	3,487	3,548	3,799	4,071	4,351
Guadalupe	1,661	1,883	2,102	2,248	2,385	2,590	2,797
Subtotal	4,909	5,333	5,589	5,796	6,184	6,661	7,148
Steam-Elect Power							
Comal	0	0	0	0	0	0	0
Guadalupe	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0
Irrigation							
Comal	409	393	377	360	346	331	317
Guadalupe	2,303	2,177	2,058	1,945	1,838	1,738	1,642
Subtotal	2,712	2,570	2,435	2,305	2,184	2,069	1,959
Mining							
Comal	946	5,570	5,464	5,628	5,796	3,590	2,224
Guadalupe	0	186	188	190	192	197	203
Subtotal	946	5,756	5,652	5,818	5,988	3,787	2,427
Livestock							
Comal	271	306	306	306	306	306	306
Guadalupe	773	848	848	848	848	848	848
Subtotal	1,044	1,154	1,154	1,154	1,154	1,154	1,154
Total							
Comal	13,533	26,201	29,801	35,120	42,429	46,438	51,839
Guadalupe	11,708	15,656	17,206	19,100	22,373	24,263	26,603
TOTAL	25,241	41,857	47,007	54,220	64,802	70,701	78,442
Texas Water Development Board 1996 Consensus Water Plan Projections.							

acft/yr (35,120 acft in Comal County and 19,100 acft in Guadalupe County) and in 2050 is 78,442 acft/yr (Table 2.3-3 and Figure 2.3-4). Of these totals, 62 percent was for municipal purposes, 20 percent was for industrial purposes, and the remaining 18 percent was for all other purposes. In 2020, the municipal share of the total is projected at 72 percent, with industrial use



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TOTAL WATER DEMAND PROJECTIONS - COMAL AND GUADALUPE COUNTIES IN GUADALUPE RIVER BASIN

FIGURE 2.3-4

at 10 percent, and all other uses at 18 percent. In 2050, the projected municipal share is 83 percent, industrial share is 9 percent, and all other users are 8 percent of the total (Table 2.3-3 and Figure 2.3-4). (See Appendix A: Table 9 for a listing of industrial users in 1990.)

2.3.2 Guadalupe-Blanco River Authority Area

The Guadalupe-Blanco River Authority Area includes all of the following 10 counties: 1.) Caldwell; 2.) Calhoun; 3.) Comal; 4.) DeWitt; 5.) Gonzales; 6.) Guadalupe; 7.) Hays; 8.) Kendall; 9.) Refugio; and 10.) Victoria. The TWDB Consensus Water Plan population and water demand projections for each county, with totals for the 10-county area are tabulated below.

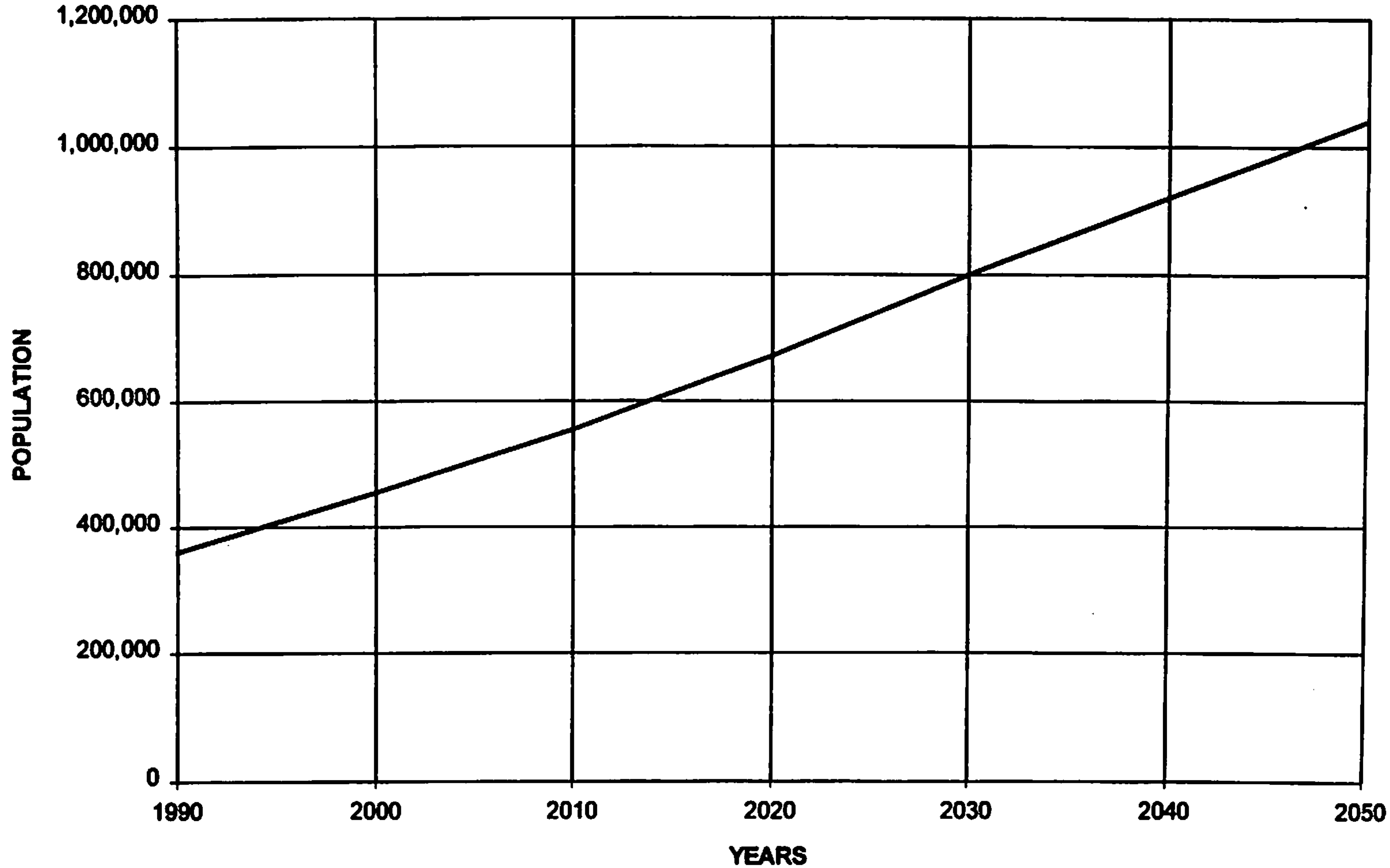
2.3.2.1 Population Projections

The population of the 10-county Guadalupe-Blanco River Authority (GBRA) statutory district was 360,735 in 1990, and is projected to increase to 670,358 in 2020, and 1,040,987 in 2050 (Table 2.3-4 and Figure 2.3-5). About 50 percent of this population was located in the mid basin areas (Comal, Guadalupe, and Hays Counties) in 1990, with about 25 percent in the coastal counties. However, the projections indicate that 64 percent of the total will be in the mid basin counties in 2020, with 75 percent in the mid basin counties in 2050 (Table 2.3-4). For individual county projections, see Table 2.3-4.

Table 2.3-4
Population Projections
Guadalupe-Blanco River Authority Counties
Trans-Texas Water Program

County	1990	Projections					
		2000	2010	2020	2030	2040	2050
Caldwell	26,392	32,158	37,872	43,279	47,086	47,220	47,355
Calhoun	19,053	21,941	23,864	26,027	28,245	30,576	33,334
Comal	51,832	79,378	106,558	144,869	187,464	226,133	267,843
DeWitt	18,840	20,242	21,206	22,367	23,579	24,803	26,061
Gonzales	17,205	17,817	18,647	19,305	19,405	19,843	20,292
Guadalupe	64,873	86,668	111,437	140,370	176,873	203,201	235,139
Hays	65,614	88,614	117,201	145,619	180,349	219,637	250,091
Kendall	14,589	17,129	19,752	22,435	25,007	27,906	31,140
Refugio	7,976	8,421	8,844	9,110	9,081	9,020	8,896
Victoria	74,361	81,909	89,539	96,977	104,205	111,710	120,836
TOTAL	360,735	454,277	554,920	670,358	801,294	920,049	1,040,987

Texas Water Development Board 1996 Consensus Water Plan Projections.



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POPULATION PROJECTIONS GUADALUPE-BLANCO RIVER AUTHORITY COUNTIES

FIGURE 2.3-5

2.3.2.2 Water Demand Projections

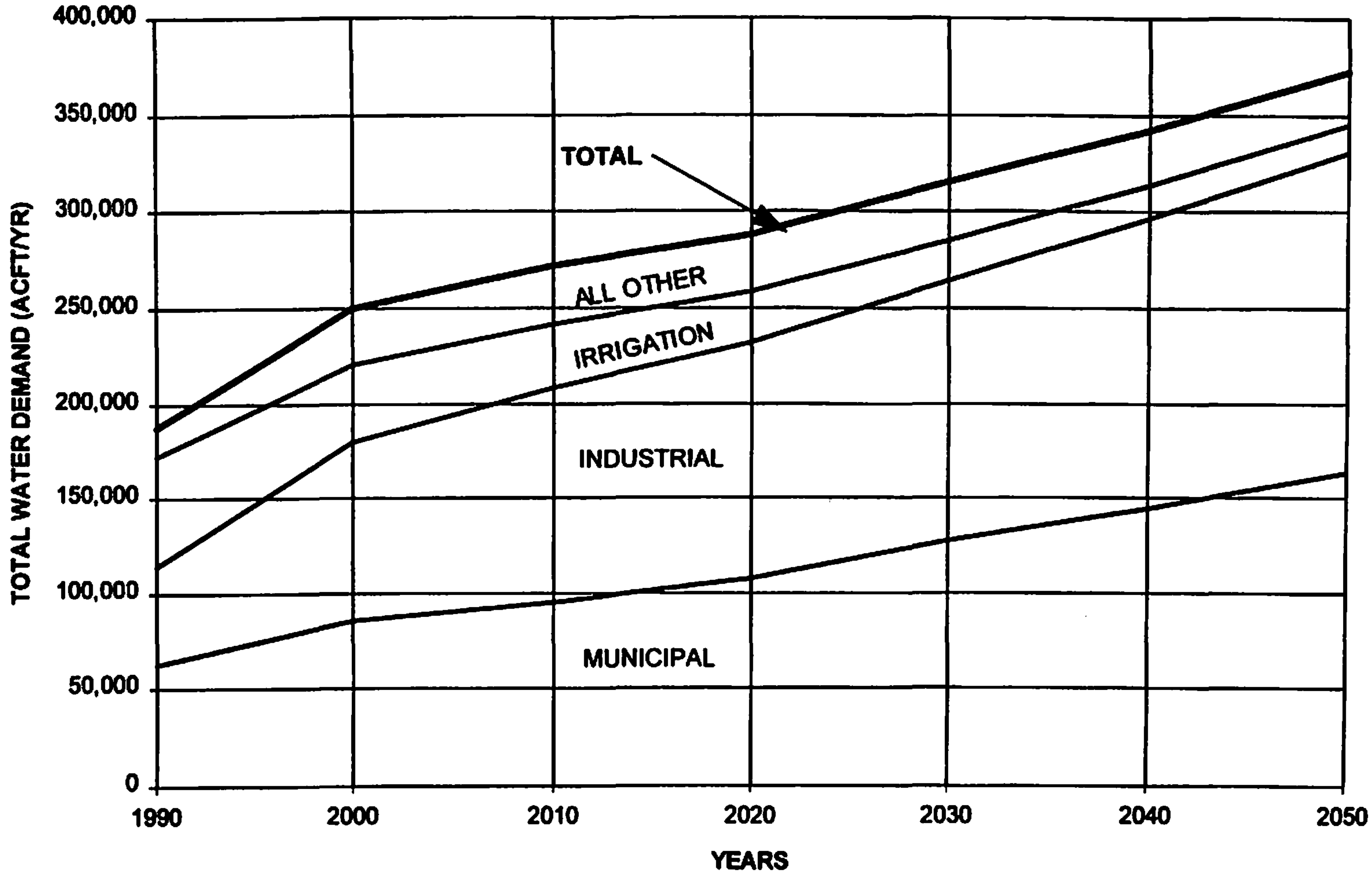
In 1990, total water use in the GBRA 10-county statutory district was 187,570 acft/yr, with projected demands in 2020 of 288,258 acft/yr, and in 2050 of 372,090 acft/yr (Table 2.3-5 and Figure 2.3-6). Projections for municipal, industrial, steam-electric power generation, irrigation, mining, and livestock uses are shown, by county, in Appendix A, Tables 10 through 15.

Of total water use in 1990 in the GBRA statutory district, due to high levels of industrial use, 60 percent was in the coastal counties of Victoria and Calhoun, and although the projections show slight reductions in the percentages of total demand in the coastal counties, the projected demands remain above 50 percent of the total.

Table 2.3-5
Total Water Demand Projections
Guadalupe-Blanco River Authority Counties
Trans-Texas Water Program

County	Use in 1990 (acft)	Projections 2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
Caldwell	7,149	7,873	8,030	8,181	8,463	8,283	8,136
Calhoun	64,230	87,646	97,152	102,106	108,886	117,331	127,146
Comal	15,404	28,422	32,527	38,640	46,924	51,994	58,528
DeWitt	5,901	6,035	5,827	5,718	5,836	5,989	6,152
Gonzales	12,366	12,932	12,396	11,948	11,636	11,477	11,370
Guadalupe	14,976	21,069	23,598	26,510	31,610	35,372	40,116
Hays	12,933	17,929	20,992	23,799	28,616	34,137	38,765
Kendall	2,901	3,462	3,569	3,690	3,972	4,298	4,665
Refugio	1,867	1,779	1,708	1,646	1,616	1,588	1,561
Victoria	49,843	62,582	65,628	66,020	67,533	71,249	75,651
Total	187,570	249,729	271,427	288,258	315,092	341,718	372,090
Summary of Projected Total Water Demand By Type of Use*							
Municipal	62,823	85,214	95,122	107,204	126,874	144,739	163,634
Industrial	50,731	93,894	113,189	124,602	136,915	151,777	167,444
Steam-Electric Power	949	8,100	10,100	10,100	10,100	10,100	10,100
Irrigation	58,145	41,385	32,633	26,183	20,946	17,080	14,116
Mining	3,618	8,748	7,995	7,781	7,869	5,634	4,408
Livestock	11,304	12,388	12,388	12,388	12,388	12,388	12,388
Total	187,570	249,729	271,427	288,258	315,092	341,718	372,090

Texas Water Development Board 1996 Consensus Water Plan Projections
* Source: Appendix A: Tables 10 through 15.



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WATER DEMAND PROJECTIONS
GUADALUPE-BLANCO RIVER
AUTHORITY COUNTIES

FIGURE 2.3-6

2.3.3 Guadalupe River Basin

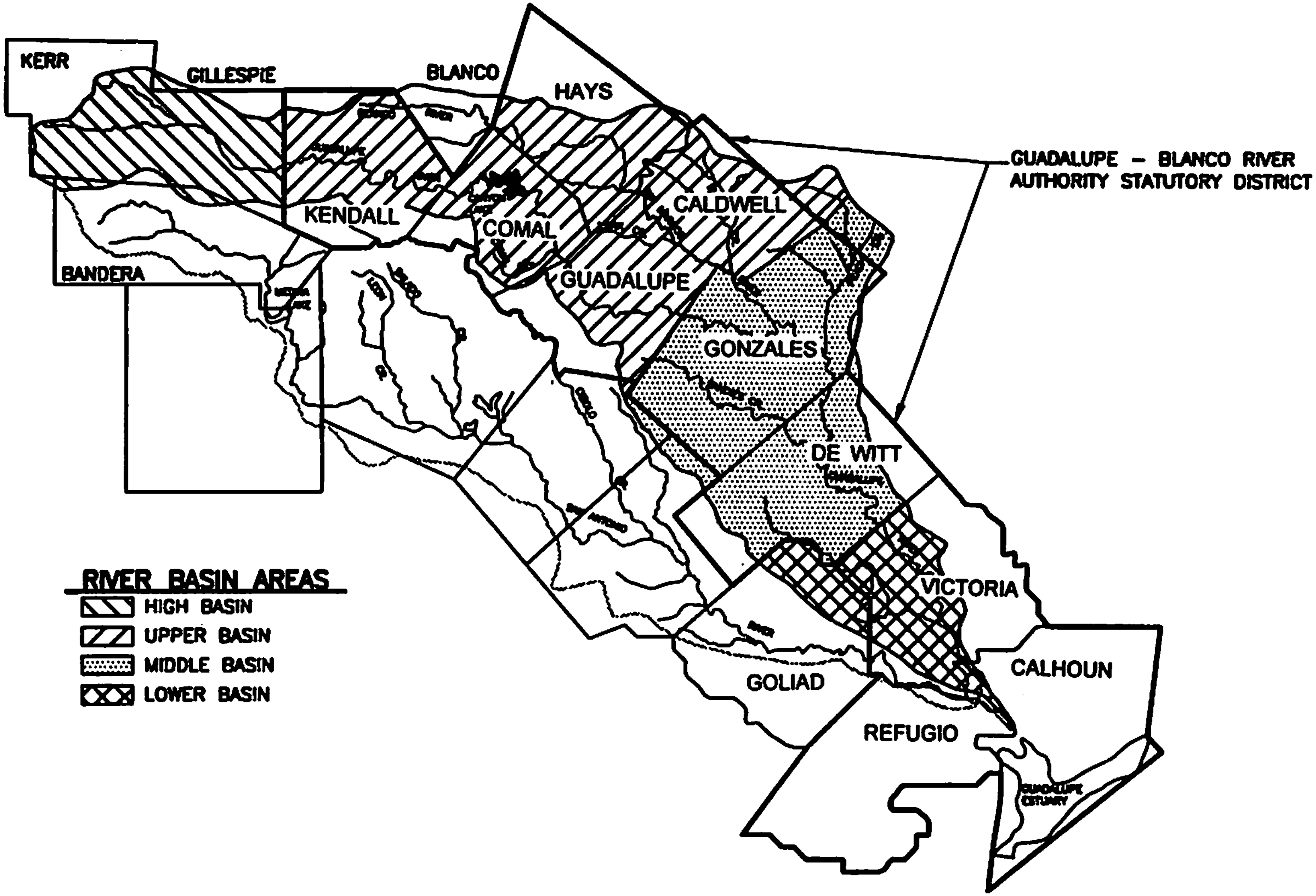
The Guadalupe River Basin contains parts of 20 counties (Figure 2.3-6a). The TWDB Consensus Water Plan population and water demand projections for that part of each county that is located in the Guadalupe Basin are tabulated below and in Appendix A: Tables 16 through 21, with counties listed in their order of location beginning with the most upstream county and proceeding downstream to the coast. For purposes of this report, those parts of the counties that are located in the Guadalupe Basin are grouped as follows: High (those parts of Kerr, Gillespie, Bandera, and Blanco that are within the basin), Upper (those parts of the Kendall, Comal, Hays, Guadalupe, Caldwell, Bastrop, and Travis Counties that are within the Guadalupe Basin), Middle (those parts of Gonzales, DeWitt, Wilson, Karnes, Fayette, and Lavaca Counties that are within the Guadalupe Basin), and Lower (those parts of Victoria, Refugio, and Calhoun Counties that are located within the Guadalupe Basin).

2.3.3.1 Population Projections

In 1990, the population of the Guadalupe River Basin was 302,409, and is projected to increase to 544,025 in 2020, and to 812,109 in 2050 (Table 2.3-6 and Figure 2.3-7). The largest proportion of the population is now, and is projected to be in the upper-basin area, with about 58 percent of the total in 1990 and 75 percent of the total in 2050 (Table 2.3-6).

2.3.3.2 Water Demand Projections

Total water use in the Guadalupe River Basin in 1990 was reported and estimated at 116,858 acft/yr, with water demand projected to increase to 184,968 acft/yr in 2020, and to 234,391 acft/yr in 2050 (Table 2.3-7 and Appendix A: Tables 16 through 21). Due to industrial use in the coastal counties, a higher percentage of the basin's water demands are located in the lower basin than is the case for population (i.e., 40 percent in 1990 for water use, with only 18 percent of the basin's population; with projections of 40 and 36 percent of basin water demand in 2020 and 2050, respectively, while population projections for lower basin areas are for 13 and 11 percent for 2020 and 2050 respectively).



NOTE:

THE GBRA STATUTORY DISTRICT INCLUDES THESE 10 COUNTIES:

CALDWELL	GUADALUPE
CALHOUN	HAYS
COMAL	KENDALL
DeWITT	REFUGIO
GONZALES	VICTORIA

NO PART OF HIGH BASIN COUNTIES ARE IN GBRA STATUTORY SERVICE AREA.

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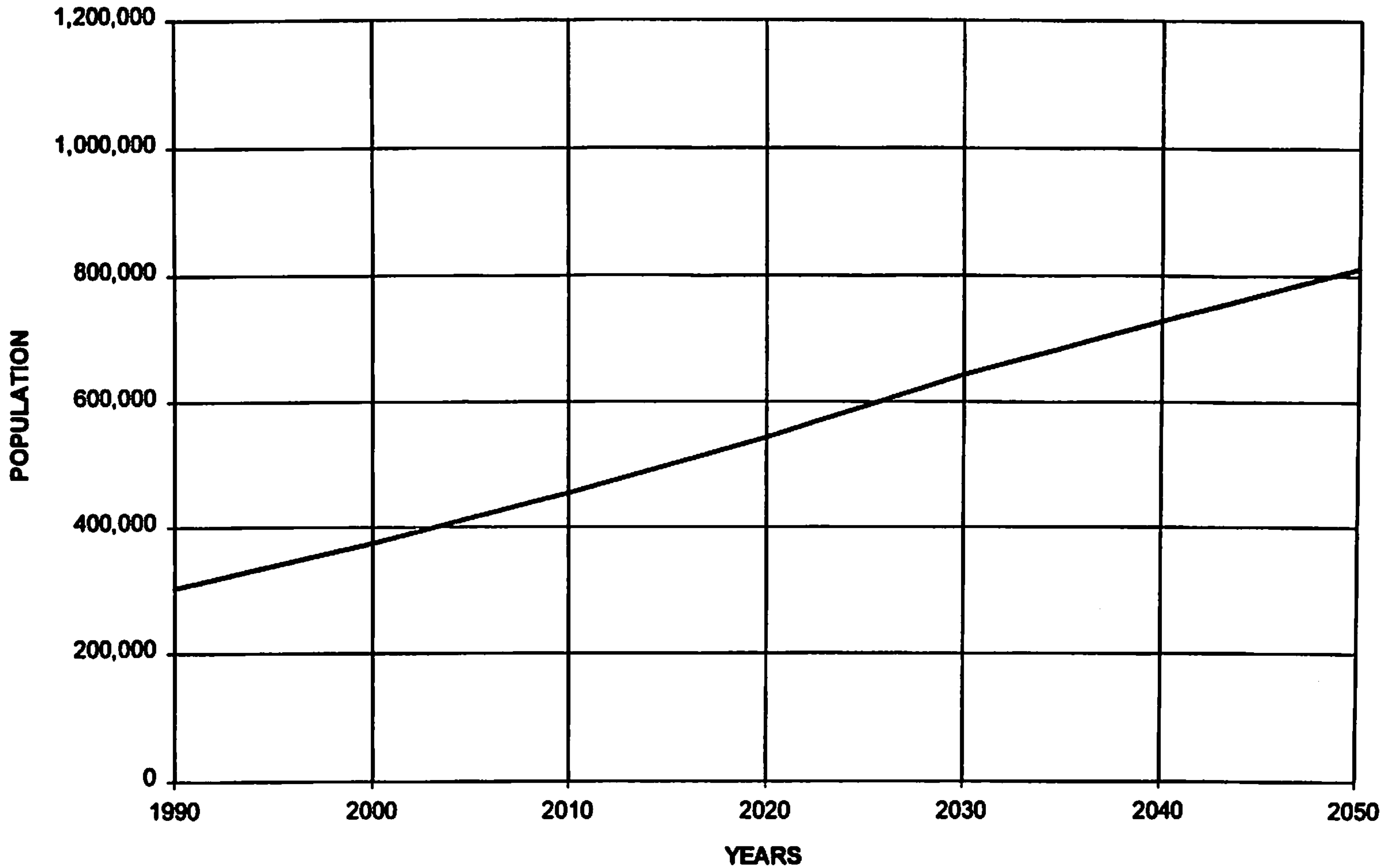
GUADALUPE RIVER BASIN AREAS

FIGURE 2.3-6a

Table 2.3-6
Population Projections - Guadalupe River Basin
Trans-Texas Water Program

County	1990	Projections 2000	2010	2020	2030	2040	2050
HIGH							
Kerr	35,421	41,850	47,092	52,186	55,960	57,530	59,050
Gillespie	69	85	95	107	114	132	143
Bandera	133	190	228	279	312	351	393
Blanco	2,999	3,642	4,263	4,925	5,418	5,647	5,520
Subtotal	38,622	45,767	51,678	57,497	61,804	63,660	65,106
UPPEP							
Kendall	5,724	6,293	6,996	7,762	8,468	9,357	10,336
Comal	45,518	68,821	92,020	124,340	160,583	192,404	226,999
Hays	51,478	67,638	87,728	107,912	132,906	161,505	185,054
Guadalupe	45,813	58,275	73,665	92,027	115,319	128,256	143,706
Caldwell	25,698	31,270	36,790	42,010	45,684	45,800	45,917
Bastrop	279	420	613	846	1,092	1,266	1,229
Travis	532	563	641	758	863	931	1,004
Subtotal	175,042	233,280	298,453	375,655	464,915	539,519	614,245
MIDDLE							
Gonzales	17,139	17,751	18,579	19,235	19,335	19,772	20,219
DeWitt	14,667	15,621	16,341	17,214	18,116	19,029	19,966
Wilson	555	658	766	863	924	985	1,086
Karnes	116	132	132	143	152	160	164
Fayette	1,814	2,058	2,275	2,530	2,818	3,127	3,492
Lavaca	99	109	113	116	121	127	133
Subtotal	34,390	36,329	38,206	40,101	41,466	43,200	45,060
LOWER							
Goliad	1,465	1,550	1,640	1,714	1,732	1,782	1,908
Victoria	52,867	58,196	63,719	69,023	74,104	79,449	85,744
Subtotal	54,332	59,746	65,359	70,737	75,836	81,231	87,652
Calhoun	23	28	31	35	38	41	46
Grand Total	302,409	375,150	453,727	544,025	644,059	727,651	812,109

* Texas Water Development Board, 1996 Consensus Texas Water Plan, Most Likely Projection; includes only those parts of counties located within the Guadalupe River Basin.



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POPULATION PROJECTIONS
GUADALUPE RIVER BASIN

FIGURE 2.3-7

Table 2.3-7 Total Water Demand Projections - Guadalupe River Basin Trans-Texas Water Program							
	Use in	Projections					
County	1990 (acft)	2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
HIGH							
Kerr	6,920	9,021	9,064	9,090	9,454	9,520	9,579
Gillespie	35	42	42	42	43	44	45
Bandera	21	27	28	30	33	35	39
Blanco	662	802	807	816	844	848	821
Subtotal	7,638	9,892	9,941	9,978	10,374	10,447	10,484
UPPER							
Kendall	1,433	1,529	1,504	1,502	1,539	1,600	1,669
Comal	13,533	26,201	29,801	35,120	42,429	46,438	51,839
Hays	10,473	14,496	16,760	18,914	22,634	26,978	30,904
Guadalupe	11,708	15,656	17,206	19,100	22,373	24,263	26,603
Caldwell	6,778	7,582	7,733	7,878	8,152	7,976	7,829
Bastrop	92	147	166	189	220	241	234
Travis	102	159	164	175	194	204	216
Subtotal	44,119	65,770	73,334	82,878	97,541	107,700	119,294
MIDDLE							
Gonzales	12,322	12,868	12,334	11,888	11,577	11,418	11,311
DeWitt	4,636	4,700	4,576	4,520	4,631	4,761	4,892
Wilson	293	350	349	352	359	373	397
Karnes	108	130	125	121	119	120	120
Fayette	516	611	615	625	666	712	768
Lavaca	50	51	50	50	50	50	51
Subtotal	17,925	18,710	18,049	17,556	17,402	17,434	17,539
LOWER							
Goliad	12,544	15,461	15,448	20,436	20,433	20,432	20,441
Victoria	34,396	45,817	51,312	53,557	56,324	60,941	65,892
Subtotal	46,940	61,278	66,760	73,993	76,757	81,373	86,333
Calhoun	236	443	513	563	616	675	741
Grand Total	116,858	156,093	168,597	184,968	202,690	217,629	234,391

* Texas Water Development Board, 1996 Consensus Water Plan Projections; includes only those parts of counties located within the Guadalupe River Basin

In 1990, municipal water use in the Guadalupe River Basin was reported at 52,958 acft/yr, or about 45 percent of total water use, and is projected to increase to 90,010 acft/yr in 2020, and 132,368 acft/yr in 2050 (Table 2.3-8 and Figure 2.3-8).

Industrial water use in the basin in 1990 was 26,263 acft/yr and is projected to increase to 38,923 acft/yr in 2020, and 51,855 acft/yr in 2050 (Table 2.3-8 and Figure 2.3-8). Projections of municipal, industrial, and steam-electric power generation, irrigation, mining, and livestock water demands are summarized for the Guadalupe Basin in Table 2.3-8 and are shown for each county in Appendix A: Tables 16 through 21, respectively.

Table 2.3-8
Total Water Demand Projections
Guadalupe River Basin - Summary by Type of Use*
Trans-Texas Water Program

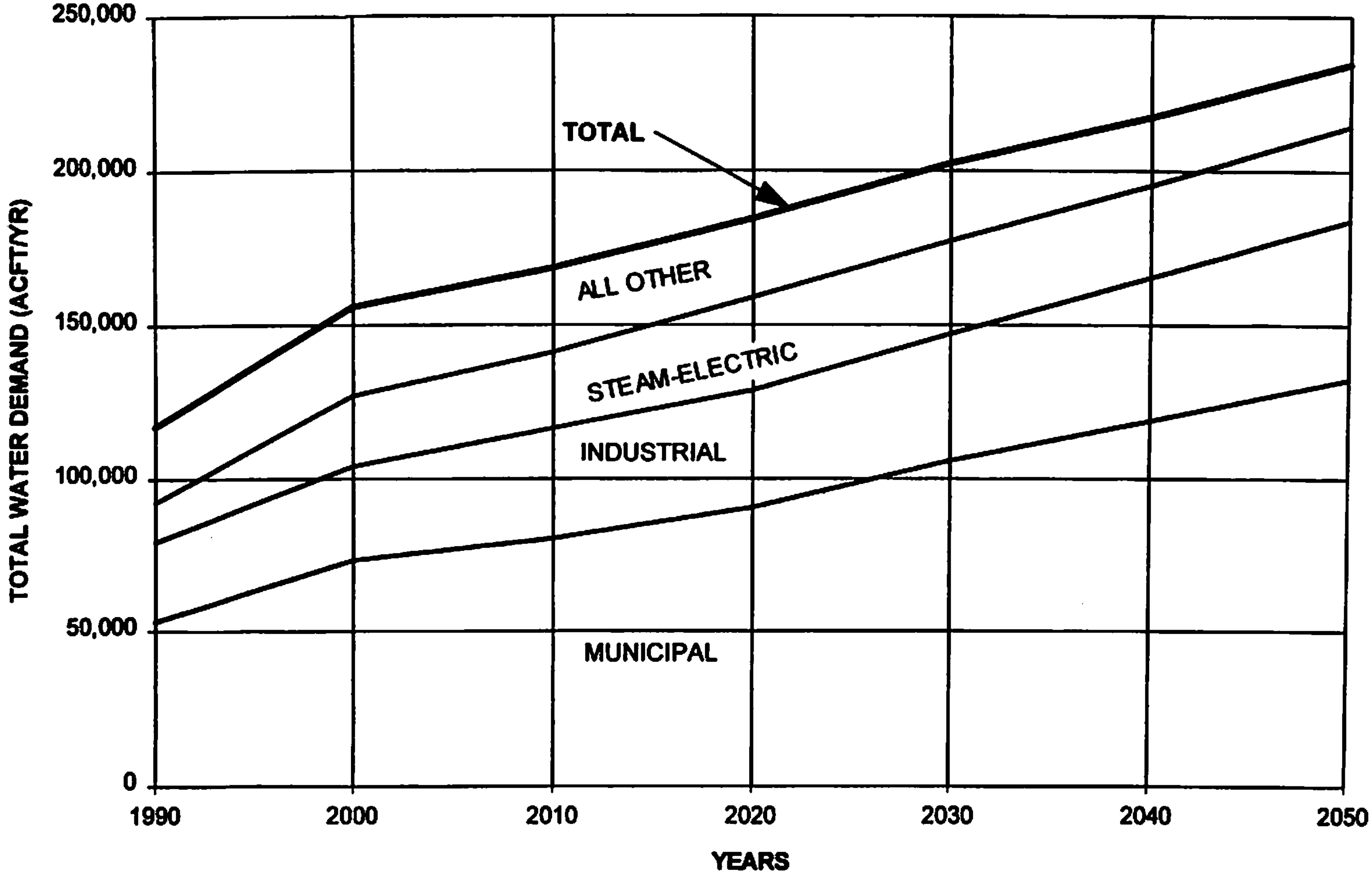
Type of Use	Use in 1990 (acft)	Projections 2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
Municipal	52,958	72,755	80,452	90,010	105,514	118,610	132,368
Industrial	26,263	31,086	35,853	38,923	41,970	46,871	51,855
Steam-Electric	13,052	23,000	25,000	30,000	30,000	30,000	30,000
Irrigation	11,614	10,274	9,131	8,155	7,316	6,596	5,969
Mining	3,486	8,085	7,268	6,987	6,997	4,659	3,306
Livestock	9,485	10,893	10,893	10,893	10,893	10,893	10,893
Total	116,858	156,093	168,597	184,968	202,690	217,629	234,391

* Source: Appendix A: Tables 16 through 21; includes only those parts of counties located within the Guadalupe River Basin.

2.3.4 Water Demand and Supply Comparisons (Guadalupe-Blanco River Authority statutory district/Guadalupe River Basin)

<u>Projected Demands</u>

The Guadalupe River Basin water demand area includes all of the 10 counties of the Guadalupe-Blanco River Authority statutory district, plus the in-basin parts of those 10 other counties which lie partially within the Basin. The demands for the area are shown in Table 2.3-9, which was drawn from sections 2.3.2 and 2.3.3 (Tables 2.3-5 and 2.3-7).



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WATER DEMAND PROJECTIONS
GUADALUPE RIVER BASIN

FIGURE 2.3-8

Table 2.3-9 Water Demand Projections Guadalupe River Basin/Guadalupe-Blanco River Authority Statutory District* Trans-Texas Water Program							
		Water Demand Projections					
County	Use in 1990 (acft)	2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
Kerr	6,920	9,021	9,064	9,090	9,454	9,520	9,579
Gillespie	35	42	42	42	43	44	45
Bandera	21	27	28	30	33	35	39
Blanco	662	802	807	816	844	848	821
Subtotal	7,638	9,892	9,941	9,978	10,374	10,447	10,484
Kendall**	2,901	3,462	3,569	3,690	3,972	4,298	4,665
Comal**	15,404	28,422	32,527	38,640	46,924	51,994	58,528
Hays**	12,933	17,929	20,992	23,799	28,616	34,137	38,765
Guadalupe**	14,976	21,069	23,598	26,510	31,610	35,372	40,116
Caldwell**	7,149	7,873	8,030	8,181	8,463	8,283	8,136
Bastrop	92	147	166	189	220	241	234
Travis	102	159	164	175	194	204	216
Subtotal	53,557	79,061	89,046	101,184	119,999	134,529	150,660
Gonzales**	12,366	12,932	12,396	11,948	11,636	11,477	11,370
DeWitt**	5,901	6,035	5,827	5,718	5,836	5,989	6,152
Wilson	293	350	349	352	359	373	397
Karnes	108	130	125	121	119	120	120
Fayette	516	611	615	625	666	712	768
Lavaca	50	51	50	50	50	50	51
Subtotal	19,234	20,109	19,362	18,814	18,666	18,721	18,858
Goliad	12,544	15,461	14,448	20,436	20,433	20,432	20,441
Refugio**	1,867	1,779	1,708	1,646	1,616	1,588	1,561
Victoria**	49,843	62,582	65,628	66,020	67,533	71,249	75,651
Calhoun**	64,230	98,646	108,152	113,106	119,886	128,331	138,146
Subtotal	128,484	178,468	189,936	201,208	209,468	221,600	235,799
Total	208,913	287,530	308,285	331,184	358,507	385,297	415,801

* Source: Tables 2.3.2-2 and 2.3.3-2.

** Guadalupe-Blanco River Authority Counties (Data for whole county.); For all other counties, data for only that part of county located in Guadalupe Basin.

In 1990, total water use for the Guadalupe River Basin/GBRA statutory districts was 208,913 acft/yr, with 128,484 acft (61 percent) in the lower basin counties of Goliad, Refugio, Victoria, and Calhoun (Table 2.3-9). In the following discussion, Guadalupe Basin projected demands are compared to projected supplies for the purpose of providing information for use in the cost analyses of this study.

Projected Supplies

Table 2.3-10 contains a summary of estimated water supply in the Guadalupe River Basin. The quantities of groundwater available in the Guadalupe River Basin service area are estimated at 182,606 acft/yr beginning in 2008 (Tables 2.3-10 and 2.3-11).[10] In the "high basin" counties (Kerr, Gillespie, Bandera, and Blanco) groundwater plus Guadalupe River rights appear to be adequate to meet most of the projected demands at both 2020 and 2050 (Table 2.3-11 and Figure 2.3-9). However, in the "upper basin" area (Kendall, Comal, Hays, Guadalupe, and Caldwell Counties), projected available ground water of 50,471 acft/yr is not adequate to meet projected demands beginning in the immediate future (Figure 2.3-9). Present plus potential run-of-river rights in this part of the basin are about 50,681 acft/yr, which with existing contracts for Canyon Lake water of 26,499 acft/yr, would meet projected needs in 2020, but would not meet projected needs in 2050 (Figure 2.3-9). Surpluses shown in the Upper Basin in 2020 are largely groundwater supplies in Kendall, Caldwell, and Bastrop Counties.

The middle Guadalupe Basin area (Gonzales, DeWitt, Wilson, Karnes, Fayette, and Lavaca Counties) has significant quantities of Carrizo Aquifer water (68,518 acft/yr), which is greater than projected demands in 2020 and 2050 (Figure 2.3-9). However, it is anticipated that the cities of Gonzales and Cuero, both located along the Guadalupe River, may find it advantageous to shift more of their future demands to surface water. In this analysis, it was projected that by 2020, Cuero would be using 842 acft/yr of groundwater and 842 acft/yr of Guadalupe River water, and that Gonzales would be using 783 acft/yr of groundwater and 782 acft/yr of Guadalupe River water (Appendix A: Table 22).

In the "lower basin" counties (Goliad, Victoria, and Calhoun), present uses and projected demands exceed the 54,416 acft/yr of available groundwater supplies (Table 2.3-10). However, water users of these counties hold run-of-river rights to Guadalupe River water, plus contracts for 32,000 acft of Lake Texana water in the neighboring Lavaca Basin that would more than meet projected needs in 2020 and 2050 (Figure 2.3-9). It is estimated, however, that for uses in Victoria and Calhoun Counties, some additional, dependable or firm supplies of surface water may be needed to firm up run-of-river rights.

[10] Unpublished planning data, Texas Water Development Board, 1992. Groundwater from the Edwards Aquifer is based upon the assumption that pumpage will be limited to 400,000 acft/yr and that users will be allocated their 1990 prorata share of this quantity.

Table 2.3-10
Estimated Water Supply
in the Guadalupe River Basin

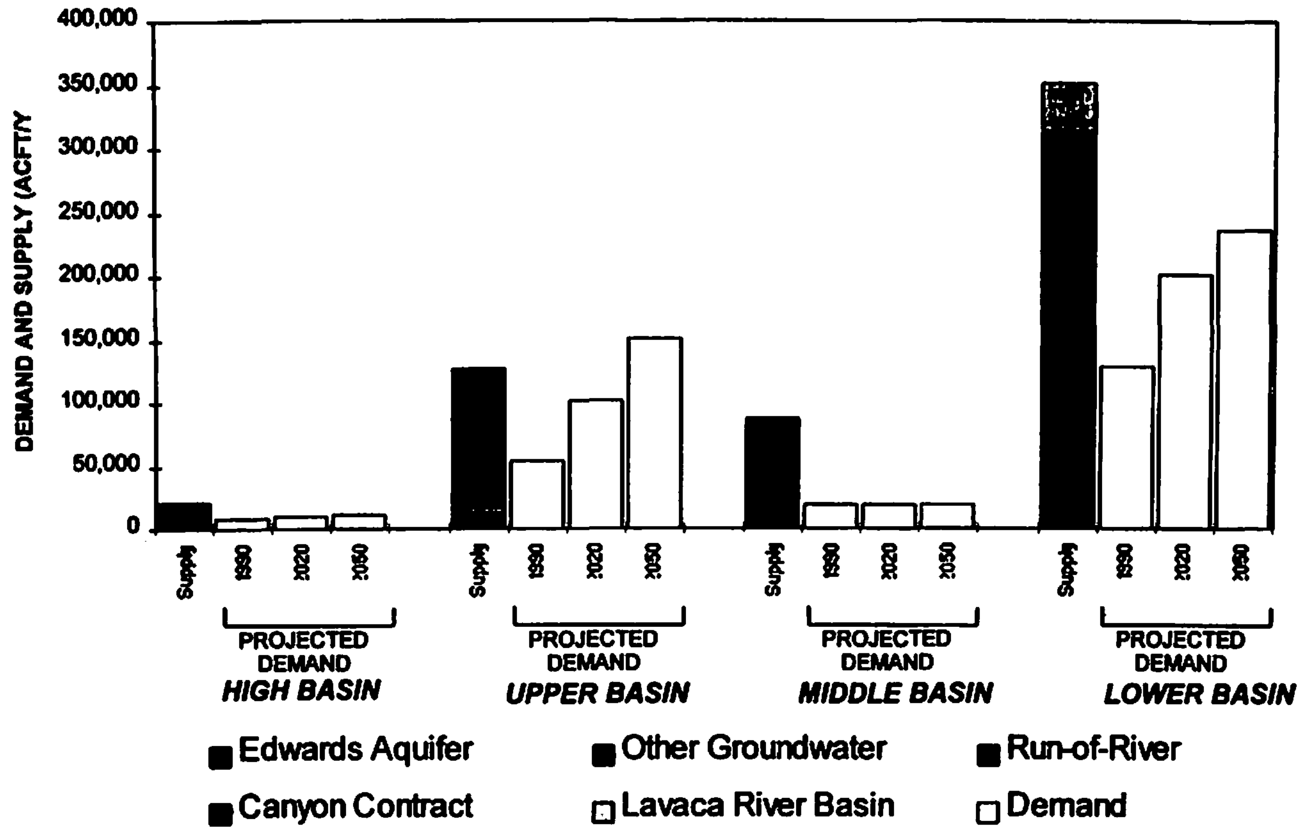
Water Source	Estimated Supply (acft/yr)
Edwards Aquifer[1]	16,560
Other Aquifers[2]	166,046
Canyon Lake	50,000
Run-of-the-River Rights[3]	338,392
Imported Water[4]	32,000
TOTAL	602,998

(1) Estimate based upon provisions of SB 1477, 1993 Texas Legislature, as amended, for conditions after year 2007.
(2) Groundwater availability data for Texas Counties; unpublished planning data; Texas Water Development Board; 1993.
(3) Includes existing water rights for all uses, except non-consumptive hydroelectric water rights not included.
(4) 32,000 acft/yr of industrial water from Lake Texana.

Table 2.3-11
Water Demand and Water Supply Comparisons
Guadalupe River Basin/Guadalupe-Blanco River Authority Statutory District
Trans-Texas Water Program

Area	Water Use In 1990 (acft)	Projected Water Demands 2020 (acft)	Projected Water Demands 2050 (acft)	Ground Water Supply Annually 2008 and Later* (acft)	Projected Surface Water Supplies: Run-of-the-River Rights (acft)	Projected Surface Water Supplies: Canyon Lake Contracts 1996[3] (acft)	Total Annual Supply Available (acft)
High Basin	7,638	9.978	10,484	9,201	10,664	0	19,865
Upper Basin[1]	53,557	101,184	150,660	50,471	50,861	26,499	127,651
Middle Basin	19,234	18,814	18,858	68,518	18,742	5	87,265
Lower Basin[2]	128,484	201,208	235,799	54,416	290,305	6,000	350,721
TOTAL**	208,913	331,184	415,801	182,606	370,572	32,504	585,502

* Source: Groundwater Availability Data for Texas Counties; Unpublished Planning Data; Texas Water Development Board; 1993. Groundwater from Edwards Aquifer is based on the assumption of pumpage limits of 400,000 acft/yr.
** Guadalupe-Blanco River Authority Counties (data for whole county); For all other counties, data for only that part of county located in Guadalupe Basin.
(1) Surpluses shown in 2020 are groundwater supplies in Kendall, Caldwell, and Bastrop Counties. The additional supply needed from Canyon Lake is to meet demands in Hays, Guadalupe, and western Caldwell Counties.
(2) 32,000 acft of firm supply is obtained from Lake Texana of the Lavaca Basin. Demand includes 11,000 acft of canal conveyance losses.
(3) Additional supply available from Canyon Lake is not included here.



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DEMAND AND SUPPLY COMPARISONS - GUADALUPE RIVER BASIN SERVICE AREA

FIGURE 2.3-9

3.0 WATER SUPPLY ALTERNATIVES

3.0.1 Overview

Several alternatives have been studied to utilize surface water from the Guadalupe River. Alternatives have been grouped into six categories, according to the point of diversion and water treatment plant (WTP) location. These alternatives include: intake and WTP located at Canyon Lake (Alt G-34); intake at New Braunfels with treatment at an expanded New Braunfels Utility WTP (Alt. G-35); intake at Lake Dunlap with treatment at an expanded Canyon Regional Water Authority (CRWA) plant (Alt G-36); intake at Lake Dunlap with construction of a regional water treatment plant near Marion (Alt G-37); intake at Gonzales downstream of the Guadalupe and San Marcos river confluence, with construction of a regional water treatment plant near Marion (Alt G-38); and a dual diversion at Lake Dunlap and Gonzales, with construction of a regional water treatment plant near Marion (Alt G-39). For each diversion location, several annual diversion amounts and delivery rates have been studied as summarized in Table 3.0-1. For each supply alternative, a water delivery system was planned and preliminary engineering performed for each component, including: sizing for intakes, pump stations, and treatment plants; pipeline routes; pipeline hydraulic design; and, pumping energy consumption. From the engineering analysis, estimates of total project cost and annual power and operation and maintenance costs were made for each alternative. The cost estimates were used to develop unit costs (i.e. dollars per acft/yr) for delivery of treated water based on both a uniform delivery rate and a summer peak delivery rate. Table 3.0-2 contains monthly demand factors for a uniform annual delivery rate and a seasonal variation delivery pattern. The seasonal variation pattern (also referred to as summer peak delivery pattern) is a typical municipal demand pattern and has a summer peak delivery rate in July that is 2.0 times the annual average delivery rate. Use of the seasonal variation pattern for sizing of water delivery facilities results in larger capacity facilities than does the uniform annual demand pattern. The study of each of the alternatives also included consideration of environmental impact, possible permitting requirements, and implementation issues.

The Phase I study[1] of the Trans-Texas Water Program considered a broad array water supply alternatives for the West Central Study Area other than those considered in the Letter of

[1] "Trans-Texas Water Program, West Central Study Area, Phase I Interim Report", Vols. 1 through 4, HDR Engineering, Inc., prepared for San Antonio River Authority, Texas Water Development Board, et al, 1994 and 1995.

Table 3.0-1 Summary of Water Supply Alternatives				
Alternative No.	**Diversion Location**	**Annual Diversion (acft/yr)**	**Treated Water Delivery Rate**	**Delivery Location[3]**
G-34A G-34B G-34C G-34D	Canyon Lake	5,000 5,000 8,000 8,000	Uniform Summer Peak Uniform Summer Peak	Canyon Lake WSC, Bulverde, and SAWS
G-35A G-35B	New Braunfels	15,000 15,000	Uniform Summer Peak	Mid-Cities and SAWS
G-36A G-36B G-36C G-36D	Lake Dunlap to CRWA WTP	5,000 5,000 15,000 15,000	Uniform Summer Peak Uniform Summer Peak	Mid-Cities, CRWA, and SAWS
G-37A G-37B G-37C G-37D	Lake Dunlap to Regional WTP	15,000 15,000 50,000 50,000	Uniform Summer Peak Uniform Summer Peak	Mid-Cities, CRWA, and SAWS
G-38A G-38B G-38C G-38D	Guadalupe River near Gonzales	40,000 40,000 75,000 75,000	Uniform Summer Peak Uniform Summer Peak	Mid-Cities, CRWA, and SAWS
G-39A G-39B G-39C G-39D	Lake Dunlap and Guadalupe River near Gonzales	40,000[1] 40,000[1] 75,000[2] 75,000[2]	Uniform Summer Peak Uniform Summer Peak	Mid-Cities, CRWA, and SAWS
(1) 40,000 acft/yr annual diversion is sum of 5,000 acft/yr diverted at Lake Dunlap and 35,000 acft/yr diverted at Gonzales. (2) 75,000 acft/yr annual diversion is sum of 15,000 acft/yr diverted at Lake Dunlap and 60,000 acft/yr diverted at Gonzales. (3) SAWS: San Antonio Water System; Mid-Cities: Municipalities in western Guadalupe County, i.e., Marion, Cibolo, Schertz, and Garden Ridge; CRWA: Member entities of Canyon Regional Water Authority in Guadalupe County, i.e., Green Valley SUD, Springs Hill WSC, and Crystal Clear WSC.				

Intent. Further work in Phase II may require more detailed study of alternatives identified in Phase I and the LOI study in order to develop an integrated water supply program to meet the needs of the region.

3.0.2 Water Delivery Locations

Numerous water purveyors in the eastern Bexar County/western Guadalupe County/southern Comal County area were identified by participants of the Letter of Intent (LOI) as potentially able to receive treated surface water from the supply systems studied. Locations of significant connection points that were used to develop transmission pipeline routes, facility needs, and costs are shown on Figure 3.0-1.

The following is a description of the potential delivery locations or methods of delivery to water purveyors in western Guadalupe County, eastern Bexar County, and Comal County:

San Antonio Water System (SAWS):

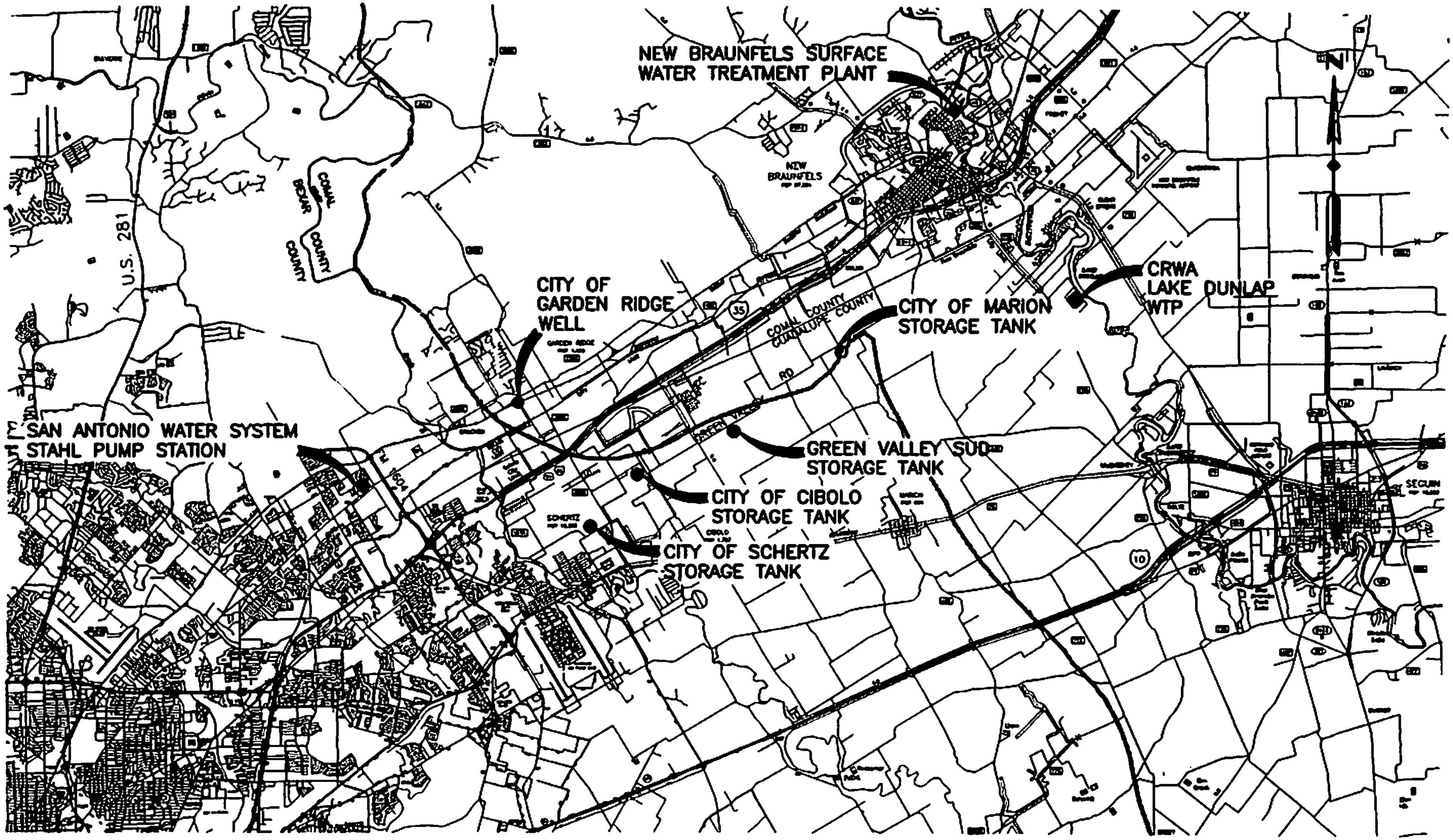
Water from Canyon Lake (Alternative G-34) would be delivered to the Marshall Reservoir site near the intersection of US 281 and Marshall Road in north-central Bexar County. Existing facilities include a 550,000 gal ground storage tank with an overflow elevation of 1258 ft.

Table 3.0-2
Monthly Demand Factors for Sizing of Facilities

Month	**Uniform Rate** (percent of annual volume)	**Seasonal Variation Rate**[1] (percent of annual volume)
January	8.5%	3.4%
February	7.7%	3.1%
March	8.5%	3.4%
April	8.2%	7.0%
May	8.5%	11.3%
June	8.2%	11.0%
July	8.5%	17.0%
August	8.5%	17.0%
September	8.2%	11.0%
October	8.5%	9.0%
November	8.2%	3.4%
December	8.5%	3.4%
TOTAL	100%	100%

[1] Adopted with minor modifications from Phase 1A Study.

Water from all other diversion locations on the Guadalupe River would be delivered to the Stahl Secondary Pumping Station located in northeast Bexar County near the intersection of Loop 1604 and FM 2252 (Nacogdoches Road). The Stahl Secondary Pumping Station services a pressure plane of 1125-ft elevation. The existing well at the site pumps directly into the distribution system. Two small standpipes located at the site are currently not in service. Facilities required to be constructed for tie-in with the regional surface water system would include an elevated storage reservoir or a ground storage reservoir and a high service pump station. The ground elevation at the site is about 940 ft, which would require an elevated storage tank height of 185 ft in order to float on the 1125-ft pressure plane.



Legend

- ■ Water Treatment Plant
- ● Connection Point to Existing Distribution System
- —— Basin Boundary

2 0 2 4 6

Approximate Scale in Miles

HDR

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TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

DELIVERY LOCATIONS FOR SURFACE WATER SUPPLY

FIGURE 3.0-1

Canyon Regional Water Authority (CRWA)

Green Valley Special Utility District: Connection would be at the existing ground storage tank on Green Valley Road; overflow elevation 817 ft.

East Central Water Supply Corporation: No pipeline connection; new water supplies would be distributed by trades of pumping rights with SAWS or others.

Crystal Clear Water Supply Corporation: No new connection is proposed; increased water supply will be through the existing connection at the CRWA Lake Dunlap Water Treatment Plant.

Springs Hill WSC: No new connection is proposed; increased water supply will be through the existing connection at the Lake Dunlap Water Treatment Plant.

City of Marion: At existing ground storage tank on Green Valley Road; overflow elevation 808.5 ft.

City of Schertz: At existing East Live Oak ground storage tank on Live Oak Road; overflow elevation 799.5 ft.

City of Cibolo: At existing ground storage tank on Green Valley Road; overflow elevation 867 ft.

City of Garden Ridge: At either interconnection with the City of Schertz distribution system or by connection to one of Garden Ridge's existing wells. For delivery through Schertz system, Garden Ridge surface water supply to be delivered at Schertz East Live Oak storage tank, overflow elevation 799.5 ft. For delivery directly to Garden Ridge, the identified delivery point is an existing well east of FM 3009 between Garden Ridge and Bracken.

Universal City: No pipeline connection; new water supplies would be acquired through trades of pumping rights with SAWS or others.

City of Converse: No pipeline connection; new water supplies would be acquired through trades of pumping rights with SAWS or others.

City of Live Oak: No pipeline connection; new water supplies would be acquired through trades of pumping rights with SAWS or others.

Bexar Metropolitan Water District (BMWD) Lackland City East Service Area: No pipeline connection; new water supplies would be distributed by trades of pumping rights with SAWS or others.

Randolph AFB: No pipeline connection; new water supplies would be acquired through trades of pumping rights with SAWS or others.

Canyon Lake Water Supply Corporation: At two tie-in points: (1) at the existing 100,000 gallon elevated ground storage tank at the Triple Peak Water Treatment Plant, overflow elevation 1215 ft; (2) at a potential elevated ground storage tank to be built in the area of Rolling Hill subdivision, approximate overflow elevation to be 1250 ft.

City of Bulverde: A regional water supply to the Bulverde area will probably require construction of a new storage tank to provide service to existing and expected new customers. Facilities required to be constructed for tie-in with the regional surface water system would include an elevated storage reservoir or a ground storage reservoir and a high service pump station. Overflow elevation is expected to be 1400 ft (matches SAWS service level 11), or higher, requiring a minimum tank height of 100 ft.

3.0.3 Cost Estimating Methods

Cost estimating methods and the cost data base used were generally consistent with Trans-Texas Water Program Phase I studies[2] and are more fully described in Appendix B. Construction and operational costs were estimated for each alternative at projected first quarter 1996 prices based on an *Engineering News Record* Construction Cost Index (ENR CCI) of 5542.

3.0.4 Environmental Overview

Introduction

This section presents methods used to perform the environmental evaluations, general descriptions of the project area and preliminary analyses of the potential environmental effects and mitigation associated with the various water supply alternatives. Additional information and environmental impacts specific to the alternatives are considered in the separate alternative sections.

Materials and Methods

The need for environmental studies and mitigation activities as part of the alternatives analysis results from the need to obtain state and federal permits. With respect to most of the alternatives considered here, the regulations that will drive environmental compliance standards include the Clean Water Act (33 USC 1344), the Rivers and Harbors Act of 1899 (33 USC 403), the Endangered Species Act (16 USC 1531 et seq.), and portions of the Texas Water Code

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[2] "Trans-Texas Water Program, West Central Study Area, Phase I Interim Report", Vols. 1 through 4, HDR Engineering, Inc., prepared for San Antonio River Authority, Texas Water Development Board, et.al.

involving water rights permits (TAC chapters 281, 287, 295, 297, 299). Section 404 of the Clean Water Act prohibits the discharge of dredged or fill material into the waters of the United States, including adjacent wetlands, while Section 10 of the Rivers and Harbors Act regulates structural alternations in the navigable waters of the United States. Both regulations are administered by the U.S. Army Corps of Engineers, although the U.S. Environmental Protection Agency can exercise a veto over Section 404 permits. It is expected that all impacts will be mitigated by 1) avoiding the impact, 2) minimizing the impact, and 3) compensating for unavoidable impacts.

Cultural resources protection on public lands in Texas, or lands affected by projects regulated under Department of the Army permits, is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction would first be surveyed by qualified professionals to determine the presence or absence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided.

Land uses, habitat types and values, and wetland occurrences have been identified and evaluated using available literature and a variety of other sources, including the Texas Parks and Wildlife Department, Resource Protection Division's Texas Natural Heritage Program (TNHP) data and mapping files for endangered, protected and sensitive resources, Texas Organization for Endangered Species' (TOES) listings of endangered, threatened and rare animals and plants, the U.S. Fish and Wildlife Service's National Wetland Inventory (NWI) maps and U. S. Department of Agriculture Soil Conservation's county Soil Surveys. This data base, including, natural resources, protected species, and potential wetland areas is on 7.5 minute quadrangles maintained at Paul Price Associates, Inc.

The proposed construction activities and locations, together with each alternative's operational characteristics were then evaluated with respect to mapped regional environmental resources in order to identify the potential effects of each alternative. Special attention was given to construction activities in or adjacent to ecologically sensitive areas, and to operational characteristics that might result in changes in stream hydrology, bays and estuary inflow regimes, and the distribution and abundance of protected species.

Environmental Setting

Climate and Economy

The projects considered here lie within the counties of Bexar, Comal, Gonzales and Guadalupe, all of which are in the South Central Climactic Division of the state.[3] The South Central division is considered to be in the humid subtropical zone which has an average rainfall of 32 inches. Temperatures of 100° F or above are common in the summer, which is very humid. Tropical storm activity increases in August. In the fall, summer-like temperatures occasionally persist into November with the first freeze taking place in late November or early December. The affects that arctic air masses have on areas to the north are usually highly attenuated by the time they reach the South Central Climactic Division. Average annual precipitation in the four-county area is lowest in Bexar (29.1 inches), the western most county, and ranges from 33.6 inches to 31.4 inches in the eastern counties of the project area. Annual average temperatures are 69 to 70 degrees Fahrenheit with hot and humid summers and mild but variable winters. Fall and spring are the most pleasant seasons, fall being characterized by warm days and cool nights, and spring alternating between warm and cool spells. Growing seasons range from 261 days to the north in Comal County to 276 days to the south in Gonzales County.

The economy of the area is diverse with Bexar County being a major urban center and agriculture being of primary importance in the surrounding counties. Bexar County ranked 38th in 1985 in state agricultural receipts, of which 52 percent was derived from crops. About 19 percent of the cropland is harvested cropland and 3 percent is irrigated. Primary crops include sorghum and corn for feed, and hay. Primary vegetables, fruits and nuts included carrots, potatoes, sweet corn, cabbage, peaches and pecans. Primary livestock and livestock products included beef and dairy cattle, sheep and wool.

In 1987, the county ranked 4th in the state in the volume of retail sales. The businesses and industries with the most employment were restaurants, special trade contractors, wholesale trade-nondurable goods, hospitals, insurance carriers, food stores, transportation and public utilities. Non farm personal income in 1986 exceeded 14.7 billion dollars.

Comal County ranked 229th in 1985 in agricultural receipts, of which 76 percent was derived from livestock and livestock products including beef cattle, sheep, wool, angora goats

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[3] Natural Fibers Information Center. 1987. The Climates of Texas Counties. The University of Texas. Austin, Texas

and mohair. About 6 percent of the agricultural land was used as harvested cropland and less than 1 percent was irrigated. Primary crops included hay, sorghum for feed, and wheat. Primary vegetables and fruits include potatoes, sweet potatoes, peaches and pecans.

In 1987 the county ranked 44th in the state in the volume of retail sales. The business and industries with the most employment were restaurants, manufacture of textile mill products, contract construction, health services and retail food stores. Non farm income in 1986 totaled about 736 million dollars.

Gonzales County ranked fourth in 1985 in agricultural receipts, of which 97 percent was derived from livestock and livestock products. In 1985 the county tied for seventh in pecan production. Primary crops included hay and corn and sorghum for feed. Primary vegetables included watermelons, tomatoes, sweet potatoes, and potatoes. Primary nuts and fruits included pecans and peaches.

In 1987 the county ranked 113th in the state in the volume of retail sales. The businesses and industries with the most employment were food and food-related products, health services, retail trade, transportation and other public utilities and wholesale trade. Non farm personal income totaled 183 million dollars.

Guadalupe County ranked 130th in 1985 in agricultural receipts, of which 64 percent was derived from livestock and livestock products. In 1986 the county ranked eighth in the state in pecan production. Primary crops included sorghum and hay for feed and wheat. Primary vegetables included cantaloupes, potatoes, sweet potatoes, tomatoes and watermelons. Primary fruits and nuts include peaches and pecans. Primary livestock and products included beef cattle, poultry and hogs.

In 1987, the county ranked 48th within the state in the volume of retail sales. The businesses and industries employing the most people were restaurants, retail food stores, health services, food and food-products, and contract construction. Non farm personal income in 1986 totaled 700 million dollars.

Lake Dunlap

Lake Dunlap is a long, moderately deep reservoir within the banks of the Guadalupe River. It is formed by a small hydroelectric dam downstream of the Guadalupe River's confluence with the Comal River. In addition to hydroelectric power generation, Lake Dunlap is used for boating, fishing and camping. Downstream from Lake Dunlap there are numerous small impoundments on the Guadalupe River.

Guadalupe River

The Academy of Natural Sciences of Philadelphia (ANSP) conducted studies of the macroinvertebrate fauna of the Guadalupe River from 1949 to 1987.[4] Six sites in Victoria County were surveyed in 1949, 1950, 1952, 1962, 1966, 1973 and 1987. In terms of species richness and abundance, populations of mollusks and crustaceans have remained uniform over the sampling period. Dominant species of mollusks and crustaceans include Asiatic clam (*Corbicula fluminea*), golden orb (*Quadrula aurea*), Texas lilliput (*Toxolasma texasensis),* grass shrimp (*Palaemontes* spp.), crayfish (*Procambarus clarkii*), and blue crab (*Callinectes sapidus*).

Kuehne,[5] Hubbs,[6] and Lee et. al.,[7] considered together, provide a comprehensive list of fishes likely to inhabit the San Antonio and Guadalupe Rivers, given appropriate habitats. Hubbs, et. al.[8] provides an inventory and bibliography dealing with the fishes of Texas. In addition to studying macroinvertebrate communities, ANSP has studied fish communities of the Guadalupe River periodically since 1949. Based on increasing capture records, populations of threadfin shad (*Polydactylus* spp.), green sunfish (*Lepomis cyanellis*), longear sunfish (*L. megalotis*), and warmouth (*L. gulosis*) appear to be increasing in the Guadalupe River. Introduced species including Mexican tetra (*Astyanax mexicanus*), orangespotted sunfish (*L. humilis*), sailfin molly (*Poecilia latipinna*), white crappie (*Pomoxis annularis*), black crappie (*P. nigromaculatus*) and white bass (*Morone chrysops*) also appear to be increasing in abundance.

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[4] Academy of Natural Sciences. 1991. A Review of Chemical and Biological Studies on the Guadalupe River, Texas, 1949-1989. Report No. 91-9. Acad. Nat. Sci. Phil. Philadelphia, PA.
[5] Kuehne, R.A. 1955. Stream surveys of the Guadalupe and San Antonio Rivers. IF Report No. 1. Texas Game and Fish Commission, Austin, TX.
[6] Hubbs, C. 1982. A Checklist of Texas Freshwater Fishes. Tech. Series No. 11:1-12. Texas Parks and Wildlife Department, Austin, Texas.
[7] Lee, S. L., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, J.R. Stauffer, Jr. 1980. Atlas of North American Freshwater Fishes. Publ. No. 1980-12 of the North Carolina Biological Survey.
[8] Hubbs, C., J.D. McEachran and C.R. Smith. 1994. Freshwater and Marine Fishes of Texas and the Northwestern Gulf of Mexico. The Texas System of Natural Laboratories, Inc., Austin, TX.

Guadalupe-San Antonio Estuary

The Guadalupe-San Antonio Estuary includes a system of freshwater, brackish, and saltwater marshes.[9] Many plant species found in marshes can tolerate a wide range of salinities and may occur in more than one type of marsh. Other plants may have narrower niche requirements and can be characteristic of a particular type of marsh habitat. Drier, high marshes are characterized by species such as gulf cordgrass (*Spartina spartinae*), paspalum (*Paspalum* spp.), smartweed (*Polygonum* spp.), panicgrass (*Panicum* spp.), sea ox-eye daisy (*Borrichia frutescens*), beak rush (*Rhynchospora macrostachya*), sedge (*Fimbristylis* spp.), mexican devil-weed (*Aster spinosus*), saltmeadow cordgrass (*Spartina patens*), and scattered bulrush (*Scirpus* spp.), spike rush, and flatsedge. Wetter, low marshes are characterized by cattail (*Typha* spp.), three-square bulrush (*Eleocharis* spp.), flatsedge (*Cyperus* spp.), water hysop (*Bacopa monnieri*), rush (*Juncus* spp.), water primrose (*Ludwigia* spp.), arrowhead (*Sagittaria* spp.), and paspalum (*Paspalum lividum*). Shrubs such as rattlebush (*Sesbania drummondii*), retama (*Parkinsonia aculeata*), and black willow tend to be scattered around the margins of freshwater marshes.

Average inshore catch for all species in the Guadalupe-San Antonio Estuary for the period 1962-1976 exceeded 2.3 million pounds, the third highest out of eight estuaries in Texas. Shrimp accounted for over 90 percent of the bay harvest weight. The shellfish component consists of white shrimp (*Penaeus setiferus*), brown shrimp (*P. aztecus*), blue crab, and eastern bay oyster (*Crassostrea virginica*). The finfish component consists of croaker (Micropogon undulatus), spotted seatrout (*Cynoscion nebulosus*), red drum (*Scianenops ocellata*), black drum (*Pogonias cromis*), sheepshead (*Archosargus probatocephalus*), mullet (*Mugil* sp.), gulf menhaden (*Brevoortia patronus*), flounder (Paralichthyes sp.), and sea catfish (*Arius felis*).[10] Commercial harvesting of spotted sea trout and red drum has been banned since 1981.

The Guadalupe-San Antonio Estuary also supports a significant sport fishery. Texas Parks and Wildlife Department estimates that harvest of all fish species represents 380,000 fish totaling 420,000 pounds in a single year.[11] Sixty percent of the sport fishery is accounted for by spotted sea trout. Red drum, southern flounder (*P. lethostigma*), black drum, and sand sea trout

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[9] Longley, W.L. 1994. Freshwater inflows to Texas bays and estuaries: ecological relationships and methods for determination of needs. Texas Water Development Board and Texas Parks and Wildlife Department, Austin, Texas.
[10] TPWD. 1991. Trends in relative abundance and size of selected finfishes and shellfishes along the Texas coast: November 1975-December 1989. Texas Parks and Wildlife Department, Austin, Texas.
[11] Ibid

account for an additional 25 percent of the recreational harvest. Atlantic croaker (*Micropogonias undulatus*), gafftopsail catfish (*Barge marinus*), requiem shark (Carcharhinidae), and southern kingfish (*Menticirrhus americanus*) account for five percent of the recreational harvest.

The commercial and sport fish depend upon many estuarine species for survival. Spotted seatrout, southern flounder, and red drum depend on shrimp, pinfish (*Lagodon rhomboides*), menhaden, anchovy (*Anchoa* sp.), and mullet for food. Larval fish depend upon plankton, polychaete worms, and crustaceans for food. Shrimp feed on detritus, polychaetes, epiphytes, and plankton. Gizzard shad (*Dorosoma cepedianum*), striped and white mullet, gulf menhaden, bay anchovy, clams (*Rangia cuneata* and *R. flexuosa*), and eastern bay oyster represent ecologically important species that feed directly on detritus and plankton. Shrimp and small fishes such as pinfish, gulf killifish and longnose killifish (*Fundulus* spp.), sheepshead minnows (*Cyprinodon variegatus*), silversides (*Menidia* sp.), silver perch and juvenile fish are a significant source of food for higher level consumers such as red drum, herons, egrets, porpoise, and spotted sea trout.

Biogeography

Three Vegetational Areas of Texas form bands running east to west through the project area counties. These are from north to south the Edwards Plateau in Bexar and Comal Counties, Blackland Prairies (in Bexar and Guadalupe Counties), Post Oak Savannah in Bexar, Guadalupe and Gonzales Counties) and South Texas Plain in Bexar County and the southwestern corner of Gonzales County.

The Edwards Plateau is a deeply dissected, rapidly drained rocky plain with broad, flat to undulating divides. Historically the vegetation was grassland or open savannah-type plains with tree or brushy species found along rocky slopes and stream bottoms. In Bexar and Comal Counties the Balcones Escarpment forms a distinct border of the plateau on its southern boundary with the Blackland Prairies. Streams and rivers fed by numerous springs have cut canyons through the plateau, especially near its margins, forming unique niches for a variety of plant species. The ferns as well as many of the flowering plants are primarily lithophilous ("rock-loving"), and are represented primarily by various species of lipferns, (*Cheilanthes* spp.), cloak-ferns (*Notholaena* spp.) and cliff brakes (*Pellaea* spp.). Columbine (*Aquilegia canadensis*), and endemic species such as *Anemone edwardsensis* and wand butterfly-bush

(*Buddlega racemosa*) are sometimes found together with other species on large boulders in shaded ravines along with such species as mockorange (*Philadelphus* spp.), American smoke-tree (*Cotinus americana*), spicebush (*Benzoin aestivale*) and the endemic silver bells (*Styrax platanifolia* and *S. texana*).

The most important climax grasses of the Plateau include switchgrass, several species of bluestems and gramas, Indian grass (*Sorghastrum nutans*), Canada wild-rye (*Elymus canadensis*), curly mesquite (*Hilaria berlangeri*) and buffalograss (*Buchloe dactyloides*). The rough, rocky areas typically support a tall or mid-grass understory and a brush overstory complex consisting primarily of live oak (*Quercus virginiana*), Texas oak (*Q. buckleyi*), shinnery oak (*Q. havardii*), juniper species (*Juniperus*) and mesquite (*Prosopis glandulosa*). Throughout the region, the brush species are generally considered as "invaders" with the climax stages composed of grassland or open savannah. The steeper canyon slopes historically supported a dense oak-ashe juniper thicket.

The Balcones Escarpment is characterized by a complex of porous, faulted limestones in stream beds, sinkholes and fractures which allow substantial volumes of water to flow into the Edwards Aquifer.[12] The Edwards recharge zone has a surface area of about 1,500 square miles in Uvalde, Kinney, Medina, Bexar, Hays and Comal Counties. Streamflows contribute significantly to recharge of the Edwards Aquifer[13] which supplies water to customers in the City of San Antonio and numerous other users. Additionally, the Edwards Aquifer feeds springs which provide habitat for several endemic, endangered species.

Southeastern Comal County lies within the Blackland Prairies. The Blackland Prairies and Post Oak Savannah Vegetational Regions intermingle in Bexar, Gonzales and Guadalupe Counties and have divisions known as the San Antonio and Fayette Prairies. These well-dissected, rolling prairies represent the southern extension of the true prairie which extends from Texas to Canada. Soils in the project area range between light-colored, acid sandy loams in the upland areas, dark-gray acid sandy loams and clays (bottomland) and fairly uniform dark-colored calcareous clays.

Blackland Prairie is considered a true prairie with little bluestem (*Schizachyrium scoparium* var. *frequens*) as a climax dominant. Other important grasses include big bluestem

[12] Caran, C.S. 1982. Lineament analysis and inference of geologic structure.
[13] United States Geological Survey. 1989. Compilation of Hydrologic Data for the Edwards Aquifer, San Antonio Area, Texas, 1988. With 1934-1988 Summary, Bulletin 48, November 1989.

(*Andropogon gerardii* var. *gerardii*), Indian grass, switchgrass, sideoats grama (*Bouteloua curtipendula*), hairy grama, (*Bouteloua hirsuta*), tall dropseed (*Sporoboulus asper*), silver bluestem and Texas wintergrass (*Stipa leucotricha*). Under heavy grazing, Texas wintergrass, buffalograss (*Buchloe dactyloides*), Texas grama (*Bouteloua rigidiseta*), smutgrass (*S. indicus*) and many annuals increase or invade these areas. Mesquite also has invaded hardland sites of the southern portion of the Blackland Prairies. Post oak (*Q. stellata*) and blackjack oak (*Q. marilandica*) increase on the medium- to light-textured soils.

Although classed as a true prairie, the Blackland Prairie has substantial amounts of timber, especially along the streams that traverse it. Common tree species include a variety of oaks, pecan (*Carya illinioensis*), cedar elm (*Ulmus crassifolia*), bois d'arc (*Maclura pomifera*) and mesquite.

Some authorities consider the plant association as part of the oak-hickory formation. Based on the fact that the typical understory vegetation is tall grass, others classify the area as part of the true prairie association of the grassland formation. There is evidence that the brush and tree densities have increased tremendously from the virgin condition.

Topography of the Post Oak Savannah is gently rolling to hilly. Rainfall averages 35 to 45 inches annually. Soils on the uplands are light-colored, acid sandy loams or sands. Bottomland soils are light-brown to dark-gray and acid, ranging in texture from sandy loams to clays.

Although most of the Post Oak Savannah is in native or improved pastures, small farms are common. Climax grasses include little bluestem, Indian grass, switchgrass (*Panicum virgatum*), purpletop (*Tridens flavus*), silver bluestem (*Bothriochloa saccharoides*), Texas wintergrass (*Stipa leucotricha*) and narrowleaf woodoats (*Chasmanthium sessiliflorum*). The overstory is primarily post oak and blackjack oak. Many other brush and weedy species are also common. Some invading plants are red lovegrass (*Eragrostis oxylepis*), broomsedge (*Andropogon virginicus*), splitbeard bluestem (*Andropogon ternarius*), yankeeweed (*Eupatorium compositifolium*), bullnettle (*Cnidoscolus texanus*), greenbrier (*Smilax* sp.), yaupon (*Ilex vomitoria*), smutgrass (*Sporobolus indicus) and* western ragweed (*Ambrosia trifida*).

The South Texas Plains are also termed the Rio Grande Plains, or Tamaulipan Brushlands.[14] The South Texas Plains Vegetational Area corresponds to the Southern Texas

[14] Correll, D.S. and M.C. Johnstion. 1979. Manual of Vascular Plants of Texas. The University of Texas at Dallas.

Plains Ecoregion.[15] The topography is level to rolling, and the land is dissected by arroyos or by streams flowing into the Rio Grande and Gulf of Mexico. It is characterized by open prairies and a growth of mesquite, grangeno (*Celtis pallida*), cacti, clepe (*Ziziphus obtusifolia*), coyotillo (*Karwinskia Humboldtiana*), guayacan (*Porlieria angustifolia*), white brush (*Aloysia gratissima*), brasil (*Condalia Hookeri*), bisbirinda (*Castela texana*), cenizo (*Leucophyllum* spp.), huisache (*Acacia Farnesiana*), catclaw (*A. greggii*), black brush (*A. rigidula*), guajillo (*A. Berlandieri*) and other small trees and shrubs which are found in varying degrees of abundance and composition.[16] Although historically the area was grassland or savannah-type climax vegetation, long-continued heavy grazing and other factors have resulted in a general change to a cover of shrubs and low trees. Among the several species of shrubs and trees that have made dramatic increases are mesquite, live oak, post oak, *Opuntia* spp. and *Acacia* spp.[17] Blair[18] described the South Texas Plains (Tamaulipan Province) as being characterized by the predominance of thorny brush vegetation. This brushland stretches from the Balcones fault line southward into Mexico. A few species of plants account for the bulk of the brush vegetation and give it a characteristic aspect throughout the Tamaulipan Biotic Province of Texas. The most important include: mesquite, lignum vitae (*Porliera angustifolia*), cenizo (*L. texanum*), white brush (*A. gratissima*), prickly pear (*O. lindheimeri*), tasajillo (*O. leptocaulis*), *Condalia* sp. and *Castela* sp. The brush on sandy soils differs in species and aspect from that on clay soils. Mesquite, in an open stand and mixed with various grasses, is characteristic of sandy areas. Clay soils usually have all of the species listed above, including mesquite. Although rangeland predominates throughout the South Texas Plains/Tamaulipan Brushland, land use also includes significant acreages in croplands.

Environmental Issues

Alternatives considered in the present volume involve diversions from the Guadalupe River or existing reservoirs on the Guadalupe River and transport by pipeline to delivery points within the basin. Thus, the main issues involved concern the effects of changes in instream flow,

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[15] Omernik, James M. 1986. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers, 77(1):pp. 118-125.
[16] Correll, D. S. and M. C. Johnston. 1979. Op. Cit.
[17] Gould, F. W. 1975. The grasses of Texas. Texas A&M University Press.
[18] Blair, F.W. 1950. The biotic provinces of Texas. The Texas Journal of Science. 2:93-117.

changes in flow to the bays and estuaries, and the effects of constructing and maintaining the infrastructure required for treatment and delivery of the water. Flows in the Guadalupe River or existing reservoirs considered for diversion and for purposes of estimating instream flows at the diversion points and at Saltwater Barrier were from several sources including, uncommitted firm yield of Canyon Lake, enhanced springflows resulting from legislatively mandated reductions in withdrawals from the Edwards Aquifer, projected year 2020 underutilized water rights and unappropriated water rights subject to environmental criteria. Assumptions pertaining to these water sources are discussed in detail in Appendix C. The discussion presented in the environmental issues section for each alternative focuses on projected net changes in freshwater availability to the Guadalupe River at the diversion point and at the mouth of the river at Saltwater Barrier.

Pipeline installation and operation affect narrow, linear areas of habitat. A mowed ROW is maintained free of woody vegetation for the life of the project. The long-term effects of pipeline installation vary with construction techniques used and the types of habitat affected. For example, those portions of a pipeline through crop and grass can be returned to crop and grass immediately following installation of a buried pipeline. Although brush can be expected to invade areas disturbed by construction in perhaps 5 to 10 years, brush would be removed from the maintenance ROW. More significant effects can be expected where pipeline ROWs traverse park and wood (e.g. riparian woodlands at river crossings). Because of the relative flexibility of pipeline route selection, disturbance of sensitive resources often can be avoided or substantially minimized by using environmental surveys (habitat and archaeological studies) to aid route selection.

3.1 Canyon Lake Water Supply to Canyon Lake WSC/Bulverde/North Bexar County (G-34)

3.1.1 Description of Alternative

Historically, the rapidly growing areas around Canyon Lake and western Comal County have obtained their water supply from the underlying Trinity Group Aquifer (see Figure 3.1-1). This aquifer is not adequate over the long term to meet the demands upon it, according to studies sponsored by the TWDB. In 1991, the GBRA completed a regional water plan[1] which included an evaluation of providing treated water for the Canyon Lake area as well as Bulverde. Because the cost of a new surface water system significantly exceeded costs of groundwater, local interest was insufficient to implement a surface water system at that time. However, awareness of projected area water needs and interest in higher quality water was increased[2], and the Comal County Commissioner's Court appointed a Water Study Group to review alternatives. Recommendations received by the Court included creation of a regional water supply entity to serve as large an area as feasible, including the Bulverde area, if possible.

In 1991, the Canyon Lake Water Supply Corporation (CLWSC) was formed for several purposes, including implementing a regional plan for development of surface water supply and distribution facilities in the Canyon Lake area. In 1994, CLWSC acquired and began operating approximately 30 independent water supply systems in the area and has constructed a 0.5 mgd surface water treatment plant near the south end of Canyon Dam, as shown on Figure 3.1-1. CLWSC is continuing planning efforts to increase surface water supplies to the area. As part of their regional plan, CLWSC has identified two potential locations for delivery of treated water. The locations are: at the existing 100,000 gal ground storage tank at the Triple Peak Water Treatment Plant; and, at a potential elevated storage tank in the area of Rolling Hills subdivision. Both of these locations are shown on Figure 3.1-1.

In the Water Supply Study for Western Comal County[3], GBRA studied options to lower costs for treated surface water. A key goal of GBRA was to determine a plant size, delivery system, and customer base that met these objectives: (1) size the plant large enough to reach economies of scale; (2) provide service to customers with large base loads to more fully utilize

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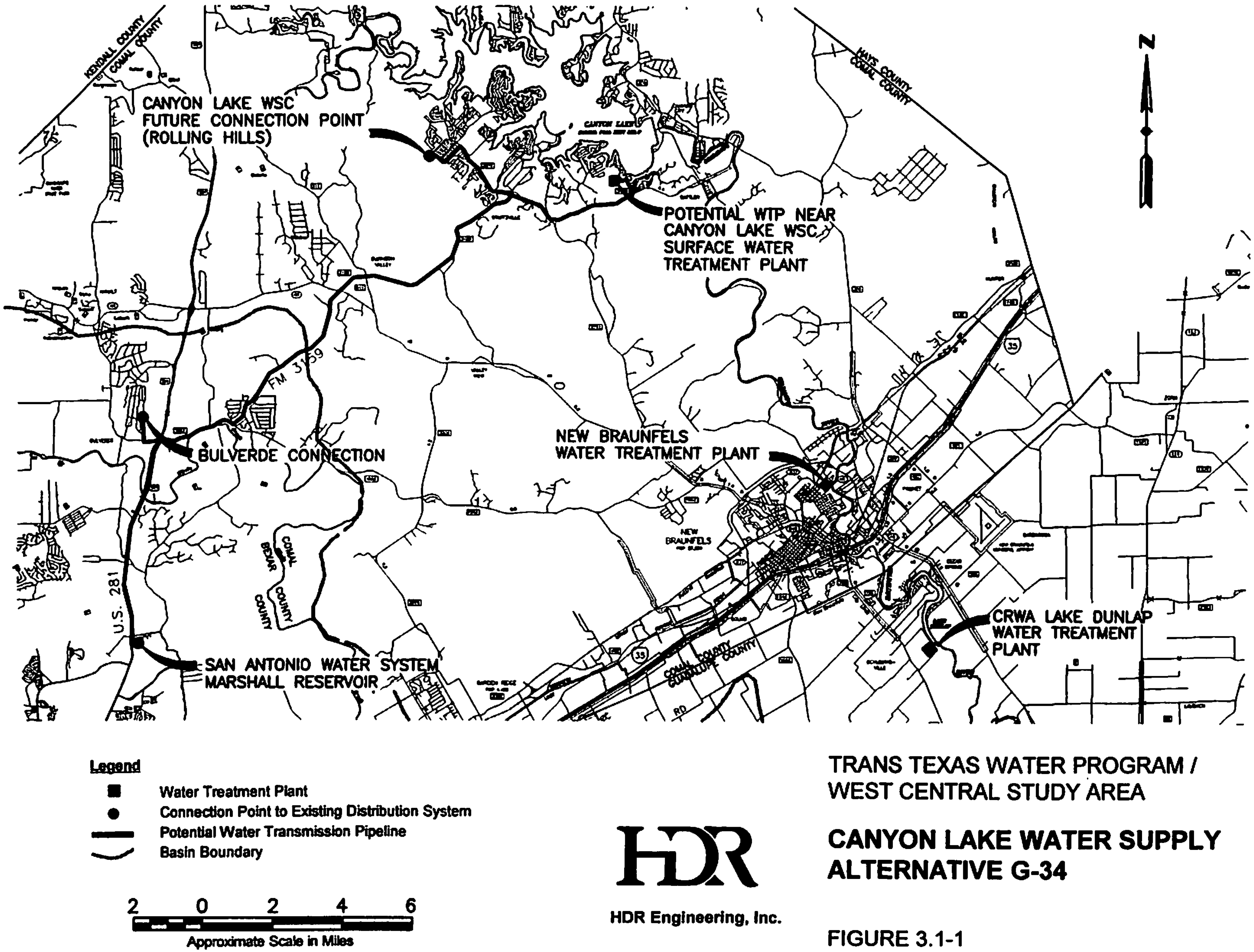
[1] "Regional Water Plan", Guadalupe-Blanco River Authority, 1991.
[2] "Water Supply Study for Western Comal County (Draft)", Guadalupe-Blanco River Authority, 1993.
[3] Ibid.



HDR

HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM /
WEST CENTRAL STUDY AREA

CANYON LAKE WATER SUPPLY
ALTERNATIVE G-34

FIGURE 3.1-1

facilities; and, (3) use modular treatment equipment to reduce costs. The San Antonio Water System offers a base-load customer that could initially receive and use all the water from a Canyon Lake regional water system thereby optimizing utilization of facilities with a resulting lowering of unit costs.

This alternative would involve construction of these facilities: an intake and raw water pump station on the south side of Canyon Lake near the dam; a surface water treatment plant and treated water pump station; water transmission pipeline to SAWS' Marshall Reservoir (potential route shown on Figure 3.1-1); water delivery pipelines to the Rolling Hills and Bulverde connections; new ground storage tanks at the treatment plant, Rolling Hills, and Bulverde; and booster pump stations.

3.1.2 Available Water Supply and Projected Demand

This water supply alternative is for a regional water system that would provide treated surface water supply to Canyon Lake WSC, the Bulverde area, and to the San Antonio Water System (Marshall Reservoir facility). Diversion quantities of 5,000 acft/yr and 8,000 acft/yr of stored water in Canyon Lake have been studied. From these quantities, 2,000 acft/yr was reserved for delivery to Canyon Lake WSC. Bulverde would receive quantities up to their projected year 2020 shortage (596 acft/yr). Annual diversion quantities, type of delivery rates, and delivery locations are listed in Table 3.1-1. Tables 3.1-2 and 3.1-3 summarize the water allocation to each potential customer for an annual diversion of 5,000 acft/yr. Tables 3.1-4 and 3.1-5 summarize the allocation for an annual diversion of 8,000 acft/yr.

As indicated in Tables 3.1-2 through 3.1-5, allocations of water to entities in the GBRA statutory district are about equal to year 2020 shortages and delivery facilities were sized for these annual allocations with peak day factors applied (see Section 3.1.5, Engineering and Costing). A planning horizon date of 2020 was chosen for sizing of facilities in the GBRA statutory area as providing a reasonable amount of capacity for growth, but not oversizing facilities. Facilities sized to deliver projected year 2020 shortages would become fully utilized at about the time project debt is retired, assuming a 20 year debt service period.

Tables 3.1-3 and 3.1-5 indicate quantities of 2,404 acft/yr and 5,404 acft/yr, are available in year 2020 to Bexar County (delivered to SAWS). However, prior to year 2020, more than these amounts would be available to SAWS. In the near future, most, if not all, of the amount

Table 3.1-1 Definition of Alternatives for Canyon Lake Water Supply to Canyon Lake WSC/Bulverde/North Bexar County (Alternative G-34)			
Alternative	**Diversion Quantity (acft/yr)**	**Delivery Rate**	**Delivery Location**
G-34A	5,000	uniform	Triple Peak (CLWSC), Rolling Hills (CLWSC), Bulverde, SAWS
G-34B	5,000	summer peaking	Triple Peak (CLWSC), Rolling Hills (CLWSC), Bulverde, SAWS
G-34C	8,000	uniform	Triple Peak (CLWSC), Rolling Hills (CLWSC), Bulverde, SAWS
G-34D	8,000	summer peaking	Triple Peak (CLWSC), Rolling Hills (CLWSC), Bulverde, SAWS

Table 3.1-2 Allocation of 5,000 acft/yr Canyon Lake Supply Delivered to Canyon Lake WSC/Bulverde/North Bexar County (Alternatives G-34A and G-34B)				
	1990	**PROJECTED SHORTAGES (1)**		**ALLOCATION OF NEW**
DELIVERY POINT	**DEMAND (acft/yr)**	**YEAR 2020 (acft/yr)**	**YEAR 2050 (acft/yr)**	**SUPPLY (acft/yr)**
Entities in GBRA Statutory District:				
Canyon Lake WSC (2)	1,093	2,676	3,609	2,000
Bulverde (3)	224	596	1,117	596
GBRA Area Subtotal	1,317	3,272	4,726	2,596
Amount Remaining for Delivery to Bexar County:				2,404

(1) Projected shortages in other areas of Guadalupe and Comal counties not included in this alternative.
(2) Delivery of new water supply to Canyon Lake WSC will be made at two points, each receiving 1,000 acft/yr.
(3) Source: "West Central Study Area, Phase I Interim Report" Volume 3, Table 3.35-1, Trans-Texas Water Program, November, 1994, HDR Engineering, Inc.

Table 3.1-3 Allocation of 2,404 acft/yr Potential Supply from Canyon Lake Delivered to Bexar County (Alternatives G-34A and G-34B)				
	1990	**PROJECTED SHORTAGES**		**ALLOCATION OF NEW**
DELIVERY POINT	**DEMAND (acft/yr)**	**YEAR 2020 (acft/yr)**	**YEAR 2050 (acft/yr)**	**SUPPLY (acft/yr)**
Entities in Bexar County:				
SAWS/BMWD & Remainder of Bexar County	238,238	226,477	391,531	2,404

Table 3.1-4
Allocation of 8,000 acft/yr Canyon Lake Supply
Delivered to Canyon Lake WSC/Bulverde/North Bexar County
(Alternatives G-34C and G-34D)

DELIVERY POINT	1990 DEMAND (acft/yr)	PROJECTED SHORTAGES (1) YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	ALLOCATION OF NEW SUPPLY (acft/yr)
Entities in GBRA Statutory District:				
Canyon Lake WSC (2)	1,093	2,676	3,609	2,000
Bulverde (3)	224	596	1,117	596
GBRA Area Subtotal	1,317	3,272	4,726	2,596
Amount Remaining for Delivery to Bexar County:				5,404

(1) Projected shortages in other areas of Guadalupe and Comal counties not included in this alternative.
(2) Delivery of new water supply to Canyon Lake WSC will be made at two points, each receiving 1,000 acft/yr.
(3) Source: "West Central Study Area, Phase I Interim Report" Volume 3, Table 3.35-1, Trans-Texas Water Program, November, 1994, HDR Engineering, Inc.

Table 3.1-5
Allocation of 5,404 acft/yr Potential Supply from Canyon Lake
Delivered to Bexar County (Alternatives G-34C and G-34D)

DELIVERY POINT	1990 DEMAND' (acft/yr)	PROJECTED SHORTAGES YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	ALLOCATION OF NEW SUPPLY (acft/yr)
Entities in Bexar County:				
SAWS & Remainder of Bexar County:	238,238	226,477	391,531	5,404

diverted from Canyon Lake would be available for delivery to SAWS. With implementation of SB 1477, immediate demands for new water supplies in Bexar County are about 31,000 acft/yr. Consequently, delivery facilities to SAWS for this alternative were sized for the full delivery amounts (5,000 acft/yr and 8,000 acft/yr). The LOI participants recognize that this alternative meets a small portion of the projected shortages. However, this project has fewer required permits and appears to be able to be implemented quickly, thereby potentially taking the first step to bring new water sources to San Antonio.

3.1.3 Environmental Issues

The project area lies within Comal and Bexar Counties. The proposed pipeline route traverses Brackett-Comfort-Real (shallow, undulating to steep soils over limestone or strongly cemented chalk on uplands of the Edwards Plateau), Comfort-Rumple-Eckrant (very shallow to moderately deep, undulating to steep and hilly soils over indurated limestone on uplands of the Edwards Plateau), and Lewisville-Gruene-Krum (deep, shallow, and very shallow nearly level to gently sloping soils over loamy, clayey, and gravely sediments on stream terraces and valley fills of the Blackland Prairie and Edwards Plateau) soil associations in Comal County.[4] In Bexar County, the pipeline route traverses Lewisville-Houston Black, terrace, association (Deep, calcareous clayey soils in old alluvium) and Tarrant-Brackett (shallow and very shallow soils over limestone) soil associations[5]

Most of Comal County lies within the Edwards Plateau Ecological Area except for a narrow strip along the southeastern county line which lies within the Blackland Prairies Ecological Area.[6] The northern quarter of Bexar County also lies within the Edwards Plateau and the central part of the county lies within the Blackland Prairies. These ecological areas are described in the environmental overview section (Section 3.0.4). Vegetational habitats in the project area have been characterized as Live Oak - Ashe Juniper Parks, Live Oak - Mesquite - Ashe Juniper Parks, and Live Oak - Ashe Juniper Woods.[7] The parks are characteristic of level to gently rolling uplands and ridge tops on the Edwards Plateau. Live Oak - Ashe Juniper Woods are found primarily on shallow limestone soils on the hills and escarpment of the Edwards Plateau.

The proposed pipeline route from Canyon Lake to the delivery points is about 28 miles long and would mostly follow existing roadways (FM 2673, FM 3159, and SH 281). Installation of the pipeline, assuming a construction ROW width of 140 feet, would affect a total of 453.1 acres including 30.5 acres grass (6.7 percent), 56 acres crop (12.4 percent), 76.4 acres shrub (16.9 percent), 200.2 acres brush (44.2 percent), 28.8 acres park (6.4 percent), and 27.2 acres wood (6

[4] Soil Conservation Service. 1984. Soil Survey of Comal and Hays Counties Texas. SCS, USDA, In cooperations with Texas Agricultural Experiment Station.
[5] Soil Conservation Service. 1962. Soil Survey of Bexar County Texas. SCS, USDA, In cooperations with Texas Agricultural Experiment Station.
[6] Gould, F. W. 1975. The grasses of Texas. Texas A&M University Press.
[7] McMahan, C.A., R.G. Frye and K.L. Brown. 1984. The Vegetation Types of Texas Including Cropland. Texas Parks and Wildlife Department, Austin, Texas.

percent); 33.9 acres (7.5 percent) is residentially and commercially developed.[8] A mowed ROW planted in grasses would be maintained for the life of the project. A 40 foot wide maintenance ROW would affect a total of 129.5 acres including 8.7 acres of grass, 16 acres of crop, 21.8 acres of shrub, 57.2 acres of brush, 8.2 acres of park, and 7.8 acres of wood. Areas presently in grass and crop can be returned to their original condition following pipeline installation. The construction ROW would be seeded in appropriate grasses. Without further disturbance brush would be expected to heavily reinvade areas outside the maintenance ROW within 5 to 10 years following construction.

Protected species and candidate species for possible protection by USFWS and TPWD for Bexar, Comal, and Guadalupe Counties are presented in Appendix D, Tables 1 - 4. Reported occurrences of the Texas salamander (*Eurycea neotenes*) and hill country wild-mercury (*Argythamia aphoroides*) are recorded in TNHP files on the Smithson Valley quadrant.[9] Although Texas salamander has not be reported to occur in the immediate project area, hill country wild-mercury is reported to occur along the proposed pipeline route southwest of the City of Startzville.[10] The hill country wild-mercury is a rare endemic plant that inhabits dry sandy and rocky soil over limestone on the Edwards Plateau. It is listed as a federal candidate (C2) species and a TOES species Category V plant.[11] Additionally, the TOES list of sensitive plants reported to potentially occur in the Counties of Bexar and Comal includes the following species: bracted twistflower (*Streptanthus bracteatus*), south Texas rushpea (*Caesalpinia phyllanthoides*), Comal snakewood (*Colubrina stricta*), Texas gourd (*Cucurbita texana*), Lindheimer's tickseed (*Desmodium lindheimeri*), Heller's marbleseed (*Onosmodium helleri*), Canyon mockorange (*Philadelphus ernestii*), Texas mockorange (*P. texensis*), Correl's false dragonhead (*Physostegia correlli*), Park's jointweed (*Polygonella parksii*), big red sage (*Salvia penstemonoides*), dark noseburn (*Tragia nigricans*). Bracted twistflower is listed as a TOES category III (state endangered). The remaining plants are listed as TOES category V (watch list).

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[8] These preliminary estimates were based on available Soil Conservation Service Maps and USGS 7.5 minute quadrants: Smithson Valley, Sattler, Annhalt and Bulverde, and should be updated using aerial photographs from the EROS data center in a later phase of project development.

[9] TPWD. 1996 (January). Unpublished maps and data files, Texas Natural Heritage Program, Department of Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

[10] Ibid.

[11] Texas Organization For Endangered Species. 1993. Endangered, Threatened and Watch Lists of Texas Plants. TOES. Austin, Texas.

Although listed by TOES some of these plants are very unlikely to be encountered by any of the projects considered herein. For example, the habitat for Lindheimer's tickseed in unknown and its last documented occurrence in the state was in the 1840's by Ferdinand Lindheimer.[12]

Guadalupe bass (*Micropterus treculi*), Texas salamander, canyon mockorange (*Philadelphus ernestii*), and Texas amorpha (*Amorpha roemeriana*) are reported by the TNHP on the Sattler quadrant.[13] Comal Blind salamander (*Eurycea tridentifera*), Cagle's map turtle (*Graptemys caglei*), golden-cheeked warbler (*Dendroica chrysoparia*), Guadalupe bass, Texas salamander (*Eurycea neotenes*) are reported on the Annhalt quadrant.[14] Texas salamander and Buckley tridens (*Buckleyannus tridens*) are reported on the Bulverde quadrant.[15]

Comal County is within the range of the golden-cheeked warbler and black-capped vireo (*Vireo atricapillus*). The golden-cheeked warbler inhabits mature oak-ashe juniper woods. It requires strips of Ashe juniper bark for nest material. The black-capped vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories. Because Alternative G-34 would involve construction mostly along existing ROWs, for the most part, habitat for either of these birds is unlikely to be encountered. Additionally, important habitats can be avoided by selection of the pipeline route.

The Texas salamander is endemic to the Balcones Escarpment and adjacent portions of the Edwards Plateau of south central Texas.[16] Because the Texas salamander inhabits springs, seeps, and small cavern streams, populations are reproductively isolated. Reproductive isolation favors genetic/evolutionary divergence. Local populations vary in coloration, size, robustness, and head shape. Diversity between isolated populations can result in endemism where each population constitutes a unique species. The Texas salamander is neotenic, retaining gills which typically are characteristic of larval salamanders. Although the Texas salamander is not listed as an endangered or threatened species, because it inhabits isolated springs, it is listed as S3 ("Rare or uncommon in state, 21 to 100 occurrences") by TPWD and C2 (candidate, Category 2,

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[12] Ibid.
[13] TPWD, 1996 (January), op. cit.
[14] Ibid.
[15] Ibid.
[16] Conant, R. 1975. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Houghton Mifflin Company, Boston.

consideration for threatened/endangered status may be appropriate, however, data are insufficient to support immediate preparation of rules) by USFWS.[17]

Generally, impacts to terrestrial species can be avoided by selecting a pipeline route that avoids critical habitat for the species. For example, the Texas salamander occurs in springs. Selecting a pipeline route following existing highway and utility ROWs also would reduce the likelihood of encountering protected or rare species. Habitat surveys of the proposed route should be conducted in a later phase of the project to accurately assess impacts and aid in the selection of an easement that would avoid or minimize environmental impacts.

Alternative G-34 would require the purchase of either 5,000 acft/yr or 8,000 acft/yr of Canyon Lake water from GBRA. This purchase could be made under the existing Canyon Lake permit. The purchased water would be released from Canyon Lake to an intake near the existing CRWA intake on Lake Dunlap.

In the event diversions are made under the existing Canyon Lake permit, no in-stream flow studies would be needed. In the event that the Canyon Lake permit is amended to allow increased annual diversions, the current FERC release requirements should meet instream flow requirements. In-stream flow studies may be needed for the affected reach to evaluate the potential effects of the project on the general ecology of the river and on Cagle's map turtle (*Graptemys caglei*) and Guadalupe bass (*Micropterus treculi*).

Cagle's map turtle and Guadalupe bass are species of concern associated with the Guadalupe River. Cagle's map turtle is a small turtle found only in the Guadalupe River system in the southeast-central part of the state. It is highly aquatic and is rarely seen on land except when nesting. Cagle's map turtle prefers slow-moving stretches of the river and its tributaries. It requires adequate basking sites, such as exposed rocks, cypress knees, or partially submerged logs. Currently, Cagle's map turtle is listed as a C1 candidate by USFWS.[18]

Guadalupe bass occurs in central Texas streams of the Edwards Plateau. Although its range extends from the Edwards Plateau, through the Blackland Prairie and to the Coastal Plain abundance declines as streams cross the Coastal Plain. The range includes portions of the drainage systems of the San Antonio, Guadalupe, Colorado and Brazos river systems. It also

[17] USFWS. 1994. Endangered and Threatened Wildlife and Plants; Animal Candidate Review for Listing as Endangered or Threatened Species; proposed Rule. Federal Register: November 15, 1994.
[18] Ibid.

now occurs in the Nueces and Sabinal Rivers due to introductions by TPWD. Guadalupe bass is reported to occur typically in flowing water, and is often observed near riffles feeding on insects. However, in a study of fish-habitat associations conducted on the Colorado River there was no statistically significant association between Guadalupe Bass and particular habitat types.[19] The Guadalupe bass is listed by U.S. Fish and Wildlife Service as a C2 candidate species. The diversion considered in Alternative G-34 concerns available water from the permitted firm yield of Canyon Lake. Blue sucker (*Cycleptus elongatus*) is a federal candidate for protection and is listed by TPWD as threatened. It is a large river fish possibly occurring in the Guadalupe River. However, Hubbs, et al, does not report blue sucker as having been collected from the upper Guadalupe River.[20] Significant adverse impacts on Cagle's map turtle and the Guadalupe bass, as well as other riverine species is not expected.

Canyon Lake is a water conservation and flood control reservoir located on the Guadalupe River in Comal County.[21] The reservoir was filled in 1964 and has a conservation pool elevation of 909 ft msl. Canyon Lake covers about 8,231 surface acres at conservation pool elevation and has a capacity of 382,000 acft.

In addition to the Guadalupe River several creeks drain into Canyon Lake. These include Rebecca Creek, Schultz Creek, Potters Creek, Jentsch Creek, Tom Creek and some unnamed creeks. Like most creeks in the area, these are intermittent streams which tend to be dry in the summer but may have isolated pools within their streambeds during some years. At the mouths of drainages on the lake, shallow coves tend to support more wetland and mesic shoreline habitats than other areas. Emergent vegetation and broadleaf shrub in shoreline wetlands are more common along the upper shoreline away from the dam.[22]

Canyon Lake is primarily surrounded by residential and recreational developments including public parks. In addition to Canyon Lake itself, the Guadalupe River above and below the lake is a popular recreational destination that has seen substantial shoreline development in recent years. Surrounding land use is predominately rangeland with a spreading ring of suburban

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[19] Mosier, D.T. and R.T. Ray. 1992. Instream Flows for the Lower Colorado River. Lower Colorado River Authority. Austin, Texas.
[20] Hubbs, C., R.J. Edwards and G.P. Garrett. 1991. An Annotated Checklist of the Freshwater Fishes of Texas, With Keys to Identification of Species. Texas Journal of Science, 43(4),1-56.
[21] HDR, Inc. et. al. 1994. Trans-Texas Water Program. West Central Study Area. Volume 3.
[22] U.S. Fish and Wildlife Service. 1990. National Wetland Inventory Map Series; Devils Backbone; Fischer; Sattler; and Smithson Valley, U.S. Geological Service Quadrangles, U.S. Department of the Interior.

residential developments centered around the lake shore. Public access to scenic views and the lake shore is provided at parks operated by the U.S. Army Corps of Engineers. Private marinas, restaurants, and vacation properties allow additional lake access to tourists and area residents. Randolph Air Force Base Recreational Area and the 5th Army Retreat are located on the north shore of the lake near the dam.

The proposed pipeline route crosses several small intermittent streams, but no major rivers. The proposed diversion involves Canyon Lake firm yield already permitted for use. No environmental effects on Canyon Lake or on the river downstream in addition to those already addressed in the permitting process are expected.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction will be first surveyed by qualified professionals for the presence of significant cultural resources.

3.1.4 Water Quality and Treatability

[To be completed in subsequent phases of the study.]

3.1.5 Engineering and Costing

For this alternative, surface water would be supplied from a new treatment plant to be built near the existing CLWSC Triple Peak water treatment plant with treated water supplied on a wholesale basis to CLWSC (two delivery points), Bulverde, and San Antonio Water System. Figure 3.1-1 shows a possible water treatment plant location with pipeline routes, however, facility locations may be adjusted once route studies and on-the-ground surveys have been performed in subsequent project phases.

Raw water would be pumped to the treatment plant from the water intake to be located in the general vicinity of the south end of Canyon Dam. Treatment would consist of conventional surface water treatment (flocculation, settling, filtration, and chlorine disinfection), possibly utilizing modular treatment units (such as the type of units already in use at the CLWSC plant).

The major facilities required to implement this alternative are:

- Reservoir Intake and Pump Station
- Raw Water Pipeline to Treatment Plant

- Water Treatment Plant
- Treated Water Pump Station
- Transmission Pipeline
- Interconnect to CLWSC at Triple Peak
- Interconnect to CLWSC at Rolling Hills
- Interconnect to Bulverde
- Ground Storage Tanks (one at Rolling Hills and one at Bulverde)
- Booster Pump Station

Alternative G-34A and G-34B: Delivery of 5,000 acft/yr of Canyon Lake Water to Canyon Lake WSC/Bulverde/North Bexar County

Delivery facilities were sized to deliver year 2020 projected shortages to CLWSC (1,000 acft/yr at Triple Peak area and 1,000 acft/yr at Rolling Hills) and 596 acft/yr to Bulverde. Delivery facilities to the San Antonio Water System Marshall Reservoir were sized to deliver 5,000 acft/yr. Two delivery rate scenarios were considered: a uniform annual delivery rate (Alternative G-34A); and, a summer month peak rate of 2.0 times the uniform annual delivery rate (Alternative G-34B). Table 3.1-6 summarizes the design delivery rate and pipeline sizes at the raw water intake and at each of the delivery locations.

<table>
<tr><th colspan="7">Table 3.1-6
Delivery Rates and Pipeline Sizes for Alternatives G-34A and G-34B</th></tr>
<tr><th rowspan="3">Location</th><th rowspan="3">Annual Delivery Amount (acft/yr)</th><th rowspan="3">Description of Connection & Capital Cost Item</th><th colspan="4">Design Delivery Rate and Size</th></tr>
<tr><th colspan="2">Uniform Annual Delivery (G-34A)</th><th colspan="2">Summer Peak Delivery (G-34B)</th></tr>
<tr><th>Delivery Rate (mgd)</th><th>Pipeline Diameter</th><th>Delivery Rate (mgd)</th><th>Pipeline Diameter</th></tr>
<tr><td>Raw Water Intake</td><td>5,000</td><td>----</td><td>4.5</td><td>18"</td><td>8.9</td><td>24"</td></tr>
<tr><td>CLWSC-Triple Peak</td><td>1,000</td><td>Connection to existing WTP</td><td>0.9</td><td>8"</td><td>1.8</td><td>10"</td></tr>
<tr><td>CLWSC-Rolling Hills</td><td>1,000</td><td>New 1,000 gallon GST</td><td>0.9</td><td>8"</td><td>1.8</td><td>10"</td></tr>
<tr><td>Bulverde</td><td>596</td><td>New 100,000 gallon GST</td><td>0.5</td><td>6"</td><td>1.1</td><td>8"</td></tr>
<tr><td>SAWS-Marshal Reservoir</td><td>2,404</td><td>Connection to existing GST</td><td>4.5</td><td>18"</td><td>8.9</td><td>24"</td></tr>
</table>

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water, land, and environmental mitigation. Cost estimates for Alternatives G-34A and G-34B are presented in Table 3.1-7. The total estimated project cost of Alternative G-34A, based on a uniform annual delivery rate, is $21,490,000 (Table 3.1-7), which results in a total annual cost, including operation and maintenance and purchase of stored water, of $3,025,000. The total estimated project cost for Alternative G-34B, based on a summer peak delivery rate, is $29,550,000 (Table 3.1-7), which results in a total annual cost, including operation and maintenance and purchase of stored water, of $4,145,000. The operating cost was determined for a total static lift from Canyon Lake to the SAWS Marshall Reservoir of 358 ft and an annual delivery of 5,000 acft.

Table 3.1-7
Cost Estimate Summaries for Potential Supply from Canyon Lake Delivered to Canyon Lake WSC/Bulverde/North Bexar County 5,000 acft/yr (Alternatives G-34A and G-34B) (First Quarter - 1996 Prices)

Item	Alt. G-34A Uniform Annual Delivery	Alt. G-34B Summer Peak Delivery
Capital Costs		
Intake and Treatment Plant	$5,270,000	$9,110,000
Transmission Pipelines	7,890,000	9,300,000
Booster Pump Stations	770,000	1,310,000
Interconnects to Participants	1,080,000	1,080,000
Total Capital Cost	$15,010,000	$20,800,000
Engineering, Contingencies, and Legal Costs	4,910,000	6,870,000
Environmental Studies and Mitigation	370,000	370,000
Land Acquisition	370,000	370,000
Interest During Construction	830,000	1,140,000
Total Project Cost	$21,490,000	$29,550,000
Annual Costs		
Annual Debt Service	$2,010,000	$2,770,000
Annual Operation and Maintenance		
Water Treatment Plant	290,000	620,000
Transmission Pipeline	120,000	150,000
Annual Power Cost	340,000	340,000
Purchase of Stored Water(1)	265,000	265,000
Total Annual Cost	$3,025,000	$4,145,000

(1) Cost of stored water purchased from GBRA is $53/acft

The estimated cost of each alternative was allocated to each delivery location based on the pro-rata capacity of each component dedicated to meeting years 2000 and 2020 demands at the delivery location. Thus, for raw water and treatment facility costs, participants would pay a pro-rata share based solely on the percent of total capacity dedicated to meeting their year 2000 and year 2020 water demands. The participant's location relative to the water source did not affect the cost allocation for treatment. For transmission and pump station costs, allocation was made on a pro-rata allocation of the facilities needed to deliver water to them, consequently, costs to participants that are furthest from the water source are proportionately greater.

For Alternatives G-34A and G-34B (annual delivery of 5,000 acft), Tables 3.1-8 and 3.1-9 summarize the total annual cost and the annual unit cost of treated water for years 2000 and 2020 conditions. Early in project operation, small quantities of water will be delivered to participants and all remaining water will be delivered to SAWS. The cost of water for full usage at a uniform delivery rate varies from $315 per acft/yr for delivery to CLWSC at Triple Peak to $760 per acft/yr (Table 3.1-8) delivered to Bulverde. For a summer peaking distribution pattern, and full usage of the allotted amount, the unit cost of water varies from $491 per acft/yr for delivery to CLWSC at Triple Peak to $1,003 per acft/yr (Table 3.1-9) delivered to Bulverde.

For the case of all 5,000 acft/yr being delivered to Bexar County at the SAWS Marshall Reservoir (as possibly would happen in the early years of project operation), the annual unit cost was estimated to be $586 per acft/yr at a uniform delivery rate and $801 per acft/yr for a summer peaking delivery pattern. These unit costs are inclusive of all systems costs (capital and O&M) for all system components except lateral pipelines and connections to intermediate delivery points.

Alternative G-34C and G-34D: Delivery of 8,000 acft/yr of Canyon Lake Water to Canyon Lake WSC/Bulverde/North Bexar County

Delivery facilities were sized to deliver year 2020 projected shortages to CLWSC (1,000 acft/yr at Triple Peak area and 1,000 acft/yr at Rolling Hills) and 596 acft/yr to Bulverde. Delivery facilities to the San Antonio Water System Marshall Reservoir were sized to deliver 8,000 acft/yr. Two delivery rate scenarios were considered: a uniform annual delivery rate (Alternative G-34C); and, a summer month peak rate of 2.0 times the uniform annual delivery

Table 3.1-8 Summary of Costs by Delivery Location Potential Supply from Canyon Lake Delivered to Canyon Lake WSC/Bulverde/North Bexar County 5,000 acft/yr, Uniform Annual Delivery (G-34A) (First Quarter - 1996 dollars)								
	Year 2000				Year 2020			
Delivery Location (Max. Delivery Rate, mgd; Connection Pipe Size, in)	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft/yr	Unit Cost(2) $/1000 gal	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft/yr	Unit Cost(2) $/1000 gal
CLWSC--Triple Peak (0.90 mgd, 8")	204	$179,000	$876	$2.69	1,000	$317,000	$315	$0.97
CLWSC--Rolling Hills (0.90 mgd, 8")	204	$367,000	$1,801	$5.53	1,000	$506,000	$504	$1.55
Bulverde (0.53 mgd, 6")	106	$341,000	$3,217	$9.88	596	$453,000	$760	$2.33
SAWS--Marshall Reservoir (4.5 mgd, 18")	4,486	$2,138,000	$476(3)	$1.46(3)	2,404	$1,749,000	$730(3)	$2.24(3)
Total	5,000	$3,025,000	$605	$1.86	5,000	$3,025,000	$605	$1.86

(1) Not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include the operating cost of the participants distribution system.
(3) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water, and the cost to transport the water, may occur before year 2020.
Note: The unit cost for delivery of all 5,000 acft/yr to SAWS would be about $586 per acft/yr (or $1.80/1,000 gallons).

Table 3.1-9 Summary of Costs by Delivery Location Potential Supply from Canyon Lake Delivered to Canyon Lake WSC/Bulverde/North Bexar County 5,000 acft/yr, Summer Peaking Delivery (G-34B) (First Quarter - 1996 dollars)								
	Year 2000				**Year 2020**			
Delivery Location (Max. Delivery Rate, mgd; Connection Pipe Size, in)	**Annual Volume(1) (acft/yr)**	**Annual Cost**	**Unit Cost(2) \$/acft/yr**	**Unit Cost(2) \$/1000 gal**	**Annual Volume(1) (acft/yr)**	**Annual Cost**	**Unit Cost(2) \$/acft/yr**	**Unit Cost(2) \$/1000 gal**
CLWSC--Triple Peak (1.8 mgd, 10")	204	$295,000	$1,445	$4.44	1,000	$491,000	$491	$1.51
CLWSC--Rolling Hills (1.8 mgd, 10")	204	$498,000	$2,446	$7.50	1,000	$695,000	$695	$2.13
Bulverde (1.1 mgd, 8")	106	$451,000	$4,254	$13.06	596	$598,000	$1,003	$3.08
SAWS--Marshall Reservoir (8.9 mgd, 24")	4,486	$2,901,000	$647(3)	$1.99(3)	2,404	$2,361,000	$982(3)	$3.01(3)
Total	5,000	$4,145,000	$829	$2.54	5,000	$4,145,000	$829	$2.54

(1) Not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include the operating cost of the participant's distribution system.
(3) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water, and the cost to transport the water, may occur before year 2020.
Note: The cost to deliver all 5,000 acft/yr to SAWS would be about $801 per acft/yr ($2.46/1,000 gallons).

rate (Alternative G-34D). Table 3.1-10 summarize the design delivery rate and pipeline sizes at the raw water intake and at each of the delivery locations.

Table 3.1-10
Delivery Rates and Pipeline Sizes for Alternatives G-34C and G-34D

Location	Annual Delivery Amount (acft/yr)	Description of Connection & Capital Cost Item	Design Delivery Rate and Size: Uniform Annual Delivery (G-34A) Delivery Rate (mgd)	Uniform Annual Delivery (G-34A) Pipeline Diameter	Summer Peak Delivery (G-34B) Delivery Rate (mgd)	Summer Peak Delivery (G-34B) Pipeline Diameter
Raw Water Intake	8,000	----	7.1	24"	14.3	30"
CLWSC-Triple Peak	1,000	Connection to existing WTP	0.9	8"	1.8	10"
CLWSC-Rolling Hills	1,000	New 100,000 gallon GST	0.9	8"	1.8	10"
Bulverde	596	New 100,000 gallon GST	0.5	6"	1.1	8"
SAWS-Marshal Reservoir	5,404	Connection to existing GST	7.1	24"	14.3	30"

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water, land, and environmental mitigation. Cost estimates for Alternatives G-34C and G-34D are presented in Table 3.1-11. The total estimated project cost of Alternative G-34C (uniform delivery) is $26,300,000 (Table 3.1-11), which results in a total annual cost, including operation and maintenance of $3,834,000. The total estimated project cost for Alternative G-34D (summer peak delivery) is $37,600,000 (Table 3.1-11), which results in a total annual cost, including operation and maintenance of $5,464,000. The operating cost was determined for a total static lift from Canyon Lake to the SAWS Marshall Reservoir of 358 ft and an annual delivery of 8,000 acft at each annual delivery rate. The annual cost for the summer peaking option is about 43 percent greater than the uniform delivery option.

The estimated cost of each alternative was allocated to each delivery location based on the pro-rata capacity of each component dedicated to meeting year 2000 and 2020 demands at the delivery location. Thus, participants would pay a pro-rata share of raw water and treatment facility costs based solely on the percent of total capacity dedicated to meeting their year 2000 and 2020 water demands and the participant's location relative to the water source did not affect calculation of the cost allocation for treatment. For transmission and pump station costs, each participant pays a pro-rata share only of the facilities needed to deliver water to them,

Table 3.1-11 Cost Estimate Summaries for Potential Supply from Canyon Lake Delivered to Canyon Lake WSC/Bulverde/North Bexar County 8,000 acft/yr (Alternatives G-34C and G-34D) (First Quarter - 1996 Prices)		
Item	**Alt. G-34C Uniform Annual Delivery**	**Alt. G-34D Summer Peak Delivery**
Capital Costs		
Intake and Treatment Plant	$7,350,000	$12,140,000
Transmission Pipelines	9,290,000	11,730,000
Booster Pump Stations	770,000	1,670,000
Interconnects to Participants	1,080,000	1,080,000
Total Capital Cost	$18,490,000	$26,620,000
Engineering, Contingencies, and Legal Costs	6,060,000	8,790,000
Environmental Studies and Mitigation	370,000	370,000
Land Acquisition	370,000	370,000
Interest During Construction	1,010,000	1,450,000
Total Project Cost	$26,300,000	$37,600,000
Annual Costs		
Annual Debt Service	$2,460,000	$3,520,000
Annual Operation and Maintenance		
Water Treatment Plant	360,000	880,000
Transmission Pipeline	130,000	180,000
Annual Power Cost	460,000	460,000
Purchase of Stored Water(1)	424,000	424,000
Total Annual Cost	$3,834,000	$5,464,000

(1) Cost of stored water purchased from GBRA is $53/acft

consequently, costs to participants that are furthest from the water source are proportionately greater.

For Alternatives G-34C and G-34D (annual delivery of 8,000 acft), Tables 3.1-12 and 3.1-13 summarize the total annual cost and the unit cost of treated water per acre-foot for year 2000 and year 2020. Early in project operation, small quantities of water will be delivered to participants and all available remaining water will be delivered to SAWS. The cost of water for full usage at a uniform delivery rate varies from $278 per acft for CLWSC at Triple Peak to $585

Table 3.1-12
Summary of Costs by Delivery Location
Potential Supply from Canyon Lake Delivered to Canyon Lake WSC/Bulverde/North Bexar County
8,000 acft/yr, Uniform Annual Delivery (G-34C)
(First Quarter - 1996 dollars)

	Year 2000				Year 2020			
Delivery Location (Max. Delivery Rate, mgd; Connection Pipe Size, in)	**Annual Volume(1) (acft/yr)**	**Annual Cost**	**Unit Cost(2)**		**Annual Volume(1) (acft/yr)**	**Annual Cost**	**Unit Cost(2)**	
			$/acft	**$/1000 gal**			**$/acft**	**$/1000 gal**
CLWSC--Triple Peak (0.90 mgd, 8")	204	$157,000	$769	$2.36	1,000	$278,000	$278	$0.85
CLWSC--Rolling Hills (0.90 mgd, 8")	204	$332,000	$1,628	$5.00	1,000	$453,000	$454	$1.39
Bulverde (0.53 mgd, 6")	106	$261,000	$2,463	$7.56	596	$349,000	$585	$1.80
SAWS--Marshall Reservoir (7.1 mgd, 24")	7,486	$3,084,000	$412(3)	$1.26(3)	5,404	$2,754,000	$510(3)	$1.57(3)
Total	8,000	$3,834,000	$479	$1.47	8,000	$3,834,000	$479	$1.47

(1) Not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include the operating cost of the participant's distribution system.
(3) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water, and the cost to transport the water, may occur before year 2020.
Note: The costs to deliver all 8,000 acft/yr to SAWS would be about $468 per acft/yr ($1.44/1,000 gallons).

Table 3.1-13
Summary of Costs by Delivery Location
Potential Supply from Canyon Lake Delivered to Canyon Lake WSC/Bulverde/North Bexar County
8,000 acft/yr, Summer Peaking Delivery (G-34D)
(First Quarter - 1996 dollars)

Delivery Location (Max. Delivery Rate, mgd; Connection Pipe Size, in)	Year 2000				Year 2020			
	Annual Volume[1] (acft/yr)	Annual Cost	Unit Cost[2] $/acft	Unit Cost[2] $/1000 gal	Annual Volume[1] (acft/yr)	Annual Cost	Unit Cost[2] $/acft	Unit Cost[2] $/1000 gal
CLWSC--Triple Peak (1.8 mgd, 10")	204	$250,000	$1,227	$3.77	1,000	$429,000	$429	$1.32
CLWSC--Rolling Hills (1.8 mgd, 10")	204	$441,000	$2,162	$6.64	1,000	$619,000	$619	$1.90
Bulverde (1.1 mgd, 8")	106	$353,000	$3,332	$10.23	596	$476,000	$799	$2.45
SAWS--Marshall Reservoir (14.3 mgd, 30")	7,486	$4,420,000	$591[3]	$1.81[3]	5,404	$3,940,000	$730[3]	$2.24[3]
Total	8,000	$5,464,000	$684	$2.10	8,000	$5,464,000	$684	$2.10

(1) Not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include the operating cost of the participant's distribution system.
(3) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water, and the cost to transport the water, may occur before year 2020.
Note: The cost to deliver all 8,000 acft/yr to SAWS would be about $671 per acft/yr ($2.06/1,000 gallons).

per acft (Table 3.1-12) for Bulverde. For a summer peaking distribution pattern, and full usage of the allotted amount, the unit cost of water varies from $429 per acft for CLWSC at Triple Peak to $799 per acft (Table 3.1-13) for Bulverde.

For the case of all 8,000 acft/yr being delivered to Bexar County at the SAWS Marshall Reservoir (as possibly would happen in the early years of project operation), the unit cost was estimated to be $468 per acft at a uniform delivery rate and $671 per acft for a summer peaking delivery pattern. These unit costs are inclusive of all system costs (capital and O&M) for all system components, except lateral pipelines and connections to intermediate delivery points.

3.1.6 Implementation Issues

Implementation steps include:

- Commitment of project participants
- Phasing of project elements
- Water purchase contracts with GBRA
- Financing
- Engineering
- Permitting
- Construction
- Operations and Maintenance

Requirements Specific to Diversion of Water from Canyon Lake

1. Necessary permits:
    a. TNRCC Interbasin Transfer Approval
    b. U.S. Army Corps of Engineers (USCE) Sections 10 and 404 dredge and fill permits for the intake.
2. Agreements with USCE and, possibly, Guadalupe-Blanco River Authority to construct and operate an intake and pump station at Canyon Lake.
3. Agreement with GBRA for purchase of stored water from Canyon Lake.

Requirements Specific to Pipelines

1. Necessary permits:
    a. U.S. Army Corps of Engineers (USCE) Sections 10 and 404 dredge and fill permits for stream crossings.
    b. GLO Sand and Gravel Removal permits.
    c. Coastal Coordinating Council review may be required.
    d. TPWD Sand, Gravel and Marl Removal permits.

2. Right-of-way and easement acquisition.
3. Crossings.
    a. Highways and railroads.
    b. Creeks and rivers.
    c. Other utilities.

Requirements Specific to Treatment and Distribution

A detailed study is needed of the cost of pumping and transmission pipeline improvements necessary to effectively integrate the new supply into SAWS water distribution system.

3.2 Guadalupe River Diversion at New Braunfels to Mid-Cities and Bexar County with Expanded New Braunfels Utilities' WTP (G-35)

3.2.1 Description of Alternative

New Braunfels Utilities (NBU) owns and operates an 8 mgd surface water treatment plant located northeast of downtown New Braunfels near the Guadalupe River (see Figure 3.2-1). NBU holds significant run-of-river diversion rights from Guadalupe and Comal Rivers and holds an existing contract with GBRA for the purchase of 6,720 acft/yr of Canyon Lake water.

This alternative considers the purchase of 15,000 acft/yr of uncommitted stored water in Canyon Lake for release to New Braunfels and diversion to an expanded NBU water treatment plant. This additional surface water supply could be delivered to the Mid-Cities in Guadalupe County and potentially to Bexar County. The designation of alternatives, diversion quantity, delivery rates (i.e. peaking factors), and delivery locations are summarized in Table 3.2-1.

This alternative would involve construction of these facilities: an intake and raw water pump station adjacent to the existing NBU intake; expansion of the existing NBU Water Treatment Plant; high service pump station; water transmission pipeline; water delivery pipelines and connections to intermediate delivery locations in Guadalupe County; booster pump station; and, ground storage tank at SAWS Stahl secondary pump station. The locations of these facilities are shown on Figure 3.2-1.

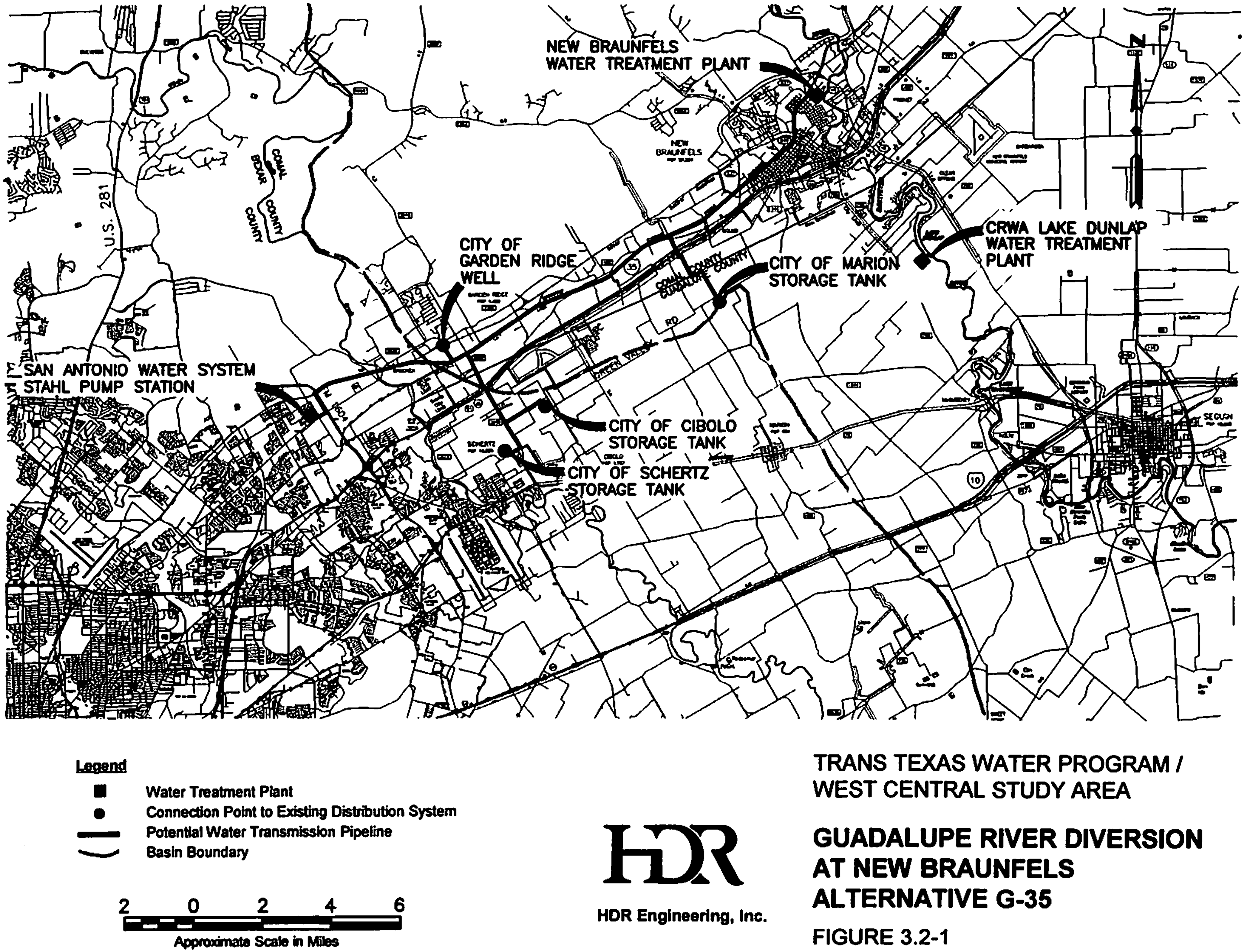
Table 3.2-1
Definition of Alternatives for Guadalupe River Diversion at New Braunfels with Expanded NBU WTP (G-35)

Alternative	Diversion Quantity (acft/yr)	Delivery Rate	Delivery Location
G-35A	15,000	uniform	Marion, Cibolo, Schertz, Garden Ridge, SAWS(1)
G-35B	15,000	summer peaking	Marion, Cibolo, Schertz, Garden Ridge, SAWS(1)

(1) Delivery to SAWS Stahl Secondary Pump Station facility.

3.2.2 Available Water Supply and Projected Demand

This alternative would require the purchase of 15,000 acft/yr of Canyon Lake water from GBRA. This water would be released from Canyon Lake to an expanded existing intake located near New Braunfels on the Guadalupe River.



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GUADALUPE RIVER DIVERSION AT NEW BRAUNFELS ALTERNATIVE G-35

FIGURE 3.2-1

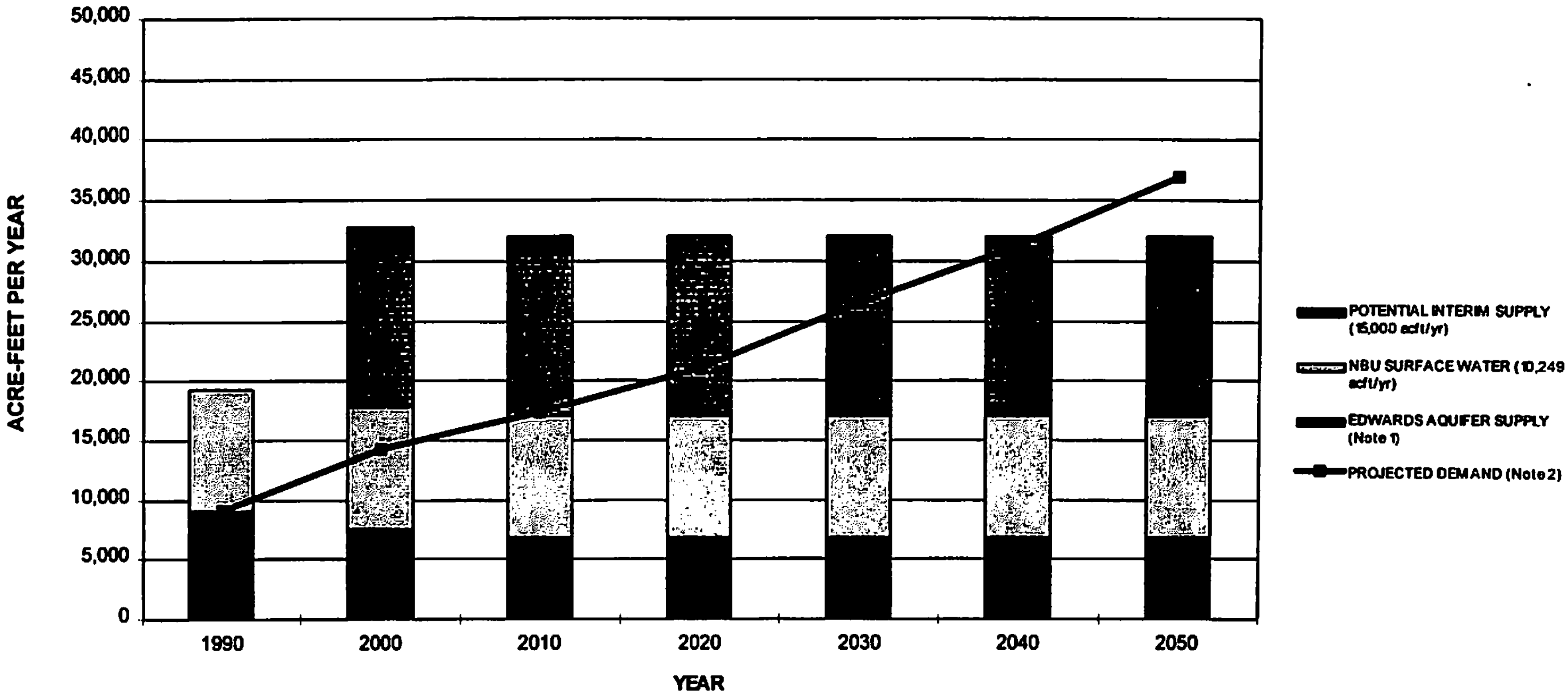
Table 3.2-2 contains projected water demands and current supply for entities in the Mid-Cities area that could potentially purchase the uncommitted yield from Canyon Lake. Table 3.2-2 indicates a projected shortage of 3,968 acft/yr in year 2020 for the Mid-Cities area combined with New Braunfels.

Table 3.2-2
Mid-Cities Area Demand and Supply Including New Braunfels

Entity	Projected Demand						
	1990	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
New Braunfels	6,199	10,335	12,570	15,436	19,499	22,447	25,717
City of Marion	150	169	185	200	216	231	246
City of Garden Ridge	397	613	770	868	1,038	1,253	1,511
City of Cibolo	204	318	307	313	346	392	424
City of Schertz(1)	2,140	2,873	3,515	4,217	5,443	7,027	9,069
Projected Total Demand	**9,090**	**14,308**	**17,347**	**21,034**	**26,542**	**31,350**	**36,967**
Current Supplies							
Edwards Aquifer (2)	9,090	7,533	6,817	6,817	6,817	6,817	6,817
NBU Surface Water(3)	10,249	10,249	10,249	10,249	10,249	10,249	10,249
Total Supply	**19,339**	**17,782**	**17,066**	**17,066**	**17,066**	**17,066**	**17,066**
Projected Shortage	**0**	**0**	**281**	**3,968**	**9,476**	**14,284**	**19,901**

(1) Although a small portion of the Schertz service area is in Bexar County, all of their projected demand is reported here.
(2) Edwards aquifer supply for New Braunfels, Garden Ridge, Marion, Cibolo, and Schertz, with implementation of SB 1477.
(3) Guadalupe run-of-river rights of 2,240 acft/yr; existing GBRA Contract, 6,720 acft/yr; Comal River run-of-river rights, 1,289 acft/yr.

Figure 3.2-2 contains a bar chart plot of the Mid-Cities area and New Braunfels water supplies, including the potential Canyon Lake supply of 15,000 acft/yr, and a line plot of projected demands is superimposed. For the potential supply of 15,000 acft/yr from Canyon Lake (if committed to the Mid-Cities and New Braunfels area) the projected water shortages could be met through about year 2040 as shown on Figure 3.2-2. In 2020, projected shortages in the New Braunfels/Mid-Cities area are about 4,000 acft/yr, and the potential supply of 15,000 acft/yr would leave about 11,000 acft/yr that could be transferred to Bexar County. Engineering and costing was performed for transfers of this quantity to the San Antonio area (see Section 3.2-5, below).



NOTES:

1. EDWARDS AQUIFER SUPPLY FOR NEW BRAUNFELS, MARION, GARDEN RIDGE, CIBOLO, AND SHERTZ WITH IMPLEMENTATION OF SB 1477.
2. PROJECTED DEMAND FOR NEW BRAUNFELS, MARION, GARDEN RIDGE, CIBOLO, AND SHERTZ.

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MID-CITIES AREA DEMAND AND SUPPLY INCLUDING NEW BRAUNFELS

FIGURE 3.2-2

Table 3.2-3 indicates an available allocation of 11,571 acft/yr to Bexar County (delivered to SAWS) in year 2020. However, prior to year 2020, more than this amount would be available for delivery to SAWS[1], and facilities for delivery of potential surface water supplies to Bexar County were sized to deliver the full 15,000 acft/yr. The transmission pipeline to Bexar County was not stepped down in size at connections to intermediate customers in Guadalupe and Comal counties. Thus, the full 15,000 acft/yr can be delivered to Bexar County in the first year of operation. As water demands of Comal and Guadalupe county entities grow, more water would be delivered to them and less water would be transferred to Bexar County. By 2020, the delivery quantity to Bexar County is estimated to be reduced to about 11,500 acft/yr.

Table 3.2-3
Allocation of 15,000 acft/yr Canyon Lake Supply
Delivered to New Braunfels Utilities WTP (Alt G-35A and G-35B)

DELIVERY POINT	1990 DEMAND		PROJECTED SHORTAGES(1)		ALLOCATION OF NEW SUPPLY(2) (acft/yr)
	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	
Entities in GBRA Statutory District:					
Marion	150	5%	87	133	87
Cibolo	204	7%	160	271	160
Schertz	2,140	74%	2,612	7,464	2,612
Garden Ridge	397	14%	570	1,213	570
GBRA Area Subtotal	2,891	100%	3,429	9,081	3,429
Amount Remaining for Delivery to Bexar County:					11,571

(1) Projected shortages in other areas of Guadalupe and Comal counties, including City of New Braunfels, not included.
(2) Allocations of new water supplies to entities in GBRA Statutory Area are set equal to projected 2020 shortages.

3.2.3 Environmental Issues

The majority of the project area lies within Comal County. The Stahl Pump Station is located in Bexar County about two miles from the Comal County line. Most of the proposed pipeline route follows existing railroad and utility ROWs north of and parallel to Interstate Highway 35 between New Braunfels and northeast San Antonio. Soil association types in the project area reflect the fact that the proposed pipeline route roughly follows the boundary between the Edwards Plateau to the northwest and the Blackland Prairie to the southeast. In

[1] With implementation of SB 1477, immediate demands for new water supplies in Bexar County are about 31,000 acft/yr, thereby creating a need for all of the water potentially available from Alternative G-35.

Table 3.2-4 Allocation of 11,571 acft/yr Potential Supply from Canyon Lake Delivered to Bexar County (Alt G-35A and G-35B)					
	1990 DEMAND		PROJECTED SHORTAGES		ALLOCATION OF NEW SUPPLY(1) (acft/yr)
DELIVERY POINT	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	
Entities in Bexar County:					
Universal City	2,323	0.98%	2,444	4,458	113
Converse	1,213	0.51%	2,619	5,546	59
Live Oak	1,221	0.51%	302	822	59
Randolph AFB	1,494	0.63%	538	515	73
SAWS/BMWD & Remainder of Bexar County	231,987	97.38%	226,228	390,569	11,276
Bexar County Subtotal	238,238	100%	232,131	401,910	11,571
(1) Allocations of new water supplies to entities in Bexar County are based on percent distribution of 1990 demand.					

Comal County the soil associations traversed by the pipeline route include Comfort-Rumple-Eckrant, Lewisville-Gruene-Krum, Branyon-Krum, Heiden-Houston Black.[2] The Comfort-Rumple-Eckrant association is very shallow to moderately deep, undulating to steep and hilly soils over indurated limestone and characteristic of the Edwards Plateau. The Lewisville-Gruen-Krum soil association consists of deep, shallow, and very shallow, nearly level to gently sloping soils over loamy, clayey, and gravely sediments on stream terraces and valley fills of Blackland Prairie and Edwards Plateau. The remaining soil associations are characteristic of Blackland Prairie. Branyon-Krum soils are deep, nearly level to gently sloping soils over clayey sediments and located on ancient stream terraces and valley fills of Blackland Prairie. Heiden-Houston Black soils are deep, gently sloping to sloping soils over clay and shale on uplands of Blackland Prairie. In Bexar County the pipeline route crosses Terrant-Brackett, Crawford-Bexar, and Lewisville-Houston Black soil associations.[3] The Terrant-Brackett and Lewisville-Houston

[2] Soil Conservation Service. 1984. Soil Survey of Comal and Hays Counties Texas. SCS, USDA, In cooperations with Texas Agricultural Experiment Station.

[3] Soil Conservation Service. 1962. Soil Survey of Bexar County Texas. SCS, USDA, In cooperations with Texas Agricultural Experiment Station.

Black, terrace, associations are briefly described above (Section 3.1.3, Alternative G-34). The Crawford-Bexar association consists of moderately deep, stony soils over limestone.

The Edwards Plateau and Blackland Prairie vegetational areas are described in the environmental overview (Section 3.0.4). Land use in the project area has been characterized as crop and urban development.[4] The length of the water transmission-line from New Braunfels Surface Water Treatment Plant to the delivery points in the City of Marion, City of Cibolo, City of Schertz and City of Garden Ridge, and Stahl Pump Station totals about 24 miles. A 140-ft wide construction ROW the length of the pipeline would affect a total of 414.1 acres including 50.9 acres developed (12.3 percent), 278.3 acres crop (67.2 percent), 5.8 acres brush (4.9 percent), 37.3 acres park (9.0 percent), 27.2 acres wood (6.6 percent).[5] A mowed maintenance ROW seeded in grass would be required for the lifetime of the project. A 40-ft wide maintenance ROW, 24.4 miles long, would affect a total of 118.3 acres. However, the large proportion of this ROW that is in crop can be returned to crop following installation of the pipeline. Disturbed areas outside the maintenance ROW presently in brush and shrub can be expected to be invaded by woody vegetation in 5 to 10 years.

Protected and sensitive species potentially occurring in Bexar and Comal Counties are presented in Appendix D, Tables 1 - 4. Texas Natural Heritage Program files[6] reported occurrences of important species on 7.5 minute quadrangle maps covering the project area. These include Texas salamander (*Eurycea neotenes*), fountain darter (*Ethostoma fonticola*), Buckley tridens (*Tridens buckleyanas*), Comal Springs riffle beetle (*Heterelemis comalensis*) and Texas amorpha (*Amorpha roemeriana*) on the New Braunfels West quadrangle, Guadalupe bass (*Micropterus treculi*) on the Schertz quadrangle, and big red sage (*Salvia penstemonoides*) on the Marion quadrangle.

A brief description of the Texas Salamander is presented in Section 3.1.3, Alternative G-34. The fountain darter inhabits on the San Marcos and Comal Rivers, and prefers vegetated stream-floor habitats with a constant water temperature. The proposed pipeline route involves

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[4] McMahan, C.A., R.G. Frye and K.L. Brown. 1984. The Vegetation Types of Texas Including Cropland. Texas Parks and Wildlife Department, Austin, Texas.

[5] These preliminary estimates were based on available Soil Conservation Service Maps and USGS 7.5 minute quadrants: Smithson Valley, Sattler, Annhalt and Bulverde, and should be updated using aerial photographs from the EROS data center in a later phase of project development.

[6] TPWD. 1996. Unpublished maps and data files, Texas Natural Heritage Program, Department of Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

crossing the Comal River in New Braunfels (Landa Park). The fountain darter prefers mats of filamentous green alga (*Rhizocinium* sp.) over other vegetation and is very rarely found in areas lacking vegetation. Young fish have been collected consistently in heavily vegetated, backwater areas of the San Marcos River where flow is negligible, whereas adults occur in all suitable habitats including riffles.[7] Critical habitat for the fountain darter appears to include 1) constant water temperature, 2) undisturbed stream floor habitats with riffles, 5) a food supply of living organisms, 6) flowing water, 7) protection from severe floods. The fountain darter is considered by USFWS, TPWD, and TOES to be Endangered.

Comal Springs riffle beetle is a small aquatic beetle known from Comal Springs and San Marcos Springs (Hays County).[8] It occurs in the gravel substrate and shallow riffles in spring runs. Although the beetle has small wings these are apparently nonfunctional, making the species incapable of dispersal by flight. The larvae have been collected with adults in gravel substrate of the spring headwaters and not on submerged as is typical of other *Heterelmis* species.[9] Usual water depth in occupied habitat is 2 to 10 cm although the beetle may also occur in slightly deeper areas within the spring runs. Populations are reported to reach their greatest densities from February to April. The Comal Springs riffle beetle has been collected from spring runs 1, 2, and 3 at Comal Springs in Landa Park.

The remaining species of special interest are plants. Although none of these are protected, big red sage is classified by USFWS as a C2 candidate species (under current review for possible listing as either threatened or endangered, but USFWS is in need of additional information).

The high number of sensitive species associated with Comal Springs in Landa Park will heighten public and regulatory agency concerns regarding the installation of a water transmission pipeline through the park. The proposed route is about 3000 feet downstream from the Comal Springs. An investigation designed to delineate critical aquatic habitat at the Comal River crossing (e.g., for the fountain darter) and the potential effects of increased sedimentation from construction activities may be required if Alternative G-35 is developed. The proposed pipeline

[7] Schenck and Whiteside. 1976. Cited in Edwards Aquifer Research and Data Center summary of endangered species of the Edwards Aquifer on World Wide Web.
[8] USFWS. 1995. Endangered and Threatened Wildlife and Plants; Proposal to List Three Aquatic Invertebrates in Comal and Hays Counties, Texas, as Endangered. Federal Register 60(107): 29537-29543.
[9] Brown, H.P. and C.B. Barr. 1988. First report of stygobiontic (subterranean) riffle beetles in North America. Program abstract for April 22, 1988, meeting of the Southwest Association of Naturalists. 5 pp.

route follows existing railroad and utility ROW, and utilizes expanded intake and water treatment plant facilities which would lessen impact compared to the construction of entirely new facilities. Because the degree of impact is related to construction methods used (trenching, tunneling, etc.), impacts could be minimized by the selection of construction techniques. In the event that routing the pipeline through Landa Park is found to be unacceptable, an alternative route might follow Highway 337 around the northwest side of New Braunfels. However, this would add about 1.5 miles to the length (25.5 acres) of the pipeline, and the rocky substrate and greater relief in the land along the western leg of the highway renders this option less attractive.

The San Antonio Water System, Stahl Pump Station is in remnant areas of brush, shrub and grassland in Norther Bexar Count immediately west of Cibolo Creek. Located on the eastern edge of the Balcones Escarpment, this rapidly urbanizing area is on the Spanish Kings Highway, the Camino Real. Comanche Lookout, a new City of San Antonio park is located in the general vicinity. This 58 acre park contains sites of prehistoric, colonial and modern human activities.[10]

Generally, impacts resulting from pipeline installation can be avoided or minimized by selection of the pipeline route. Habitat surveys should be conducted to adequately estimate potential impacts and aid in selecting a pipeline route with an acceptable balance between environmental impacts and costs. With appropriate routing and construction techniques permanent impacts to protected and rare species should be avoidable.

The proposed pipeline route crosses Cibolo Creek on the Comal-Bexar County line and several smaller intermittent streams. Cibolo Creek at the pipeline crossing is classified as an intermittent stream.[11]

Alternatives G-35A and G-35B would require the purchase of 15,000 acft/yr of Canyon Lake water from GBRA. This purchase could be made under the existing Canyon Lake permit, or an amended permit allowing annual diversions in excess of current permit amounts. The purchased water would be released from Canyon Lake to an intake near the existing CRWA intake on Lake Dunlap.

In the event diversions are made under the existing Canyon Lake permit, no in-stream flow studies would be needed. In the event that the Canyon Lake permit is amended to allow increased annual diversions, then in-stream flow studies may be indicated for the affected reach

[10] TPWD. 1996 (January), op. cit.
[11] U.S. Fish and Wildlife Services. 1991. National Wetland Inventory Series. Scherz Quadrangle.

to evaluate potential effects of the project on the general ecology of the river and on Cagle's map turtle (*Graptemys caglei*) and Guadalupe bass (*Micropterus treculi*).

Cagle's map turtle (*Graptemys caglei*) and Guadalupe bass (*Micropterus treculi*) are riverine species of potential concern with regards to diverting water from the Guadalupe River. Cagle's map turtle and guadalupe bass are described briefly in Section 3.1.3, Alternative G-34. The diversion considered in Alternative G-35 involves the already permitted firm yield of Canyon Lake (as in Alternative G-34) and is not expected to significantly impact species inhabiting the river.

Determining the environmental effects of expanding the intake would require a survey of the intake location on the Guadalupe River. The effects of flow changes on the river would not be expected to be any different than those considered in the permitting process for determining the Canyon Lake firm yield. Diverting the Canyon Lake water at New Braunfels rather than at the lake would increase flows slightly in the Guadalupe River between Canyon Lake and the Guadalupe River.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction will be first surveyed by qualified professionals for the presence of significant cultural resources.

3.2.4 Water Quality and Treatability

[To be completed in subsequent phases of the study.]

3.2.5 Engineering and Costing

For this alternative, surface water would be supplied from an expansion of the NBU Water Treatment Plant and treated water would be supplied to Marion, Cibolo, Schertz, Garden Ridge, and San Antonio Water System. Figure 3.2-1 shows the location of the NBU WTP and potential pipeline routes, however, pipeline routes may be adjusted once route studies and on-the-ground surveys have been performed in subsequent project phases.

The existing NBU raw water intake and pipeline have a capacity of 16 mgd and the raw water pump station can currently pump 8 mgd and is designed to be expanded to 16 mgd. Of the existing capacity, 8 mgd is reserved for the existing treatment plant and the remaining 8-mgd capacity is potentially available for use with this alternative. Alternative G-35A would require a total capacity of 13.4 mgd, therefore, a new raw water intake and pump station with a capacity of 5.4 mgd would be needed. For Alternative G-35A, a total capacity of 26.8 mgd is needed and the raw water facility capacity would need to be increased by 18.8 mgd.

The existing water treatment plant has a capacity of 8 mgd and was originally designed for a twin 8 mgd expansion when needed. However, sufficient land as been acquired for an ultimate capacity of up to 28 mgd. For this alternative, a single expansion would be constructed of 13.4-mgd capacity for Alternative G-35A or 26.8 mgd for Alternative G-35B. Treatment would consist of conventional surface water treatment (flocculation, settling, filtration, and chlorine disinfection), which is similar to the treatment process in use by NBU.

The major facilities required to implement this alternative are:

- River Intake and Pump Station
- Raw Water Pipeline to Treatment Plant
- Water Treatment Plant Expansion
- Treated Water Pump Station
- Transmission Pipeline
- Interconnections to:
  - Marion
  - Cibolo
  - Schertz
  - Garden Ridge
  - SAWS Stahl Secondary Pump Station
- Booster Pump Station

Delivery facilities were sized to deliver year 2020 projected shortages to Marion, Cibolo, Schertz, Garden Ridge. Delivery facilities to the San Antonio Water System Stahl Pump Station were sized to deliver 15,000 acft/yr. Two delivery rate scenarios were considered: a uniform annual delivery rate (Alternative G-35A); and, a summer month peak rate of 2.0 times the uniform annual delivery rate (Alternative G-35B). Table 3.2-5 summarizes the design delivery rate and pipeline sizes at the raw water intake and at each of the delivery locations.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water, land, and environmental mitigation. The estimated costs for the water treatment plant include the cost of an expanded plant considering the savings available from use of the existing administration, laboratory and maintenance building,

Table 3.2-5 Delivery Rates and Pipeline Sizes for Alternatives G-35A and G-35B						
			Design Delivery Rate and Size			
			Uniform Annual Delivery (G-35A)		Summer Peak Delivery (G-35B)	
Location	Annual Delivery Amount (acft/yr)	Description of Connection & Capital Cost Item	Delivery Rate (mgd)	Pipeline Diameter	Delivery Rate (mgd)	Pipeline Diameter
Raw Water Intake	15,000	----	13.4	18"	26.8	36"
Marion	87	Connection to existing GST	0.08	4"	0.16	4"
Cibolo	160	----	0.17	4"	0.34	6"
Schertz	2,612	----	2.33	12"	4.66	18"
Garden Ridge	570	Connect to existing well	0.51	6"	1.02	8"
SAWS - Stahl Pump Station	11,571	New 10 MG GST	13.4	30"	26.8"	42"

(1) Spring Hill WSC and Crystal Clear WSC would receive new water supplies through the existing 24" diameter pipeline to their service area.

as well as the raw water facilities. Cost estimates for are presented in Table 3.2-6. The total estimated project cost of Alternative G-35A (uniform delivery) is $36,900,000 (Table 3.2-6), which results in a total annual cost, including operation and maintenance of $6,065,000. The total estimated project cost for Alternative G-35B (summer peak delivery) is $59,570,000 (Table 3.2-6), which results in a total annual cost, including operation and maintenance of $9,255,000. The operating cost was determined for a total static lift from Lake Dunlap to the SAWS Stahl Pump Station of 305 ft. and an annual delivery of 15,000 acft at each annual delivery rate.

The estimated cost of each alternative was allocated to each delivery location based on the pro-rata capacity of each component dedicated to meeting potential year 2000 and 2020 demands at the delivery location. Thus, participants would pay a pro-rata share of raw water and treatment

facility costs based solely on the percent of total capacity dedicated to meeting their water demands and the participant's location relative to the water source did not affect calculation of the cost allocation. For transmission and pump station costs, each participant pays a pro-rata share only of the facilities needed to deliver water to them, consequently, costs to participants that are furthest from the water source are proportionately greater.

Table 3.2-7 summarizes the total annual cost and the unit cost of treated water for year 2000 and year 2020 conditions. Early in project operation, small quantities of water could be

Table 3.2-6 Cost Estimate Summaries for Potential Supply from Canyon Lake Delivered to New Braunfels WTP 15,000 acft/yr (Alternatives G-35A and G-35B) (First Quarter - 1996 Prices)		
Item	**Alt. G-35A Uniform Annual Delivery**	**Alt. G-35B Summer Peak Delivery**
Capital Costs		
Intake and Treatment Plant	$11,090,000	$21,500,000
Transmission Pipelines	10,080,000	14,650,000
Booster Pump Stations	1,810,000	3,140,000
Interconnects to Participants	3,890,000	4,090,000
Total Capital Cost	$26,870,000	$43,380,000
Engineering, Contingencies, and Legal Costs	8,610,000	14,090,000
Environmental Studies and Mitigation	180,000	180,000
Land Acquisition	180,000	180,000
Interest During Construction	1,070,000	1,740,000
Total Project Cost	$36,900,000	$59,570,000
Annual Costs		
Annual Debt Service	$ 3,460,000	$ 5,580,000
Annual Operation and Maintenance		
Water Treatment Plant	775,000	1,700,000
Transmission Pipelines	265,000	410,000
Annual Power Cost	770,000	770,000
Purchase of Stored Water	795,000	795,000
Total Annual Cost	$ 6,065,000	$ 9,255,000
(1) Cost of stored water purchased from GBRA is $53/acft.		

delivered to participants with all remaining water delivered to SAWS. The cost of water for year 2020 conditions delivered at a uniform rate varies from $538 per acft for Marion to $352 per acft (Table 3.2-7) for Garden Ridge. For a summer peaking distribution pattern, and full usage of the allotted amount, the unit cost of water varies from $708 per acft for Marion to $554 per acft (Table 3.2-8) for Garden Ridge.

For the case of all 15,000 acft/yr being delivered to Bexar County at the SAWS Stahl pump station (as possibly would happen in the early years of project operation), the annual unit cost was estimated to be $397 per acft per year at a constant delivery rate and $608 per acft per

Table 3.2-7 Summary of Costs by Delivery Location Potential Supply from Canyon Lake Delivered to New Braunfels WTP 15,000 acft/yr, Uniform Annual Delivery (G-35A) (First Quarter - 1996 dollars)								
	Year 2000				Year 2020			
Delivery Location (Max Delivery Rate, mgd; Connection Pipe Size, in)	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft	Unit Cost(2) $/1000 gal	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft	Unit Cost(2) $/1000 gal
Marion (0.08 mgd, 4")	56	$42,000	$756	$2.32	87	$47,000	$538	$1.65
Cibolo (0.14 mgd, 4")	160	$70,000	$439	$1.35	160	$69,000	$430	$1.32
Schertz (2.33 mgd, 12")	1,268	$731,000	$577	$1.77	2,612	$928,000	$355	$1.09
Garden Ridge (0.51 mgd, 6")	315	$164,000	$520	$1.60	570	$201,000	$352	$1.08
SAWS-Stahl Pump Station (13.3 mgd, 30")	13,201	$5,058,000	$383(3)	$1.18(3)	11,571	$4,820,000	$416(3)	$1.28(3)
Total	15,000	$6,065,000	$404	$1.24	15,000	$6,065,000	$404	$1.24

(1) Not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include the operating cost of the participant's distribution system.
(3) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water, and the cost to transport the water, may occur before year 2020.
Note: The unit cost to deliver all 15,000 acft/yr to SAWS would be about $397 per acft/yr ($1.22/1,000 gallons).

Table 3.2-8
Summary of Costs by Delivery Location
Potential Supply from Canyon Lake Delivered to New Braunfels WTP
15,000 acft/yr, Summer Peaking Delivery (G-35B)
(First Quarter - 1996 dollars)

	Year 2000				Year 2020			
Delivery Location (Max Delivery Rate, mgd; Connection Pipe Size, in)	**Annual Volume(1) (acft/yr)**	**Annual Cost**	**Unit Cost(2)**		**Annual Volume(1) (acft/yr)**	**Annual Cost**	**Unit Cost(2)**	
			$/acft	**$/1000 gal**			**$/acft**	**$/1000 gal**
Marion (0.16 mgd, 4")	56	$55,000	$990	$3.04	87	$61,000	$708	$2.17
Cibolo (0.28 mgd, 4")	160	$104,000	$650	$1.99	160	$102,000	$640	$1.96
Schertz (4.66 mgd, 18")	1,268	$1,179,000	$930	$2.85	2,612	$1,465,000	$561	$1.72
Garden Ridge (1.02 mgd, 6")	315	$262,000	$832	$2.55	570	$315,000	$554	$1.70
SAWS-Stahl Pump Station (26.6 mgd, 42")	13,201	$7,655,000	$580(3)	$1.78(3)	11,571	$7,312,000	$632(3)	$1.94(3)
Total	15,000	$9,255,000	$617	$1.89	15,000	$9,255,000	$617	$1.89

(1) Cost of treated water delivered on a wholesale basis and does not include the operating cost of the participant's distribution system.
(2) Not adjusted for treatment, transmission, and other losses.
(3) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water, and the cost to transport the water, may occur before year 2020.
Note: The unit cost to deliver all 15,000 acft/yr to SAWS would be about $608 per acft/yr ($1.87/1,000 gallons).

year for a summer peaking delivery pattern. These unit costs are inclusive of all system costs (capital and O&M) for all system components except lateral pipelines and connecting to intermediate delivery points.

3.2.6 Implementation Issues

Implementation steps include:

- Commitment of project participants
- Phasing of project elements
- Negotiate water purchase contracts with GBRA
- Financing
- Engineering
- Permitting
- Construction
- Operation and Maintenance

Requirements Specific to Pipelines

1. Necessary permits:
    a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
    b. GLO and Gravel Removal permits.
    c. TPWD Sand, Gravel Removal permits.
    d. Coastal Coordinating Council review may be required.
2. Right-of-way and easement acquisition.
3. Crossings.
    a. Highways and railroads.
    b. Creeks and rivers.
    c. Other utilities.

Guadalupe River Intake

1. It will be necessary to obtain these permits:
    a. U.S. Army Corps of Engineers (USCE) Sections 10 and 404 dredge and fill permits for the intake.
    b. GLO Easement for use of state-owned land.
2. Permitting, at a minimum, will require these studies:
    a. Environmental studies.
    b. Cultural resource studies.
3. Land will need to be acquired through either negotiations or condemnation.

Requirements Specific to Diversion of Canyon Lake Water from Guadalupe River

1. Necessary permits:
   a. TNRCC Interbasin Transfer Approval
2. Permitting may require these studies:
   a. Instream flow issues and impact.
   b. Environmental studies.
3. Agreement with GBRA for use and payment for water released from Canyon Lake.

Requirements Specific to Treatment and Distribution

A detailed study is needed of the cost of pumping and transmission pipeline improvements necessary to effectively integrate the new supply into SAWS water distribution system.

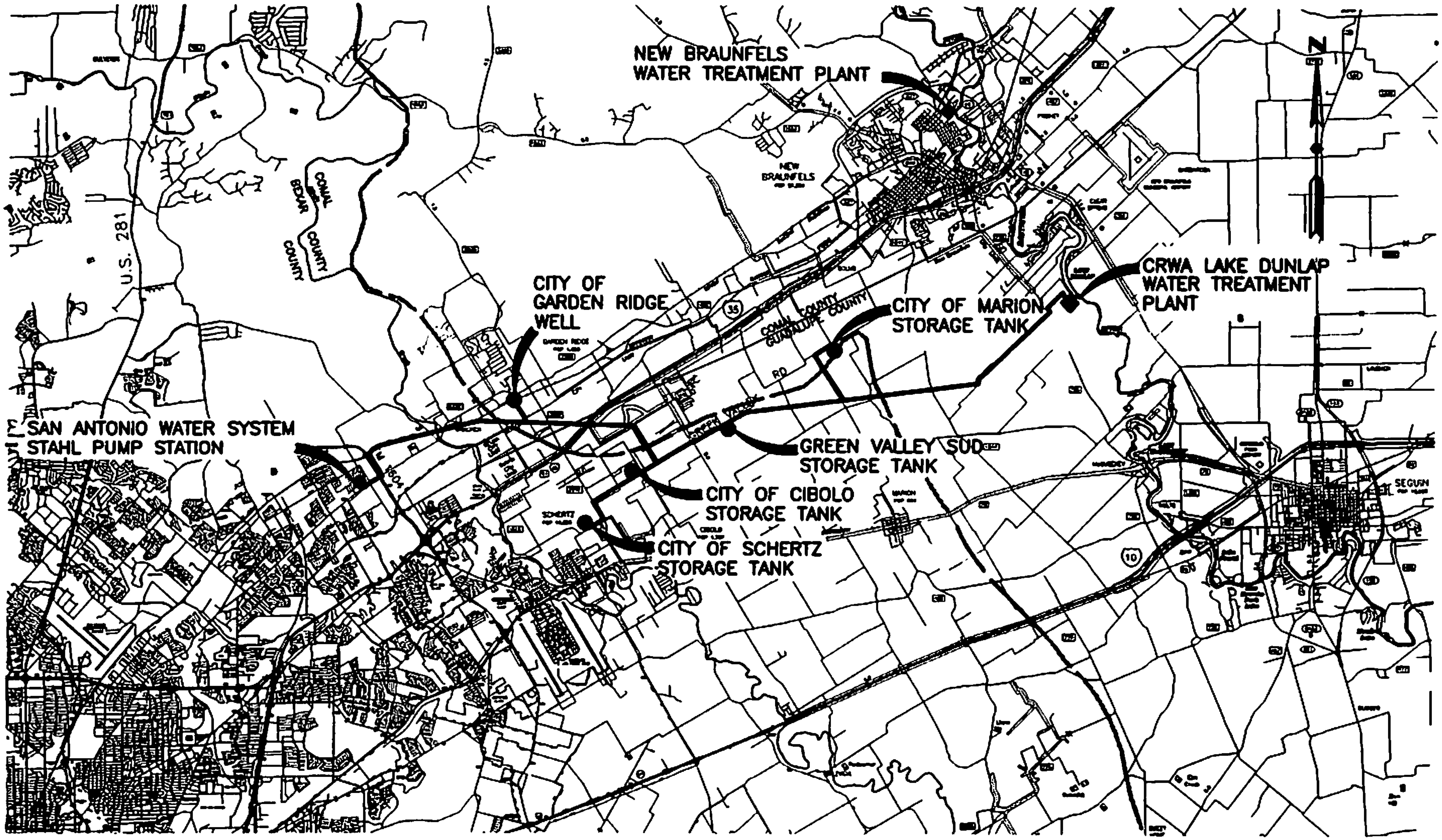
3.3 Guadalupe River Diversion at Lake Dunlap to CRWA/Mid-Cities/Bexar County with Expanded CRWA WTP (G-36)

3.3.1 Description of Alternative

The Canyon Regional Water Authority (CRWA) consists of several member retail water purveyors (Springs Hill Water Supply Corporation, Green Valley Special Utility District, Crystal Clear Water Supply Corporation, East Central Water Supply Corporation), and the Cities of Marion, Schertz, Cibolo, Garden Ridge. Of these purveyors, Springs Hill WSC, Green Valley SUD, Crystal Clear WSC, and East Central WSC hold contracts with GBRA for purchase of stored water in Canyon Lake. The purchased water is released from Canyon Lake for diversion at Lake Dunlap by CRWA for treatment at the Lake Dunlap Water Treatment Plant, and then delivered to the four members purchasing stored water. The member entities also obtain a portion of their respective water supplies from the Edwards Aquifer, San Antonio Water System, and the Carrizo/Wilcox Aquifer. Current contracts between GBRA and the CRWA members total 2,240 acft/yr for diversion at Lake Dunlap (Springs Hill WSC also holds a contract with GBRA for diversion of 1,500 acft/yr at Lake Placid). The capacity of the Lake Dunlap WTP is 2.0 mgd.

This alternative considers the purchase of uncommitted stored water in Canyon Lake for release to Lake Dunlap and diversion to an expanded CRWA Lake Dunlap WTP. This additional surface water supply could be delivered to CRWA member entities and municipalities in Guadalupe County and potentially to Bexar County. Two annual purchase volumes (5,000 acft/yr and 15,000 acft/yr) were considered for supply to several delivery locations. The supply alternatives, diversion quantities, delivery rates (i.e. peaking factors), and delivery locations are summarized in Table 3.3-1.

This alternative would involve construction of these facilities: a new intake and raw water pump station at Lake Dunlap; expansion of the existing CRWA Lake Dunlap Water Treatment Plant; high service pump station; water transmission pipeline; water delivery pipelines and connections to intermediate delivery locations in Guadalupe County; booster pump stations; and, ground storage tank at SAWS Stahl secondary pump station. The locations of these facilities are shown on Figure 3.3-1.



Legend

- ■ Water Treatment Plant
- ● Connection Point to Existing Distribution System
- Potential Water Transmission Pipeline
- Basin Boundary

2 0 2 4 6

Approximate Scale in Miles

HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

GUADALUPE RIVER DIVERSION AT LAKE DUNLAP DELIVERED TO CRWA, ALTERNATIVE G-36

FIGURE 3.3-1

Table 3.3-1 Definition of Alternatives for Guadalupe River Diversion at Lake Dunlap with Expanded CRWA WTP (G-36)			
Alternative	**Diversion Quantity (acft/yr)**	**Delivery Rate**	**Delivery Location**
G-36A	5,000	uniform	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-36B	5,000	summer peaking	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-36C	15,000	uniform	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-36D	15,000	summer peaking	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)

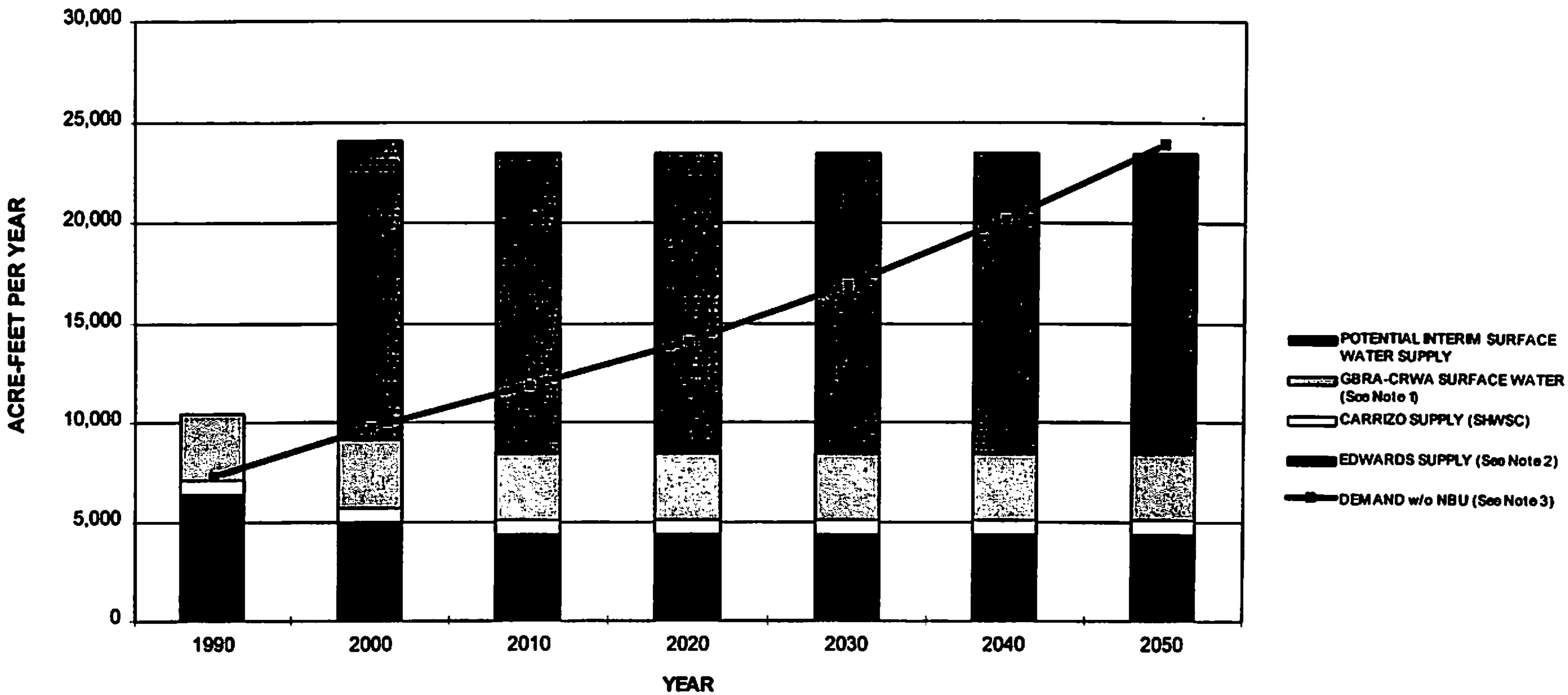
(1) Includes Green Valley SUD, Springs Hill WSC, and Crystal Clear WSC.
(2) Delivery to SAWS Stahl Secondary Pump Station facility.

3.3.2 Available Water Supply and Projected Demand

This alternative would require the purchase of either 5,000 acft/yr or 15,000 acft/yr of Canyon Lake water from GBRA. This water would be released from Canyon Lake to an expanded CRWA intake on Lake Dunlap.

Table 3.3-2 contains projected water demands and current supply for entities in Guadalupe County that could potentially purchase stored water from Canyon Lake. Table 3.3-2 indicates a projected shortage of 5,652 acft/yr in year 2020. Because the potential supply of 5,000 acft/yr (Alternatives G-36A and G-36B) is not sufficient to meet projected shortages of the entities in Guadalupe County (i.e. GBRA statutory area), potential transfer into Bexar County is not considered in Alternatives G-36A and G-36B.

Figure 3.3-2 contains a bar chart plot of projected Guadalupe County water supplies, including the potential Canyon Lake supply of 15,000 acft/yr (Alternatives G-36C and G-36D), and a line plot of projected demands is superimposed. For the potential supply of 15,000 acft/yr from Canyon Lake (if committed only to the Guadalupe County area) the projected water shortages of Guadalupe County could be met through about year 2050 as shown on Figure 3.3-2.



NOTES:

1. SH WSC: 2220, GV SUD: 720, CC WSC: 500

2. EDWARDS SUPPLY FOR MARION, CIBOLO, GREEN VALLEY, GARDEN RIDGE, SCHERTZ, AND CRYSTAL CLEAR WSC WITH IMPLEMENTATION OF SB 1477.

3. INCLUDES DEMAND FOR MARION, CIBOLO, GREEN VALLEY, GARDEN RIDGE, SCHERTZ, CRYSTAL CLEAR WSC, AND SPRING HILL WSC.

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

GUADALUPE COUNTY AREA DEMAND AND SUPPLY

HDR Engineering, Inc.

FIGURE 3.3-2

Table 3.3-2 Guadalupe County Area Demand and Supply							
	Projected Demand						
Entity	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Springs Hill WSC	1486	2,003	2,523	3,043	3,562	4,082	4,601
Crystal Clear WSC	1042	1,280	1,519	1,758	1,998	2,237	2,476
City of Marion	150	169	185	200	216	231	246
Green Valley SUD	1804	2,435	3,066	3,695	4,327	4,960	5,592
City of Garden Ridge	397	613	770	868	1,038	1,253	1,511
City of Cibolo	204	318	307	313	346	392	424
City of Schertz(1)	2,140	2,873	3,515	4,217	5,443	7,027	9,069
Projected Total Demand	**7,223**	**9,691**	**11,885**	**14,094**	**16,930**	**20,182**	**23,919**
Current Supplies							
Edwards Aquifer (2)	6,339	4,933	4,302	4,302	4,302	4,302	4,302
Canyon Lake (3) (GBRA Contract)	3,440	3,440	3,440	3,440	3,440	3,440	3,440
Carrizo Aquifer	700	700	700	700	700	700	700
Total Supply	**10,479**	**9,073**	**8,442**	**8,442**	**8,442**	**8,442**	**8,442**
Projected Shortage	**0**	**618**	**3,443**	**5,652**	**8,490**	**11,470**	**15,477**

(1) Although a small portion of the Schertz service area is in Bexar County, all of their projected demand is reported here.
(2) Edwards aquifer supply for Marion, Cibolo, Green Valley SUD, Garden Ridge, Schertz, and Crystal Clear with implementation of SB 1477. In 1990, SHWSC obtained 602 acft from the Edwards Aquifer through NBU. However, SHWSC will have no Edwards Aquifer supply after August, 1994. Future supply is computed without the 602 acft of 1990 use.
(3) Springs Hill WSC: 2,220 acft (1,500 acft at Lake Placid); Green Valley SUD: 720 acft; Crystal Clear WSC: 500 acft.

In 2020, projected shortages in Guadalupe County are about 5,652 acft/yr, and the potential supply of 15,000 acft/yr would leave about 9,348 acft/yr that could be transferred to Bexar County. Engineering and costing was performed for transfers of this quantity to the San Antonio area (see Section 3.3-5, below).

Delivery facilities for entities in Guadalupe County have been sized as follows: (1) for delivery of 5,000 acft/yr (Alternatives G-36A and G-36B), which is less than the projected Guadalupe County 2020 shortages, facilities were sized to deliver the pro-rata allocation of the available supply as shown in Table 3.3-3; (2) for delivery of 15,000 acft/yr (Alternatives G-36B and G-36C), delivery facilities were sized to deliver the projected year 2020 shortage (Table 3.3-4).

Table 3.3-3 Allocation of 5,000 acft/yr Canyon Lake Supply Delivered to Lake Dunlap and CRWA WTP (Alt G-36A and G-36B)					
DELIVERY POINT	1990 DEMAND		PROJECTED SHORTAGES(1)		ALLOCATION OF NEW SUPPLY(2) (acft/yr)
	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	
Entities in GBRA Statutory District:					
Marion	150	2%	87	133	87
Cibolo	204	3%	160	271	160
Schertz	2,140	30%	2,612	7,464	2,139
Garden Ridge	397	5%	570	1,213	391
Crystal Clear WSC	1,042	14%	476	1,194	476
Green Valley SUD	1,804	25%	1,624	3,519	1,624
Springs Hill WSC	1,486	21%	123	1,681	123
GBRA Area Subtotal	7,223	100%	5,652	15,475	5,000
Amount Remaining to Deliver to Bexar County:					-0-

(1) Projected shortages in other areas of Guadalupe and Comal counties not included in this alternative.
(2) Allocations of new water supplies to entities in GBRA Statutory Area are based on the lesser of projected year 2020 shortages, or on percent distribution of 1990 demand times available supply.

Table 3.3-4 Allocation of 15,000 acft/yr Potential Supply from Canyon Lake Delivered to Lake Dunlap and CRWA WTP (Alt G-36C and G-36D)					
DELIVERY POINT	1990 DEMAND		PROJECTED SHORTAGES(1)		ALLOCATION OF NEW SUPPLY(2) (acft/yr)
	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	
Entities in GBRA Statutory District:					
Marion	150	2%	87	133	87
Cibolo	204	3%	160	271	160
Schertz	2,140	30%	2,612	7,464	2,612
Garden Ridge	397	5%	570	1,213	570
Crystal Clear WSC	1,042	14%	476	1,194	476
Green Valley SUD	1,804	25%	1,624	3,519	1,624
Springs Hill WSC	1,486	21%	123	1,681	123
GBRA Area Subtotal	7,223	100%	5,652	15,475	5,652
Amount Remaining for Delivery to Bexar County:					9,348

(1) Projected shortages in other areas of Guadalupe and Comal counties not included in this alternative.
(2) Allocations of new water supplies to entities in GBRA Statutory Area are set equal to projected 2020 shortages.

Table 3.3-5 indicates an allocation of 9,348 acft/yr to Bexar County (delivered to SAWS) in year 2020 for Alternative G-36C and G-36D. However, prior to year 2020, more than this amount would be available for delivery to SAWS[1], and facilities for delivery of potential surface water supplies to Bexar County were sized to deliver 15,000 acft/yr. The transmission pipeline to Bexar County was not stepped down in size at connections to intermediate customers in Guadalupe and Comal Counties. Thus, the full 15,000 acft/yr can be delivered to Bexar County in the first year of operation. As water demands of Comal and Guadalupe county entities grow, more water would be delivered to them and less water would be transferred to Bexar County. For Alternatives G-36C and G-36D, the 2020 delivery quantity to Bexar County would be reduced to about 9,348 acft/yr.

Table 3.3-5
Allocation of 9,348 acft/yr Potential Supply Diverted at Lake Dunlap and Delivered to Bexar County (Alt G-36C and G-36D)

DELIVERY POINT	1990 DEMAND: DEMAND (acft/yr)	1990 DEMAND: PERCENT OF TOTAL	PROJECTED SHORTAGES: YEAR 2020 (acft/yr)	PROJECTED SHORTAGES: YEAR 2050 (acft/yr)	ALLOCATION OF NEW SUPPLY(1) (acft/yr)
Entities in Bexar County:					
East Central WSC	1,130	0.47%	1,168	2,354	44
BMWD Northeast	3,229	1.33%	4,484	8,024	124
Universal City	2,323	0.96%	2,444	4,458	90
Converse	1,213	0.50%	2,619	5,546	47
Live Oak	1,221	0.50%	302	822	47
Randolph AFB	1,494	0.62%	538	515	58
SAWS & Remainder of Bexar County	231,987	95.63%	220,576	380,191	8,939
Bexar County Subtotal	242,597	100%	232,131	401,910	9,348

(1) Allocations of new water supplies to entities in Bexar County are based on percent distribution of 1990 demands.

3.3.3 Environmental Issues

The project area lies primarily in the Blackland Prairie Vegetational Area, however, the City of Garden Ridge and Stahl Pump Station service areas are on soils characteristic of the

[1] With implementation of SB 1477, immediate demands for new water supplies in Bexar County are about 31,000 acft/yr, thereby creating a need for all of the water potentially available from Alternative G-36.

Edwards Plateau. In Guadalupe County the proposed pipeline route traverses Sunev-Sequin, Branyon-Barbarosa-Lewisville, Houston Black-Heiden, and Austin-Eddy soil associations.[2] Sunev-Seguin soils are deep, well drained, nearly level to gently sloping, loamy soils on bottom lands. The Branyon-Barbarosa-Lewisville soil association consist of deep, moderately well drained to well drained, nearly level to gently sloping, clayey soils on stream terraces. Houston Black-Heiden soils are deep, moderately well drained to well drained, gently slopping to moderately steep, clayey soils on uplands. The Austin-Eddy soils are moderately deep to very shallow, well drained, gently sloping, clayey to gravelly loamy soils on uplands. In Comal and Bexar Counties the proposed route traverses Heiden-Houston Black, Comfort-Rumple-Eckrant, Branyon-Krum, Lewisville-Gruene-Krum, Terrant-Brackett, Crawford-Bexar, and Lewisville-Houston Black soil associations[3,4] which were described briefly in Section 3.2.3, Alternative G-35.

The Edwards Plateau and Blackland Prairie vegetational areas are described in the environmental overview (Section 3.0.4). Land use in the project area has been characterized as crop and urban development.[5] The length of the water transmission line from Lake Dunlap Water Treatment Plant to the delivery points in the City of Marion, City of Cibolo, City of Schertz and City of Garden Ridge, and Stahl Pump Station is about 27 miles. The proposed route follows existing utility and road ROWs. A 140 foot wide construction ROW the length of the pipeline would affect a total of 458.2 acres including 13.6 acres developed (3 percent), 349.6 acres crop (76.3 percent), 17 acres brush (3.7 percent), 30.5 acres park (6.7 percent), 47.5 acres wood (10.4 percent).[6] A mowed maintenance ROW seeded in grass would be required for the lifetime of the project. A 40 foot wide maintenance ROW, 27 miles long, would affect a total of 131 acres including 3.9 acres developed, 99.9 acres crop, 4.8 acres brush, 8.7 acres park, 13.6 acres wood. However, the large proportion of this ROW that is in crop can be returned to crop

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[2] Soil Conservation Service. 1977. Soil Survey of Guadalupe County Texas. SCS, USDA, In cooperations with Texas Agricultural Experiment Station.

[3] Soil Conservation Service. 1984. Soil Survey of Comal and Hays Counties Texas. SCS, USDA, In cooperations with Texas Agricultural Experiment Station.

[4] Soil Conservation Service. 1962. Soil Survey of Bexar County Texas. SCS, USDA, In cooperations with Texas Agricultural Experiment Station.

[5] McMahan, C.A., R.G. Frye and K.L. Brown. 1984. The Vegetation Types of Texas Including Cropland. Texas Parks and Wildlife Department, Austin, Texas.

[6] These preliminary estimates were based on available Soil Conservation Service Maps and USGS 7.5 minute quadrants: New Braunfels East, McQueeney, Marion, Schertz, New Braunfels West, and should be updated using aerial photographs from the EROS data center in a later phase of project development.

following installation of the pipeline. Disturbed areas outside the maintenance ROW presently in brush and shrub can be expected to be invaded by woody vegetation in 5 to 10 years.

Important species reported to occur in Bexar, Comal and Guadalupe Counties are presented in Appendix D, Tables 1 - 4. Although there are no threatened or endangered species reported by Texas Natural Heritage Program in the immediate project area, important species recorded on 7.5 minute quadrant maps covering the project area include Buckley tridens, Texas Amorpha, Guadalupe bass, and mountain plover (*Charadrius montanus*) on the New Braunfels, East quadrant, big red sage on the Marion quadrant, and Guadalupe bass on the Schertz quadrant.

The mountain plover inhabits shortgrass prairie, overgrazed pasture, plowed fields and deserts. It is a rare summer resident in the western panhandle and Trans-Pecos, rare transient throughout the state, except in the eastern quarter where it is absent, and rare winter resident in the southern half of the state. The mountain plover breeds in dry, western Great Plains from southern Canada to western Texas and winters in California, Arizona, Texas, and northern Mexico. It is categorized by USFWS as a C2 candidate for protection.[7]

Because a pipeline route can be adjusted to avoid critical habitats, appropriate habitat and endangered species surveys designed to delineate impacts and aid in final selection of the pipeline easement should be conducted to avoid and minimize impacts. The effects of pipeline installation and operation should be largely temporary and no long-term effects on rare and protected species are expected.

This alternative would require the purchase of either 5,000 acft/yr or 15,000 acft/yr of Canyon Lake water from GBRA. This purchase could be made under the existing Canyon Lake permit, or an amended permit allowing annual diversions in excess of current permit amounts. The purchased water would be released from Canyon Lake to an expanded CRWA intake at Lake Dunlap. Lake Dunlap is a long, moderately deep reservoir within the banks of the Guadalupe River. It is formed by a small hydroelectric dam downstream of the Guadalupe River's confluence with the Comal River. In addition to hydroelectric power generation, Lake Dunlap is used for boating, fishing and camping.

In the event diversions are made under the existing Canyon Lake permit, no in-stream flow studies would be needed. In the event that the Canyon Lake permit is amended to allow

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[7] USFWS. 1994. Endangered and Threatened Wildlife and Plants; Animal Candidate Review for Listing as Endangered or Threatened Species; Proposed Rule. Federal Register. November 15, 1994.

increased annual diversions, then in-stream flow studies may be indicated for the affected reach. If in-stream flow studies are indicated, evaluation of the potential effects of the project on the general ecology of the river and on Cagle's map turtle (*Graptemys caglei*), Guadalupe bass (*Micropterus treculi*) and blue sucker (*Cycleptus elongatus*) which are federal candidate species might be needed. In Texas the blue sucker is listed as threatened. In the Guadalupe River Cagle's map turtle, Guadalupe bass and blue sucker range from the Edwards Plateau, through the Blackland Prairie and to the Coastal Plain in the Guadalupe River. The Guadalupe bass may occur in Lake Dunlap. However, the Guadalupe bass is better adapted to flowing water and is often found near riffles feeding on insects. The blue sucker (a candidate for federal protection) is a large river fish that could occur in Guadalupe Count, however, Hubbs reported no occurrences of blue sucker in the Guadalupe River Basin.[8]

The proposed pipeline route crosses Cibolo Creek, an intermittent stream, and several smaller intermittent creeks.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction will be first surveyed by qualified professionals for the presence of significant cultural resources.

3.3.4 Water Quality and Treatability

[To be completed in subsequent phases of the study.]

3.3.5 Engineering and Costing

For this alternative, surface water would be supplied from an expansion of the CRWA Lake Dunlap Water Treatment Plant adjacent to Lake Dunlap and treated water would be supplied on a wholesale basis to Springs Hill WSC, Green Valley SUD, Crystal Clear WSC, Marion, Cibolo, Schertz, and Garden Ridge. San Antonio Water System would receive water from implementation of Alternatives G-36C and G-36D only. For Alternatives G-36A and G-36B, Garden Ridge would not be connected directly to the transmission system, but would

[8] Hubbs, C., J.D. McEachran, and C.R. Smith. 1994. Freshwater and Marine Fishes of the Texas and the Nortwestern Gulf of Mexico. The Texas System of Natural Laboratories, Inc. Austin, Texas.

receive water at the Schertz delivery point and water would potentially be passed through the Schertz distribution system. For Alternative G-36C and G-36D, water would be delivered directly to Garden Ridge. Figure 3.3-1 shows the location of the Lake Dunlap WTP and potential pipeline routes, however, pipeline routes may be adjusted once route studies and on-the-ground surveys have been performed in subsequent project phases.

The existing CRWA intake and pipeline have a capacity of 4.0 mgd and the raw water pump station can currently pump 2.0 mgd, but can be expanded to 4.0 mgd by changing pumps. Because Alternative G-36A requires a capacity of 4.5 mgd and G-36B requires 8.9 mgd, a new raw water intake, pump station, and raw waterline would be required with a capacity of 2.5 mgd (G-36A) or 7.9 mgd (G-36B).

The existing water treatment plant has a capacity of 2 mgd and no excess capacity available for use with this alternative. However, sufficient land is owned by CRWA for substantial expansion and no additional land costs were included.

Raw water would be pumped to the treatment plant from a new water intake to be located adjacent to the existing CRWA intake at Lake Dunlap. Treatment would consist of conventional surface water treatment (flocculation, settling, filtration, and chlorine disinfection), which is similar to the treatment process in use by CRWA.

The major facilities required to implement this alternative are:

- Reservoir Intake and Pump Station
- Raw Water Pipeline to Treatment Plant
- Water Treatment Plant Expansion
- Treated Water Pump Station
- Transmission Pipeline
- Interconnections to:
    - Marion
    - Cibolo
    - Schertz
    - Green Valley
    - SAWS Stahl Secondary Pump Station
- Booster Pump Station (Alternatives G-36C and G-36D, only)

<u>Alternative G-36A and G-36B: Delivery of 5,000 acft/yr of Canyon Lake Water (Diverted at Lake Dunlap) to CRWA/Mid-Cities/Bexar County with Expanded CRWA WTP</u>

Delivery facilities were sized to deliver a pro-rata allocation of 2020 projected shortages to Marion, Cibolo, Schertz, Garden Ridge and Green Valley SUD. Delivery to Springs Hill WSC and Crystal Clear WSC would be made at the Lake Dunlap WTP through the existing transmission pipeline currently supplying water to these entities. Garden Ridge would not be connected directly to the transmission pipeline, but would potentially receive water by pass-through from Schertz. The delivery volumes and facility sizes at Schertz include the Garden Ridge allocation.

Two delivery rate scenarios were considered: a uniform annual delivery rate (Alternative G-36A); and, a summer month peak rate of 2.0 times the uniform annual delivery rate (Alternative G-36B). Table 3.3-6 summarizes the design delivery rate and pipeline sizes at the raw water intake and at each of the delivery locations.

Table 3.3-6
Delivery Rates and Pipeline Sizes for Alternatives G-36A and G-36B

			Design Delivery Rate and Size			
			Uniform Annual Delivery (G-36A)		Summer Peak Delivery (G-36B)	
Location	Annual Delivery Amount (acft/yr)	Description of Connection & Capital Cost Item	Delivery Rate (mgd)	Pipeline Diameter	Delivery Rate (mgd)	Pipeline Diameter
Raw Water Intake	5,000	----	4.5	16"	8.9	24"
Springs Hill WSC	123	(1)	0.11	(1)	0.22	(1)
Crystal Clear WSC	476	(1)	0.43	(1)	0.86	(1)
Marion	87	Connection to existing GST	0.08	4"	0.16	4"
Cibolo	160	Connection to existing GST	0.18	4"	0.34	6"
Green Valley SUD	1,624	Connection to existing GST	1.57	12"	3.06	14"
Schertz(2)	2,139	Connection to existing GST	2.25	12"	4.50	16"
Garden Ridge	391	Connection to existing GST	0.35	(2)	0.70	(2)

(1) Spring Hill WSC and Crystal Clear WSC would receive new water supplies through the existing 24" diameter pipeline to their service area.
(2) Schertz and Garden Ridge supplies are combined at Schertz delivery point. Schertz will potentially pass-through new water supply to Garden Ridge.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water, land, and environmental mitigation. The estimated costs for the water treatment plant include the costs of an expanded plant considering the savings available from use of the existing laboratory and maintenance building. Cost estimates for Alternatives G-36A and G-36B are presented in Table 3.3-7. The total estimated project cost of Alternative G-36A (uniform delivery) is $12,740,000 (Table 3.3-7), which results in a total annual cost, including operation and maintenance and purchase of stored water, of $1,995,000. The total estimated project cost for Alternative G-36B (summer peak delivery) is $19,730,000 (Table 3.3-7), which results in a total annual cost, including operation and maintenance and purchase of stored water, of $2,995,000. The operating cost was determined for a total static lift from Lake Dunlap to the Schertz ground storage tank of 165 ft and an annual delivery of 5,000 acft.

Table 3.3-7
Cost Estimate Summaries for Potential Supply from Canyon Lake Diverted at Lake Dunlap to CRWA WTP
5,000 acft/yr (Alternatives G-36A and G36-B)
(First Quarter - 1996 Prices)

Item	Alt. G-36A Uniform Annual Delivery	Alt. G-36B Summer Peak Delivery
Capital Costs		
Intake and Treatment Plant	$5,170,000	$9,010,000
Transmission Pipelines	3,490,000	4,730,000
Booster Pump Stations	0	0
Interconnects to Participants	470,000	470,000
Total Capital Cost	$9,130,000	$14,210,000
Engineering, Contingencies, and Legal Costs	3,000,000	4,710,000
Environmental Studies and Mitigation	120,000	120,000
Land Acquisition	120,000	120,000
Interest During Construction	370,000	570,000
Total Project Cost	$12,740,000	$19,730,000
Annual Costs		
Annual Debt Service	$1,190,000	$1,850,000
Annual Operation and Maintenance		
Water Treatment Plant	290,000	620,000
Transmission Pipelines	60,000	70,000
Power Cost	190,000	190,000
Annual Cost of Water(1)	265,000	265,000
Total Annual Cost	$1,995,000	$2,995,000

(1) Cost of stored water purchased from GBRA is $53/acft.

The estimated cost of each alternative was allocated to each delivery location based on the pro-rata capacity of each component dedicated to meeting potential year 2000 and 2020 demands at the delivery location. Thus, for raw water and treatment facility costs, participants would pay a pro-rata share based solely on the percent of total capacity dedicated to meeting their water demands, and the participant's location relative to the water source did not affect the cost allocation for treatment. For transmission and pump station costs, allocation was made on a pro-rata allocation only of the facilities needed to deliver water to them, consequently, costs to participants that are furthest from the water source are proportionately greater.

For Alternatives G-36A and G-36B (annual delivery of 5,000 acft), Table 3.3-8 summarizes the total annual cost and the annual unit cost of treated water for year 2000 and 2020. Early in project operation, less than the allotted quantity of water will be delivered to each customer. The cost of water for year 2020 conditions delivered at a uniform delivery rate varies from $297 per acft per year for Crystal Clear WSC to $701 per acft per year (Table 3.3-8) delivered to Marion. For a summer peaking distribution pattern, the unit cost of water for year 2020 varies from $469 per acft per year for Crystal Clear WSC to $897 per acft per year (Table 3.3-9) for Marion.

Alternative G-36C and G-36D: Delivery of 15,000 acft/yr of Canyon Lake Water (Diverted at Lake Dunlap) to CRWA/Mid-Cities/Bexar County with Expanded CRWA WTP

Delivery facilities were sized to deliver year 2020 projected shortages to Marion, Cibolo, Schertz, Garden Ridge, and Green Valley SUD. Delivery facilities to the San Antonio Water System Stahl Pump Station were sized to deliver 15,000 acft/yr. Two delivery rate scenarios were considered: a uniform annual delivery rate (Alternative G-36C); and, a summer month peak rate of 2.0 times the uniform annual delivery rate (Alternative G-36D). Table 3.3-10 summarizes the design delivery rate and pipeline sizes at the raw water intake and at each of the delivery locations.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water, land, and environmental mitigation. Cost estimates for Alternatives G-36C and G-36D are presented in Table 3.3-11. The total estimated project cost of Alternative G-36C is $37,270,000, which results in a total annual cost, including operation and maintenance of $6,081,000. The total estimated project cost for Alternative G-36D

Table 3.3-8 Summary of Costs by Delivery Location Potential Supply from Canyon Lake Diverted at Lake Dunlap to CRWA WTP 5,000 acft/yr, Uniform Annual Delivery (G-36A) (First Quarter - 1996 dollars)								
	Year 2000				Year 2020			
Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2)		Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2)	
			$/acft	$/1000 gal			$/acft	$/1000 gal
Spring Hills (0.11 mgd)	0	$20,000	(3)	(3)	123	$36,000	$297	$0.91
Crystal Clear (0.43 mgd)	0	$70,000	(3)	(3)	476	$142,000	$297	$0.91
Marion (0.08 mgd, 4")	56	$55,000	$982	$3.01	87	$61,000	$701	$2.15
Green Valley (1.57 mgd, 12")	362	$407,000	$1,115	$3.42	1,624	$608,000	$374	$1.15
Cibolo (0.18 mgd, 4")	160	$73,000	$456	$1.40	160	$74,000	$463	$1.42
Garden Ridge(4)	315(4)	$182,000	$578	$1.77	391(4)	$166,000	$425	$1.30
Schertz (2.21 mgd, 12")	1,268(4)	$734,000	$578	$1.77	2,139(4)	$908,000	$425	$1.30
Total	2,161	$1,541,000	$713	$2.19	5,000	$1,995,000	$399	$1.23

(1) Annual volume not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the participant's distribution system.
(3) Annual costs for debt service will accrue, even though no water deliveries are projected.
(4) Schertz and Garden Ridge supplies are combined at Schertz delivery point. Schertz will potentially pass-through new water supply to Garden Ridge.

Table 3.3-9 Summary of Costs by Delivery Location Potential Supply from Canyon Lake Diverted at Lake Dunlap to CRWA WTP 5,000 acft/yr, Summer Peaking Delivery (G-36B) (First Quarter - 1996 dollars)								
	Year 2000				Year 2020			
Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft/yr	Unit Cost(2) $/1000 gal	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft/yr	Unit Cost(2) $/1000 gal
Spring Hills (0.22 mgd)	0	$33,000	(3)	(3)	123	$58,000	$469	$1.44
Crystal Clear (0.86 mgd)	0	$118,000	(3)	(3)	476	$223,000	$469	$1.44
Marion (0.16 mgd, 4")	56	$69,000	$1,232	$3.78	87	$78,000	$897	$2.75
Green Valley (3.06 mgd, 14")	362	$639,000	$1,765	$5.42	1,624	$920,000	$567	$1.74
Cibolo (0.34 mgd, 6")	160	$106,000	$663	$2.03	160	$107,000	$669	$2.05
Garden Ridge(4)	315(4)	$275,000	$874	$2.68	391(4)	$249,000	$637	$1.95
Schertz (4.30 mgd, 16")	1,268(4)	$1,108,000	$874	$2.68	2,139(4)	$1,360,000	$637	$1.95
Total	2,161	$2,348,000	$1,087	$3.34	5,000	$2,995,000	$599	$1.84

(1) Annual volume not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the participant's distribution system.
(3) Annual costs for debt service will accrue, even though no water deliveries are projected.
(4) Schertz and Garden Ridge supplies are combined at Schertz delivery point. Schertz will potentially pass-through new water supply to Garden Ridge.

Table 3.3-10
Delivery Rates and Pipeline Sizes for Alternatives G-36C and G-36D

			Design Delivery Rate and Size			
			Uniform Annual Delivery (G-36C)		Summer Peak Delivery (G-36D)	
Location	Annual Delivery Amount (acft/yr)	Description of Connection & Capital Cost Item	Delivery Rate (mgd)	Pipeline Diameter	Delivery Rate (mgd)	Pipeline Diameter
Raw Water Intake	15,000	----	13.4	30"	26.8	42"
Springs Hill WSC	123	(1)	0.11	(1)	0.22	(1)
Crystal Clear WSC	476	(1)	0.43	(1)	0.86	(1)
Marion	87	Connection to existing GST	0.08	4"	0.16	4"
Cibolo	160	Connection to existing GST	0.17	4"	0.34	6"
Schertz	2,612	Connection to existing GST	2.33	12"	4.66	18"
Green Valley SUD	1,624	Connection to existing GST	1.53	12"	3.06	14"
Garden Ridge	570	Connect to existing well	0.51	6"	1.02	8"
SAWS - Stahl Pump Station	9,348	New 10 MG GST	13.4	30"	26.8"	42"

(1) Spring Hill WSC and Crystal Clear WSC would receive new water supplies through the existing 24" diameter pipeline to their service area.

is $56,400,000 (Table 3.3-11), which results in a total annual cost, including operation and maintenance of $8,915,000. The operating cost was determined for a total static lift from Lake Dunlap to the SAWS Stahl Pump Station of 350 ft. and an annual delivery of 15,000 acft at each annual delivery rate.

The estimated cost of each alternative was allocated to each delivery location based on the pro-rata capacity of each component dedicated to meeting potential year 2000 and 2020 demands at the delivery location. Thus, participants would pay a pro-rata share of raw water and treatment facility costs based solely on the percent of total capacity dedicated to meeting their water demands and the participant's location relative to the water source did not affect calculation of the cost allocation for these items. For transmission and pump station costs, each participant pays a pro-rata share only of the facilities needed to deliver water to them, consequently, costs to participants that are furthest from the water source are proportionately greater.

For Alternatives G-36C and G-36D (annual delivery of 15,000 acft), Table 3.3-12 summarizes the total annual cost and the unit cost of treated water year 2000 and 2020. Early in project operation, less water will be delivered to participants and all remaining available water

Table 3.3-11
Cost Estimate Summaries for Potential Supply from Canyon Lake
Delivered at Lake Dunlap to CRWA WTP
15,000 acft/yr (Alternatives G-36C and G-36D)
(First Quarter - 1996 Prices)

Item	Alt. G-36C Uniform Annual Delivery	Alt. G-36D Summer Peak Delivery
Capital Costs		
Intake and Treatment Plant	$11,720,000	$19,670,000
Transmission Pipelines	9,530,000	14,060,000
Booster Pump Stations	1,870,000	3,140,000
Interconnects to Participants	3,970,000	4,200,000
Total Capital Cost	$27,090,000	$41,070,000
Engineering, Contingencies, and Legal Costs	8,720,000	13,310,000
Environmental Studies and Mitigation	190,000	190,000
Land Acquisition	190,000	190,000
Interest During Construction	1,080,000	1,640,000
Total Project Cost	$37,270,000	$56,400,000
Annual Costs		
Annual Debt Service	$3,490,000	$5,290,000
Annual Operation and Maintenance		
Water Treatment Plant	740,000	1,670,000
Transmission Pipelines	206,000	310,000
Annual Power Cost	850,000	850,000
Purchase of Stored Water (1)	795,000	795,000
Total Annual Cost	$6,081,000	$8,915,000

(1) Cost of stored water purchased from GBRA is $53/acft.

will be delivered to SAWS. The cost of water for year 2020 conditions delivered at a uniform rate varies from $252 per acft for Crystal Clear WSC to $483 per acft (Table 3.3-12) for Marion. For a summer peaking distribution pattern, and full usage of the allotted amount, the unit cost of water varies from $389 per acft for Crystal Clear WSC to $637 per acft (Table 3.3-13) for Marion.

For the case of all 15,000 acft/yr being delivered to Bexar County at the SAWS Stahl pump station (as possibly would happen in the early years of project operation), the annual unit cost was estimated to be $397 per acft per year at a uniform delivery rate and $584 per acft per year for a summer peaking delivery pattern. These costs are inclusive of all system costs (capital

Table 3.3-12 Summary of Costs by Delivery Location Potential Supply from Canyon Lake Diverted at Lake Dunlap to CRWA WTP 15,000 acft/yr, Uniform Annual Delivery (G-36C) (First Quarter - 1996 dollars)								
	Year 2000				Year 2020			
Delivery Location (Max. Delivery rate, mgd; connection pipe size, in)	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2)		Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2)	
			$/acft/yr	$/1000 gal			$/acft/yr	$/1000 gal
Spring Hills (0.11 mgd)	0	$16,000	(3)	(3)	123	$31,000	$252	$0.77
Crystal Clear (0.43 mgd)	0	$54,000	(3)	(3)	476	$120,000	$252	$0.77
Marion (0.08 mgd, 4")	56	$38,000	$680	$2.09	87	$42,000	$483	$1.48
Green Valley (1.53 mgd, 12")	362	$301,000	$832	$2.55	1,624	$483,000	$298	$0.91
Cibolo (0.17 mgd, 4")	160	$59,000	$368	$1.13	160	$57,000	$356	$1.09
Garden Ridge (0.51 mgd, 6")	315	$178,000	$564	$1.73	570	$218,000	$383	$1.18
Schertz (2.33 mgd, 12")	1,268	$682,000	$538	$1.65	2,612	$873,000	$334	$1.03
SAWS-Stahl Pump Station (13.4 mgd, 30")	12,839	$4,753,000	$370(4)	$1.14(4)	9,348	$4,257,000	$455(4)	$1.40(4)
Total	15,000	$6,081,000	$405	$1.24	15,000	$6,081,000	$405	$1.24

(1) Annual volume not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the participant's distribution system
(3) Annual costs for debt service will accrue, even though no water deliveries are projected.
(4) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water, and the cost to bring the water, may occur before year 2020.
Note: The unit cost to deliver all 15,000 acft/yr to SAWS would be about $397 per acft/yr ($1.22/1,000 gallons).

Table 3.3-13
Summary of Costs by Delivery Location
Potential Supply from Canyon Lake Diverted at Lake Dunlap to CRWA WTP
15,000 acft/yr, Summer Peaking Delivery (G-36D)
(First Quarter - 1996 dollars)

	Year 2000				Year 2020			
Delivery Location (Max. Delivery rate, mgd; connection pipe size, in)	**Annual Volume**[(1)] **(acft/yr)**	**Annual Cost**	**Unit Cost**[(2)] **$/acft/yr**	**Unit Cost**[(2)] **$/1000 gal**	**Annual Volume**[(1)] **(acft/yr)**	**Annual Cost**	**Unit Cost**[(2)] **$/acft/yr**	**Unit Cost**[(2)] **$/1000 gal**
Spring Hills (0.22 mgd)	0	$26,000	(3)	(3)	123	$48,000	$389	$1.19
Crystal Clear (0.86 mgd)	0	$88,000	(3)	(3)	476	$185,000	$389	$1.19
Marion (0.16 mgd, 4")	56	$49,000	$877	$2.69	87	$55,000	$637	$1.96
Green Valley (3.06 mgd, 14")	362	$468,000	$1,293	$3.97	1,624	$734,000	$452	$1.39
Cibolo (0.34 mgd, 6")	160	$85,000	$531	$1.63	160	$82,000	$515	$1.58
Garden Ridge (1.02 mgd, 8")	315	$269,000	$854	$2.62	570	$327,000	$573	$1.76
Schertz (4.66 mgd, 18")	1,268	$1,034,000	$815	$2.50	2,612	$1,314,000	$503	$1.54
SAWS-Stahl Pump Station (26.8 mgd, 42")	12,839	$6,896,000	$537[(4)]	$1.65[(4)]	9,348	$6,170,000	$660[(4)]	$2.02[(4)]
Total	15,000	$8,915,000	$594	$1.82	15,000	$8,915,000	$594	$1.82

(1) Annual volume not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the participant's distribution system
(3) Annual costs for debt service will accrue, even though no water deliveries are projected.
(4) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water, and the cost to bring the water, may occur before year 2020.
Note: The unit cost to deliver all 15,000 acft/yr to SAWS would be about $584 per acft/yr ($1.79/1,000 gallons).

and O&M for all system components, except lateral pipelines and connections to intermediate delivery points.

3.3.6 Implementation Issues

Implementation steps include:

- Commitment of project participants
- Phasing of project elements
- Negotiate water purchase contracts with GBRA
- Financing
- Engineering
- Permitting
- Construction
- Operations and Maintenance

<u>Lake Dunlap Intake</u>

1. It will be necessary to obtain these permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the intake.
   b. GLO Easement for use of state-owned land.
   c. GBRA modification or construction permit.
2. Permitting, at a minimum, will require these studies:
   a. Environmental studies
   b. Cultural resource studies.
3. Land will need to be acquired through either negotiations or condemnation.

<u>Requirements Specific to Diversion of Canyon Lake Water from Guadalupe River</u>

1. Necessary permits:
   a. TNRCC Interbasin Transfer Approval
2. Permitting may require these studies:
   a. Instream flow issues and impact.
   b. Environmental studies.
3. Agreement with GBRA for use and payment for water released from Canyon Lake.

<u>Requirements Specific to Pipelines</u>

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel and Marl Removal permits.

   d. Coastal Coordinating Council review may be required.
2. Right-of-way and easement acquisition.
3. Crossings.
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

Requirements Specific to Treatment and Distribution

A detailed study is needed of the cost of pumping and transmission pipeline improvements necessary to effectively integrate the new supply into SAWS water distribution system.

3.4 Guadalupe River Diversion at Lake Dunlap to Mid-Cities and Bexar County with Regional WTP (G-37)

3.4.1 Description of Alternative

This alternative considers diversion of water from the Guadalupe River at Lake Dunlap for treatment at a potential regional water treatment plant and delivery of treated water on a wholesale basis to several delivery points. Two annual diversion volumes (15,000 acft/yr and 50,000 acft/yr) were studied and Table 3.4-1 summarizes the numbering system for the supply alternatives, diversion quantities, delivery rates (i.e. peaking factors), and delivery locations.

Table 3.4-1
Definition of Alternatives for Guadalupe River Diversion at Lake Dunlap with Regional WTP (G-37)

Alternative	Diversion Quantity (acft/yr)	Delivery Rate	Delivery Location
G-37A	15,000	uniform	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-37B	15,000	summer peaking	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-37C	50,000	uniform	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-37D	50,000	summer peaking	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)

(1) Includes Green Valley SUD, Springs Hill WSC, and Crystal Clear WSC.
(2) Delivery to SAWS Stahl Secondary Pump Station facility.

For Alternatives G-37A and G-37B, the purchase, treatment, and delivery of 15,000 acft/yr of uncommitted stored water in Canyon Lake was studied. This water would be released from Canyon Lake for diversion at Lake Dunlap to a potential regional water treatment plant near Marion.

For Alternatives G-37C and G-37D, the 50,000 acft/yr of water potentially available for diversion at Lake Dunlap would be made up of periodically-available unappropriated water made firm by allocation of a portion of the firm yield of Canyon Lake and also from use of existing water rights projected to be underutilized in year 2020. A highlight of this alternative is the conjunctive use of multiple water sources to optimize water availability using banked storage in Canyon Lake. (Appendix C describes the use of banked storage and water availability from each source.)

This alternative would involve construction of these facilities: an intake and raw water pump station at Lake Dunlap; regional water treatment plant; high service pump station; water transmission pipeline; water delivery pipelines and connections to intermediate delivery locations in Guadalupe County; booster pump station; and a ground storage tank at SAWS Stahl secondary pump station. For Alternatives G-37C and G-37D (diversion of 50,000 acft/yr), land acquisition costs for a potential off-channel storage facility for future forebay storage and pre-sedimentation near the regional water treatment plant were included. The locations of these facilities are shown on Figure 3.4-1.

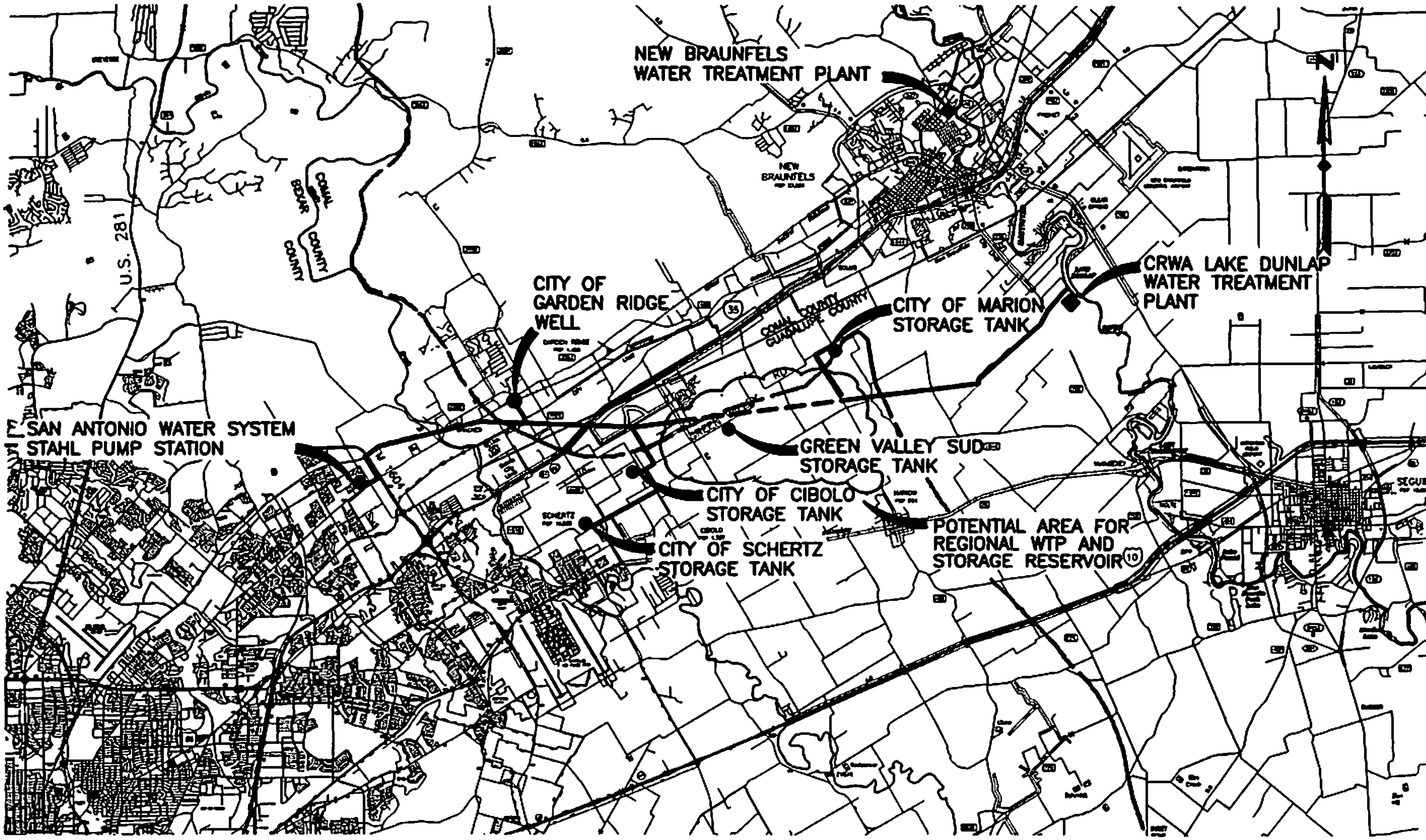
3.4.2 Available Water Supply and Projected Demand

Alternative G-37A and G-37B - Diversion of 15,000 acft/yr of Uncommitted Stored Water in Canyon Lake

This alternative requires the purchase of 15,000 acft/yr of Canyon Lake water from GBRA. This water would be released from Canyon Lake to a new intake located on Lake Dunlap.

Table 3.4-2 contains projected water demands and current supply for entities in Guadalupe County that could potentially purchase the uncommitted yield from Canyon Lake. Figure 3.4-2 contains a bar chart plot of Guadalupe County water supplies, including the potential Canyon Lake supply of 15,000 acft/yr (Alt G-37A and G-37B), and a line plot of projected demands is superimposed. For the potential supply of 15,000 acft/yr from Canyon Lake (if committed only to the Guadalupe County area) the projected water shortages of Guadalupe County could be met through the year 2050. In 2020, projected shortages in Guadalupe County are about 5,652 acft/yr, and the potential supply of 15,000 acft/yr would provide about 9,348 acft/yr that could be transferred to Bexar County and engineering and costing was performed for transfers to the San Antonio area (see Section 3.4-5, below).

Delivery facilities for entities in Guadalupe County (GBRA statutory area, see Table 3.4-2) have been sized for delivery of a pro-rata allotment of 5,652 acft/yr (Alt G-37A and G-37B), to meet projected 2020 shortages for this area. Table 3.4-3 summarizes the water allocation to each of the potential customers for Alternatives G-37A and G-37B.



Legend

- ■ Water Treatment Plant
- ● Connection Point to Existing Distribution System
- ▬ Potential Water Transmission Pipeline
- ◡ Basin Boundary

2 0 2 4 6

Approximate Scale in Miles

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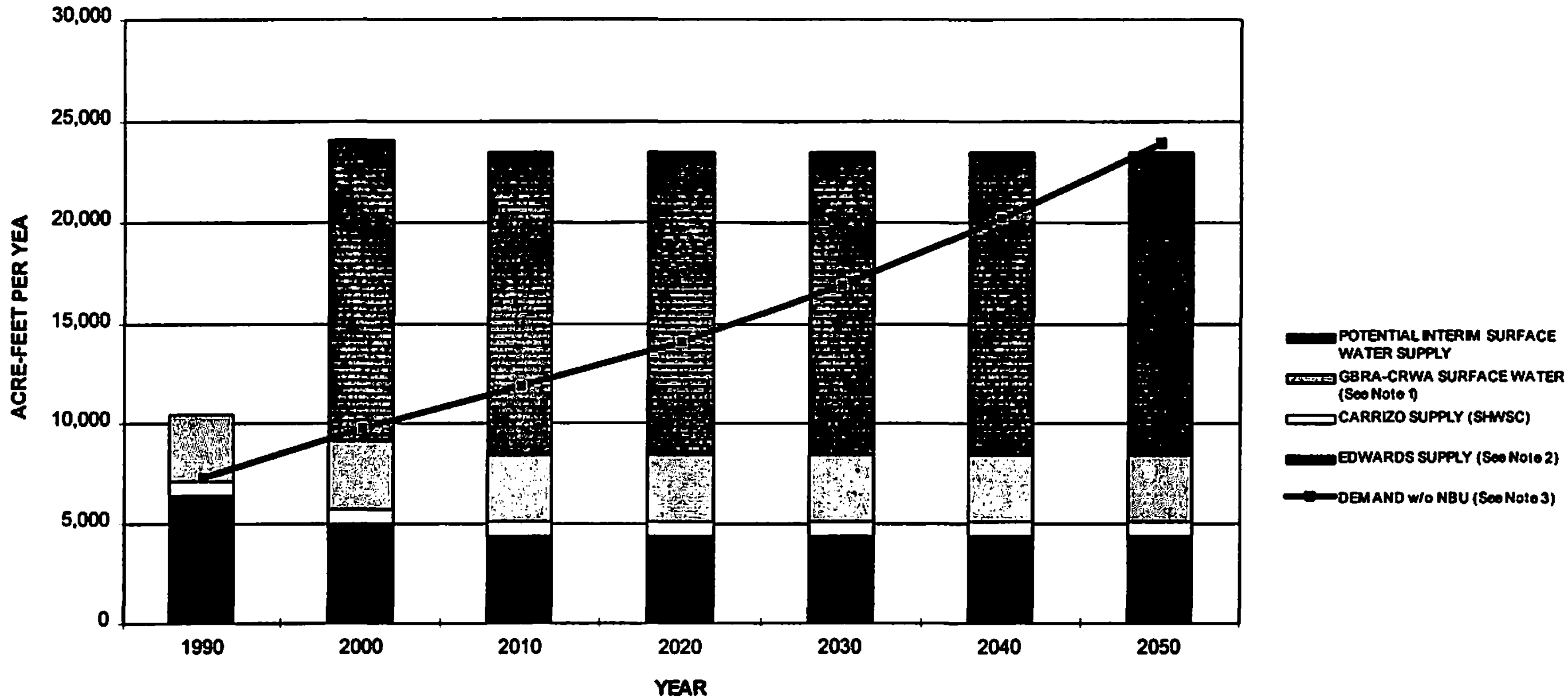
WEST CENTRAL STUDY AREA

GUADALUPE RIVER DIVERSION AT LAKE DUNLAP DELIVERED TO REGIONAL WTP, ALTERNATIVE G-37

FIGURE 3.4-1



NOTES:

1. SH WSC: 2220, GV SUD: 720, CC WSC: 500
2. EDWARDS SUPPLY FOR MARION, CIBOLO, GREEN VALLEY, GARDEN RIDGE, SCHERTZ, AND CRYSTAL CLEAR WSC WITH IMPLEMENTATION OF SB 1477.
3. INCLUDES DEMAND FOR MARION, CIBOLO, GREEN VALLEY, GARDEN RIDGE, SCHERTZ, CRYSTAL CLEAR WSC, AND SPRING HILL WSC.

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GUADALUPE COUNTY AREA DEMAND AND SUPPLY

FIGURE 3.4-2

Table 3.4-2 Guadalupe County Area Demand and Supply							
	Projected Demand						
Entity	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Springs Hill WSC	1486	2,003	2,523	3,043	3,562	4,082	4,601
Crystal Clear WSC	1042	1,280	1,519	1,758	1,998	2,237	2,476
City of Marion	150	169	185	200	216	231	246
Green Valley SUD	1804	2,435	3,066	3,695	4,327	4,960	5,592
City of Garden Ridge	397	613	770	868	1,038	1,253	1,511
City of Cibolo	204	318	307	313	346	392	424
City of Schertz(1)	2,140	2,873	3,515	4,217	5,443	7,027	9,069
Projected Total Demand	**7,223**	**9,691**	**11,885**	**14,094**	**16,930**	**20,182**	**23,919**
Current Supplies							
Edwards Aquifer (2)	6,339	4,933	4,302	4,302	4,302	4,302	4,302
Canyon Lake (3) (GBRA Contract)	3,440	3,440	3,440	3,440	3,440	3,440	3,440
Carrizo Aquifer	700	700	700	700	700	700	700
Total Supply	**10,479**	**9,073**	**8,442**	**8,442**	**8,442**	**8,442**	**8,442**
Projected Shortage	**0**	**618**	**3,443**	**5,652**	**8,490**	**11,470**	**15,477**

(1) Although a small portion of the Schertz service area is in Bexar County, all of their projected demand is reported here.
(2) Edwards aquifer supply for Marion, Cibolo, Green Valley SUD, Schertz, and Crystal Clear with implementation of SB 1477. In 1990, SHWSC obtained 602 acft from the Edwards Aquifer through NBU. However, as of August, 1994, SHWSC has no Edwards Aquifer supply after August, 1994. Future supply is computed without the 602 acft of 1990 use.
(3) Springs Hill WSC: 2,220 acft (1,500 acft at Lake Placid); Green Valley SUD: 720 acft; Crystal Clear WSC: 500 acft.

Tables 3.4-3 and 3.4-4 indicate an allocation of 9,348 acft/yr to Bexar County (delivered to SAWS) in year 2020 for Alternative G-37A and G-37B. However, prior to year 2020, more than this amount would be available for delivery to SAWS, [1] and facilities for delivery of potential surface water supplies to Bexar County were sized to deliver 15,000 acft/yr. The transmission pipeline to Bexar County was not stepped down in size at connections to intermediate customers in Guadalupe and Comal counties. Thus, the full 15,000 acft/yr can be delivered to Bexar County in the first year of operation. As water demands of Comal and Guadalupe county entities grow, more water would be delivered to them and less water would be transferred to Bexar County. For Alternative G-37A and G-37B, the 2020 delivery quantity to Bexar County would be reduced to about 9,348 acft/yr.

[1] With implementation of SB 1477, immediate demands for new water supplies in Bexar County are about 31,000 acft/yr, thereby creating a need for all of the water potentially available from Alternative G-37.

Table 3.4-3 Allocation of 15,000 acft/yr Canyon Lake Supply Delivered to Lake Dunlap and Regional WTP (Alternatives G-37A and G-37B)					
	1990 DEMAND		PROJECTED SHORTAGES[1]		ALLOCATION
DELIVERY POINT	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	OF NEW SUPPLY[2] (acft/yr)
Entities in GBRA Statutory District:					
Marion	150	2%	87	133	87
Cibolo	204	3%	160	271	160
Schertz	2,140	30%	2,612	7,464	2,612
Garden Ridge	397	5%	570	1,213	570
Crystal Clear WSC	1,042	14%	476	1,194	476
Green Valley SUD	1,804	25%	1,624	3,519	1,624
Springs Hill WSC	1,486	21%	123	1,681	123
GBRA Area Subtotal	7,223	100%	5,652	15,475	5,652
Amount Remaining for Delivery to Bexar County:					9,348
(1) Projected shortages in other areas of Guadalupe and Comal counties not included in this alternative. (2) Allocations of new water supplies to entities in GBRA Statutory Area are set equal to projected 2020 shortages.					

Table 3.4-4 Allocation of 9,348 acft/yr Potential Supply Diverted at Lake Dunlap and Delivered to Bexar County (Alternatives G-37A and G-37B)					
	1990 DEMAND		PROJECTED SHORTAGES		ALLOCATION
DELIVERY POINT	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	OF NEW SUPPLY[1] (acft/yr)
Entities in Bexar County:					
East Central WSC	1,130	0.47%	1,168	2,354	44
BMWD Northeast	3,229	1.33%	4,484	8,024	124
Universal City	2,323	0.96%	2,444	4,458	90
Converse	1,213	0.50%	2,619	5,546	47
Live Oak	1,221	0.50%	302	822	47
Randolph AFB	1,494	0.62%	538	515	58
SAWS/BMWD & Remainder of Bexar County	231,987	95.63%	220,576	380,191	8,939
Bexar County Subtotal	242,597	100%	232,131	401,910	9,348
(1)) Allocations of new water supplies to entities in Bexar County are based on percent distribution of 1990 demand.					

Alternative G-37C and G-37D - Diversion of 50,000 acft/yr from the Guadalupe River at Lake Dunlap

Under Alternative G-37, water potentially available for diversion at Lake Dunlap would be obtained from the following sources: 1) enhanced springflow resulting from a theoretical reduction in overall Edwards Aquifer pumpage from that observed in calendar year 1989 (543,677 acft) to 400,000 acft/yr; 2) flow committed to large existing water rights (permitted, but projected to be underutilized in calendar year 2020); 3) unappropriated streamflow; and 4) water delivered from Canyon Lake. The term "enhanced springflow" as used throughout this study is defined to be the estimated increase in discharge primarily from Comal and San Marcos Springs into the Guadalupe and San Marcos Rivers which, theoretically, would occur if Edwards Aquifer pumpage were reduced from an annual volume of 543,677 acft to an annual volume of 400,000 acft. For the purposes of this study, it was assumed that this water would first be dedicated to existing water rights (including Canyon Lake) with the remainder available for diversion from the Guadalupe River at Lake Dunlap and/or Gonzales. The procedures and assumptions pertinent to the computation of water potentially available from each of these sources are described in Appendix C and Table 3.4-5 summarizes estimates of water needed from each source for a total annual diversion of 50,000 acft. A highlight of this alternative is the conjunctive use of multiple water sources to increase water availability. Using banked storage in Canyon Lake to firm up water availability, conjunctive use is made of enhanced springflow, unappropriated streamflow, and underutilized water rights.

Water availability analyses for Alternative G-37 conclude that 50,000 acft/yr could be diverted from Lake Dunlap without interruption through the historical drought of record subject to either a uniform monthly diversion pattern or a peaked summer diversion pattern. For the uniform monthly diversion pattern, analyses indicate that a drought average of 22,580 acft/yr could be obtained from enhanced springflow and 11,130 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 18,830 acft/yr would need to be purchased from the yield of Canyon Lake[2] (of which about 2,580 acft/yr is needed to offset increased evaporation from banked storage as described in Appendix C) to ensure availability of 50,000 acft/yr at Lake Dunlap. For the peaked summer diversion pattern,

[2] It is important to note that the allocation of Canyon Lake firm yield to ensure firm availability presented herein is an annual average for the entire critical drought period. In any single year during the drought, deliveries from Canyon Lake to ensure firm availability may exceed the average allocation by more than 100 percent.

Table 3.4-5 Water Sources for Diversion of 50,000 acft/yr at Lake Dunlap (Alternatives G-37C and G-37D)				
	Uniform Annual Diversion (G-37C)		Summer Peak Diversion (G-37D)	
Water Source	Average(1) (acft/yr)	Drought(2) (acft/yr)	Average(1) (acft/yr)	Drought(2) (acft/yr)
Enhanced Springflow	42,000	22,580	38,200	18,670
Unappropriated Streamflow	60	40	140	60
Year 2020 Underutilized Rights	4,550	11,130	7,040	11,980
Subtotal	46,610	33,750	45,380	30,710
Canyon Firm Yield(3) (Evaporation on Banked Storage(4))	3,390	18,830 (2,580)	4,620	21,700 (2,410)
Total	50,000	50,000	50,000	50,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage calculated only during the drought and is included in Canyon Firm Yield.

analyses indicate that a drought average of 18,670 acft/yr could be obtained from enhanced springflow and 11,980 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 21,700 acft/yr would need to be purchased from the firm yield of Canyon Lake[3] (of which about 2,410 acft/yr is needed to offset increased evaporation from banked storage) to ensure availability of 50,000 acft/yr at Lake Dunlap. Subject to draft Environmental Water Needs Criteria of the Consensus Planning Process received November 27, 1995, about 60 acft/yr would be available as unappropriated streamflow during drought after considering diversions under enhanced springflow and water rights transfers. Analyses indicate that diversion of enhanced springflow would be significantly greater over the long-term than during drought, while utilization of water purchased from the yield of Canyon Lake would be significantly less.

For delivery of 50,000 acft/yr (Alt G-37C and G-37D), delivery facilities to entities in the GBRA statutory area were sized to deliver the projected year 2020 shortage as shown in Table 3.4-2. Tables 3.4-6 and 3.4-7 summarize the allocation of water supply for Alternatives G-37C and G-37D.

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[3] Ibid.

Table 3.4-6 Allocation of 50,000 acft/yr Diverted at Lake Dunlap to Regional WTP (Alternatives G-37C and G-37D)					
	1990 DEMAND		PROJECTED SHORTAGES[1]		ALLOCATION
DELIVERY POINT	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	OF NEW SUPPLY[2] (acft/yr)
Entities in GBRA Statutory District:					
Marion	150	2%	87	133	87
Cibolo	204	3%	160	271	160
Schertz	2,140	30%	2,612	7,464	2,612
Garden Ridge	397	5%	570	1,213	570
Crystal Clear WSC	1,042	14%	476	1,194	476
Green Valley SUD	1,804	25%	1,624	3,519	1,624
Springs Hill WSC	1,486	21%	123	1,681	123
GBRA Area Subtotal	7,223	100%	5,652	15,475	5,652
Amount Remaining for Delivery to Bexar County:					44,348

(1) Projected shortages in other areas of Guadalupe and Comal counties not included in this alternative.
(2) Allocations of new water supplies to entities in GBRA Statutory Area are set equal to projected 2020 shortages.

Table 3.4-7 Allocation of 44,348 acft/yr Potential Supply Diverted at Lake Dunlap and Delivered to Bexar County (Alternatives G-37C and G-37D)					
	1990 DEMAND		PROJECTED SHORTAGES		ALLOCATION
DELIVERY POINT	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	OF NEW SUPPLY[1] (acft/yr)
Entities in Bexar County:					
East Central WSC	1,130	0.47%	1,168	2,354	207
BMWD Northeast	3,229	1.33%	4,484	8,024	590
Universal City	2,323	0.96%	2,444	4,458	425
Converse	1,213	0.50%	2,619	5,546	222
Live Oak	1,221	0.50%	302	822	223
Randolph AFB	1,494	0.62%	538	515	273
SAWS/BMWD & Remainder of Bexar County	231,987	95.63%	220,576	380,191	42,408
Bexar County Subtotal	242,597	100%	232,131	401,910	44,348

(1)) Allocations of new water supplies to entities in Bexar County are based on percent distribution of 1990 demand.

Tables 3.4-6 and 3.4-7 indicate an allocation of 44,348 acft/yr to Bexar County (delivered to SAWS) in year 2020 for Alternative G-37C and G-37D. However, prior to year 2020, more than this amount would be available for delivery to SAWS, and facilities for delivery of potential surface water supplies to Bexar County were sized to deliver 50,000 acft/yr. The transmission pipeline to Bexar County was not stepped down in size at connections to intermediate customers in Guadalupe and Comal counties. Thus, the full 50,000 acft/yr can be delivered to Bexar County in the first year of operation. As water demands of Comal and Guadalupe county entities grow, more water would be delivered to them and less water would be transferred to Bexar County. For Alternative G-37C and D, the 2020 delivery quantity to Bexar County would be reduced to about 44,348 acft/yr.

3.4.3 Environmental Issues

Alternative G-37 involves the same general intake location, pipeline route, and delivery points as Alternative G-36 (Section 3.3) with the addition of a new water treatment plant near Marion. Alternatives G-37C and G-37D would include a small storage reservoir. Because the location of the new plant is as yet undetermined, potential effects of the new plant will be considered in a later study if this alternative should be developed further. Remaining environmental issues concerning terrestrial impacts of Alternative G-37 are discussed under Alternative G-36 (Section 3.3.3).

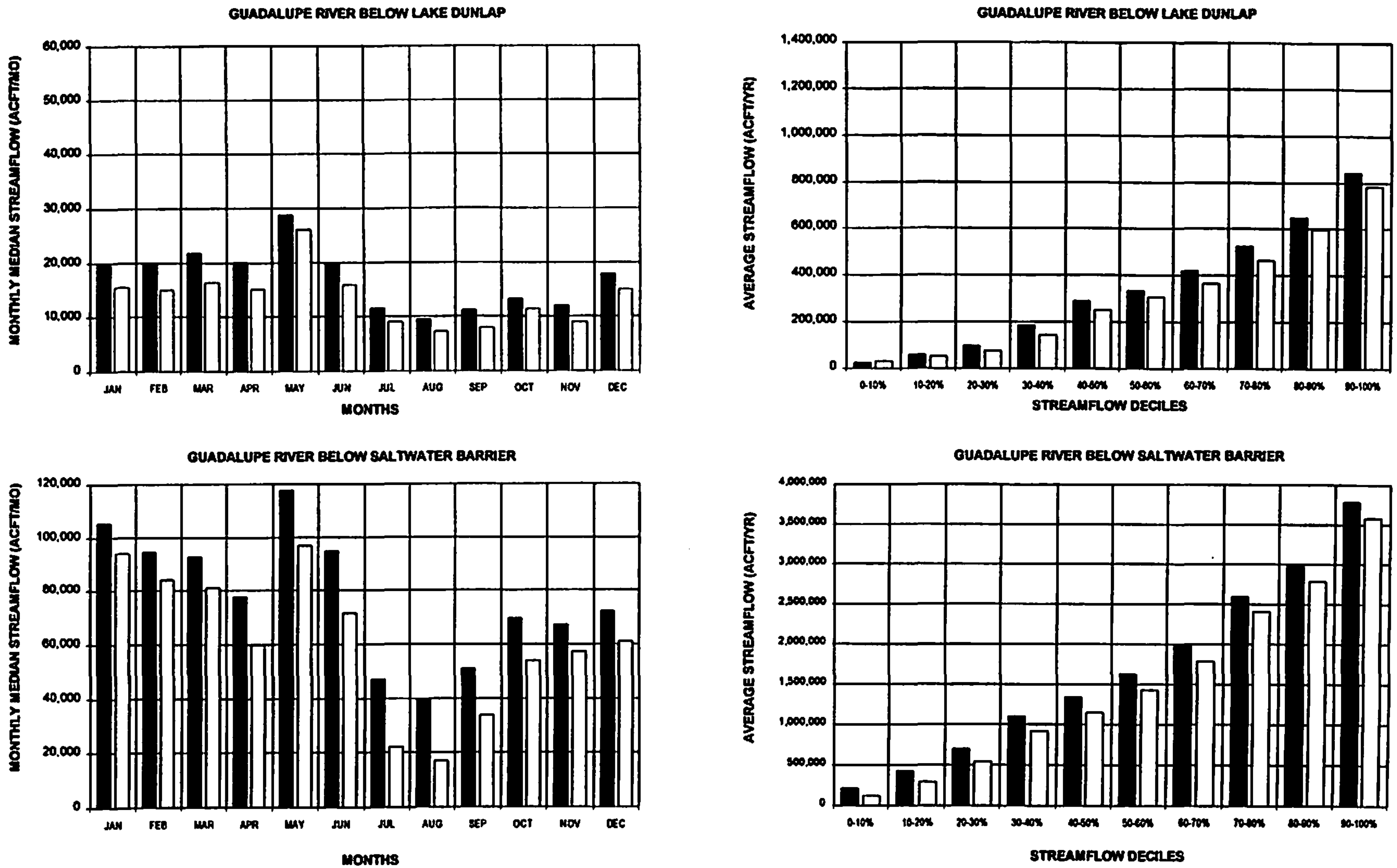
Alternatives G-37A and G-37B would require the purchase of 15,000 acft/yr of Canyon Lake water from GBRA. This purchase could be made under the existing Canyon Lake permit, or an amended permit allowing annual diversions in excess of current permit amounts. The purchased water would be released from Canyon Lake to an intake near the existing CRWA intake on Lake Dunalp. Lake Dunlap is a long, moderately deep reservoir within the banks of the Guadalupe River. It is formed by a small hydroelectric dam downstream of the Guadalupe River's confluence with the Comal River. In addition to hydroelectric power generation, Lake Dunlap is used for boating, fishing and camping.

In the event diversions are made under the existing Canyon Lake permit, no in-stream flow studies would be needed. In the event that the Canyon Lake permit is amended to allow increased annual diversions, then in-stream flow studies may be indicated for the affected reach. If in-stream flow studies are indicated, evaluation of the potential effects of the project on the general ecology of the river and on Cagle's map turtle (*Graptemys caglei*), Guadalupe bass (*Micropterus treculi*) and blue sucker (*Cycleptus elongatus*) which are federal candidate species might be needed. In Texas the blue sucker is listed as threatened. Guadalupe bass ranges from the Edwards Plateau, through the Blackland Prairie and to the Coastal Plain in the Guadalupe River. The Guadalupe bass may occur in Lake Dunlap. However, the Guadalupe bass is better adapted to flowing water and is often found near riffles feeding on insects. The blue sucker (a candidate for federal protection) is a large river fish that could occur in Guadalupe County, however, Hubbs reported no occurrences of blue sucker in the Guadalupe River Basin.[4]

Alternatives G-37C and G-37D involve diversion of water from other sources in addition to purchase of stored water. Modeling was used to estimate instream flows and inflows to the bay and estuary with and without implementation of Alternative G-37. Additionally, two diversion scenarios, uniform and summer peaking were considered with respect to evaluating impacts at the diversion point and downstream at the Saltwater Barrier. Assumptions for estimating flow without Alternative G-37 included 1989 withdrawals from the Edwards Aquifer of 543,677 acft/yr, existing water rights fully exercised, and full utilization of Canyon Lake firm yield with full subordination of hydropower water rights. Flow estimates with the project in place assumed a diversion of 50,000 acft/yr, withdrawals from the Edwards Aquifer of 400,000 acft/yr, full utilization of Canyon Lake firm yield with full subordination of hydropower water rights, major existing water rights (i.e., > 7,000 acft/yr) being exercised at projected year 2020 use, and all other water rights fully exercised.

Under the uniform diversion scenario, estimated annual median flows at Lake Dunlap based on the 1934-1989 period of record increased from 287,948 acft/yr without the project to an estimated 309,635 acft/yr with the project, an increase of 7.5 percent. Monthly median flows ranged from 7,247 acft/yr to 26,144 acft/yr without Alternative G-37C and from 9,623 acft/yr to 28,887 acft/yr with implementation of the project (Figure 3.4-3). Monthly median flows increased between 10.5 percent to 41.2 percent with implementation of the project. Plotting the annual decile average flow indicated that flow reductions averaging 27.6 percent occurred in the lowest flow decile and increased between 7.5 percent and 25.7 percent in all other deciles (Figure 3.4-3). The increased streamflows with implementation of Alternative G-37C resulted primarily

[4] Hubbs, C., J.D. McEachran, and C.R. Smith. 1994. Freshwater and Marine Fishes of the Texas and the Nortwestern Gulf of Mexico. The Texas System of Natural Laboratories, Inc. Austin, Texas.



LEGEND:

■ WITH PROJECT

□ WITHOUT PROJECT

NOTES:

1. ANNUAL DIVERSION RATE = 50,000 ACFT
2. STATISTICS BASED ON 1934-89 HISTORICAL PERIOD
3. WITH PROJECT STREAMFLOWS BASED ON EDWARDS AQUIFER PUMPAGE = 400,000 ACFT/YR
4. WITHOUT PROJECT STREAMFLOWS BASED ON EDWARDS AQUIFER PUMPAGE = 543,677 ACFT/YR

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TRANS TEXAS WATER PROGRAM /
WEST CENTRAL STUDY AREA

CHANGES IN STREAMFLOW
UNIFORM DIVERSION
GUADALUPE RIVER-LAKE DUNLAP
ALTERNATIVE G- 37C

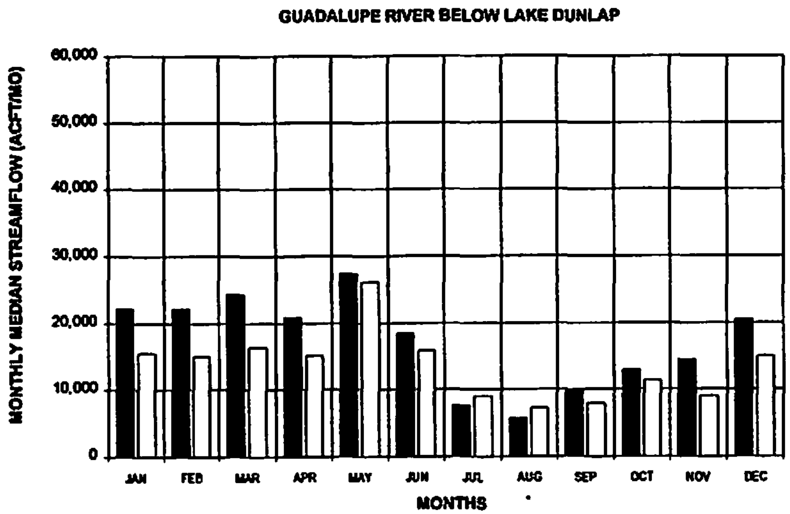
FIGURE 3.4-3

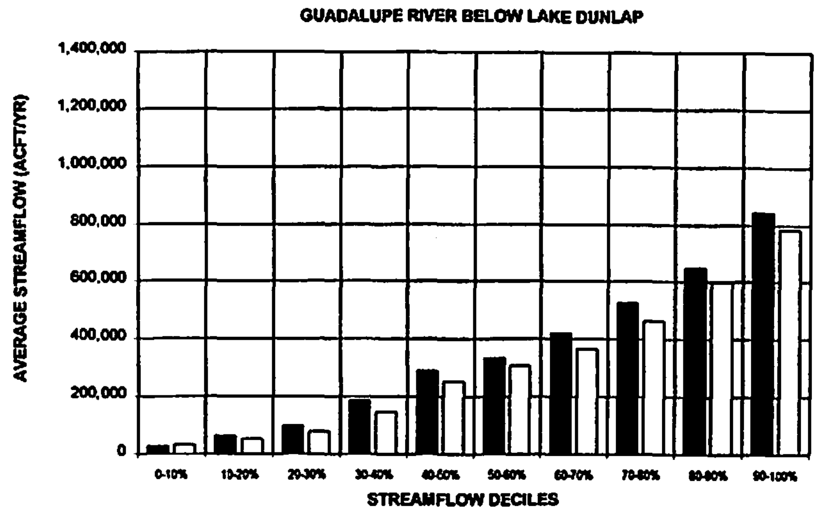
from enhanced springflow. Increasing instream flow is generally considered to have a favorable effect on riverine habitats and their inhabitants, however, increased instream flows of the magnitude considered here would not be expected to produce a significant change in the ecology of the river.

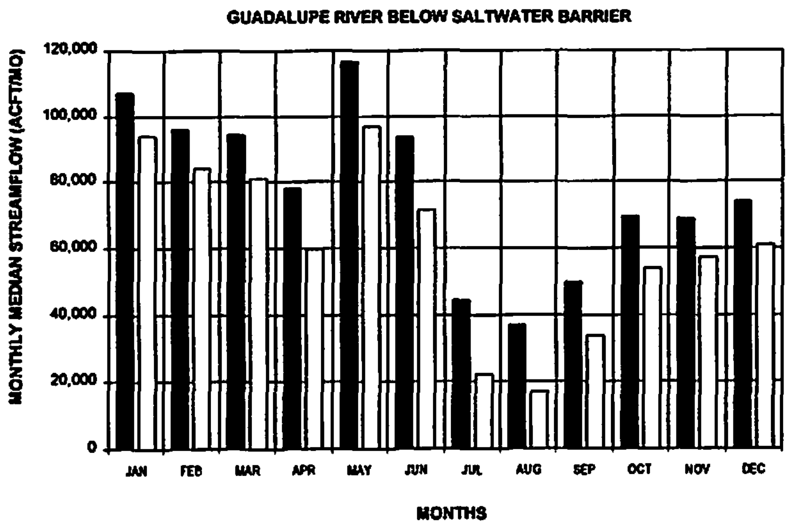
At the Saltwater Barrier (inflow to the Guadalupe-San Antonio Estuary), estimated annual median flow increased from 1,220,927 acft/yr to 1,435,622 acft/yr with implementation of Alternative G-37C, an increase of 17.6 percent. Monthly median flows ranged from an estimated 16,960 acft/yr to 96,754 acft/yr without Alternative G-37C and 39,520 acft.yr to 117,595 acft/yr with implementation of the project (Figure 3.4-3). Percent increases in monthly medians ranged from 11.9 percent to 111.5 percent. Plotting annual average deciles indicated increased flows ranging from 67.4 percent in the lowest decile to 5.6 percent in the highest decile (Figure 3.4-3). The increased flows resulted primarily from enhanced springflow to the Guadalupe River. Because freshwater inflow to estuaries is positively correlated with the productivity of several commercially important estuarine species, increased freshwater inflows to the estuary would be viewed as having a favorable effect.[5]

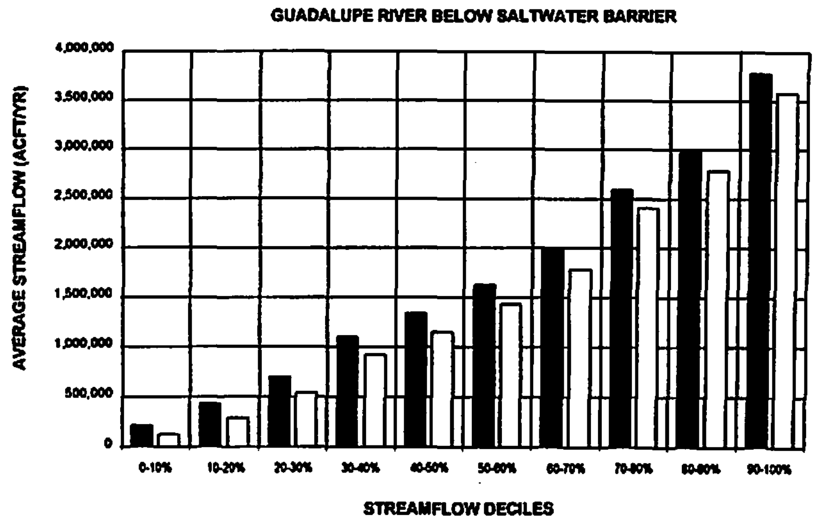
Under the summer peaked diversion scenario (Alternative G-37D) at Lake Dunlap, estimated monthly medians with implementation of the alternative ranged from 5,756 acft/yr to 27,487 acft/yr (Figure 3.4-4). Percent change in monthly medians ranged from a decrease of 20.6 percent to an increase of 61 percent. Percent change in the annual decile average ranged from a decrease of 13.9 in the lowest decile to an increase of 32.0 percent (Figure 3.4-4). The summer peaked diversion scenario resulted in substantial increases in estimated stream flows in the winter months and smaller decreases in July (14 percent) and August (21 percent). These decreases resulted from seasonally peaked demand distribution and assumptions of the model regarding the application of environmental criteria to enhanced springflows and underutilized water rights. The marked increases in monthly median flows resulted primarily from enhanced springflows. Increased flow in some months and decreased flow in other months increased annual median flows and variation in flows compared to that presently characteristic of the river. The increased flows would be expected to have a favorable effect on the ecology of the river. The increased variability in monthly median flows may increase seasonal fluctuations in the

[5] Longley, W.L., ed. 1994. Freshwater inflows to Texas bays and estuaries: ecological relationships and methods for determination of needs. Texas Water Development Board and Texas Parks and Wildlife Department, Austin, Texas.









LEGEND:

■ WITH PROJECT

□ WITHOUT PROJECT

NOTES:
1. ANNUAL DIVERSION RATE = 50,000 ACFT
2. STATISTICS BASED ON 1934-89 HISTORICAL PERIOD
3. WITH PROJECT STREAMFLOWS BASED ON EDWARDS AQUIFER PUMPAGE = 400,000 ACFT/YR
4. WITHOUT PROJECT STREAMFLOWS BASED ON EDWARDS AQUIFER PUMPAGE = 543,677 ACFT/YR

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**CHANGES IN STREAMFLOW
SUMMER PEAKED DIVERSION
GUADALUPE RIVER-LAKE DUNLAP
ALTERNATIVE G- 37D**

FIGURE 3.4-4

relative abundance of species inhabiting the river as the availability of various aquatic habitats in the river change. However, such changes seem unlikely to significantly impact sensitive species, especially considering changes from historical conditions that have already occurred.

The summer peaked diversion scenario implemented at Lake Dunlap resulted in monthly median freshwater flows at Saltwater Barrier ranging from an estimated 36,730 acft/yr to 116,609 acft/yr, monthly increases of from 13.8 percent to 116.6 percent (Figure 3.4-4). At Saltwater Barrier the differences in the effects of uniform and summer-peaked diversions are unlikely to be ecologically significant. The decile statistics of the uniform and summer peaked diversion scenarios are nearly identical. Instream flows increased in all deciles (Figure 3.4-4) with the greatest percent increases in the lowest deciles (68.7 percent in the zero to 10 percent decile). These marked increases in freshwater inflow resulted from reduced withdrawals from the Edwards Aquifer and concomitant springflow enhancement. Because over half of the freshwater inflows to the estuary come from gaged portions of the Guadalupe River alone,[6] increased streamflows may affect estuarine ecology especially in the bays nearest the mouth of the river (Mission Lake, Guadalupe Bay, Haynes Bay and San Antonio Bay). Increased freshwater inflows to the estuary are generally considered to have a favorable effect on estuarine ecology, especially since increasing diversions during historical times presumably have reduced freshwater inflows below those which occurred previously.

3.4.4 Water Quality and Treatability

[To be completed in subsequent phases of the study.]

3.4.5 Engineering and Costing

For this alternative, raw water diverted at Lake Dunlap would be treated at a potential regional water treatment plant near Marion and treated water would be supplied on a wholesale basis to Green Valley SUD, Marion, Cibolo, Schertz, Garden Ridge, and San Antonio Water System. Figure 3.4-1 shows the general location of the potential water treatment plant and potential pipeline routes, however, pipeline routes may be adjusted once route studies and on-the-ground surveys have been performed in subsequent project phases.

[6] Ibid.

Springs Hill WSC and Crystal Clear WSC currently receive treated water from the CRWA treatment plant at Lake Dunlap. Construction of a treated waterline from the regional WTP eastward to the existing CRWA WTP would not be economical. Therefore, Springs Hill WSC and Crystal Clear WSC would not be connected to the regional WTP, but potentially receive their water allocation by trading an equivalent amount of treated water with Green Valley SUD. For this arrangement, Springs Hill WSC would receive 123 acft/yr and Crystal Clear WSC would receive 476 acft/yr more water from the CRWA WTP than currently allocated and Green Valley SUD would receive 599 acft/yr less water from the CRWA WTP than currently allocated.

Raw water would be pumped to the treatment plant from a new water intake to be located near the existing CRWA intake at Lake Dunlap. Treatment would consist of conventional surface water treatment (flocculation, settling, filtration, and chlorine disinfection).

The major facilities required to implement this alternative are:

- Reservoir Intake and Pump Station
- Raw Water Pipeline to Treatment Plant
- Water Treatment Plant Expansion
- Treated Water Pump Station
- Transmission Pipeline
- Interconnections to:
  - Marion
  - Cibolo
  - Schertz
  - Green Valley SUD
  - SAWS Stahl Secondary Pump Station
- Booster Pump Station

Alternative G-37A and G-37B: Delivery of 15,000 acft/yr of Canyon Lake Water (Diverted at Lake Dunlap) to Regional WTP near Marion

Delivery facilities were sized to deliver a pro-rata allocation of 2020 projected shortages to Marion, Cibolo, Schertz, Garden Ridge and Green Valley SUD. Delivery facilities to Green Valley SUD were sized for Green Valley projected demands plus 599 acft/yr for the potential water trade with Crystal Clear and Spring Hill WSCs. Delivery facilities to the SAWS Stahl Pump Station were sized to deliver 15,000 acft/yr.

Two delivery rate scenarios were considered: a uniform annual delivery rate (Alternative G-37A); and, a summer month peak rate of 2.0 times the uniform annual delivery rate

(Alternative G-37B). Table 3.4-8 summarizes the design delivery rate and pipeline sizes at the raw water intake and at each of the delivery locations.

Table 3.4-8
Delivery Rates and Pipeline Sizes for Alternatives G-37A and G-37B

Location	Annual Delivery Amount (acft/yr)	Description of Connection & Capital Cost Item	Design Delivery Rate and Size: Uniform Annual Delivery (G-37A) Delivery Rate (mgd)	Uniform Annual Delivery (G-37A) Pipeline Diameter	Summer Peak Delivery (G-37B) Delivery Rate (mgd)	Summer Peak Delivery (G-37B) Pipeline Diameter
Raw Water Intake	15,000	----	13.4	30"	26.8	42"
Springs Hill WSC	123	(1)	0.11	(1)	0.22	(1)
Crystal Clear WSC	476	(1)	0.43	(1)	0.86	(1)
Marion	87	Connection to existing GST	0.08	4"	0.16	4"
Cibolo	160	Connection to existing GST	0.17	4"	0.34	6"
Green Valley SUD	1,624	Connection to existing GST	1.98	12"	4.0	14"
Schertz	2,612	Connection to existing GST	2.33	12"	4.66	18"
Garden Ridge	570	Connection to existing well	0.51	6"	1.02	8"
SAWS-Stahl Pump Station	12,839	New 10 MG GST	13.4	30"	26.8	42"

(1) Springs Hill WSC and Crystal Clear WSC will not be connected to the regional WTP, but would potentially receive their water allocation through a water trade with Green Valley SUD.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water, land, and environmental mitigation. Cost estimates for Alternatives G-37A and G-37B are presented in Table 3.4-9. The total estimated project cost of Alternative G-37A is $36,100,000 (Table 3.4-9), which results in a total annual cost, including operation and maintenance and purchase of stored water, of $5,905,000. The total estimated project cost for Alternative G-37B is $54,310,000 (Table 3.4-9), which results in a total annual cost, including operation and maintenance and purchase of stored water, of $8,635,000. The operating cost was determined for a total static lift from Lake Dunlap to the Stahl Pump Station well of 350 ft. and an annual delivery of 15,000 acft.

The estimated cost of each alternative was allocated to each delivery location based on the pro-rata capacity of each component dedicated to meeting potential year 2000 and 2020 demands at the delivery location. Thus, for raw water and treatment facility costs, participants would pay a pro-rata share based solely on the percent of total capacity dedicated to meeting

Table 3.4-9
Cost Estimate Summaries for Potential Supply from Canyon Lake Diverted at Lake Dunlap to Regional WTP 15,000 acft/yr (Alternatives G-37A and G-37B) (First Quarter - 1996 Prices)

Item	Alt. G-37A Uniform Annual Delivery	Alt. G-37B Summer Peak Delivery
Capital Costs		
Intake and Treatment Plant	$12,690,000	$21,210,000
Transmission Pipelines	9,530,000	14,000,000
Booster Pump Stations	0	0
Interconnects to Participants	3,920,000	4,140,000
Total Capital Cost	$26,140,000	$39,410,000
Engineering, Contingencies, and Legal Costs	8,480,000	12,890,000
Environmental Studies and Mitigation	190,000	190,000
Land Acquisition	240,000	240,000
Interest During Construction	1,050,000	1,580,000
Total Project Cost	$36,100,000	$54,310,000
Annual Costs		
Annual Debt Service	$3,380,000	$5,080,000
Annual Operation and Maintenance		
Water Treatment Plant	660,000	1,590,000
Transmission Pipelines	210,000	310,000
Annual Power Cost	860,000	860,000
Purchase of Stored Water(1)	795,000	795,000
Total Annual Cost	$5,905,000	$8,635,000

(1) Cost of Stored water purchased from GBRA is $53/acft.

their water demands, and the participant's location relative to the water source did not affect the cost allocation for treatment. For transmission and pump station costs, allocation was made on a pro-rata allocation only of the facilities needed to deliver water to them, consequently, costs to participants that are furthest from the water source are proportionately greater.

For Alternatives G-37A and G-37B (annual delivery of 15,000 acft), Tables 3.4-10 and 3.4-11 summarize the total annual cost and the annual unit cost of water for year 2000 and year 2020. Early in project operation, small quantities of water will be delivered to participants and all available water will be delivered to SAWS. The cost of water for year 2020 conditions

Table 3.4-10
Summary of Costs by Delivery Location
Potential Supply from Canyon Lake Diverted at Lake Dunlap to Regional WTP
15,000 acft/yr, Uniform Annual Delivery (G-37A)
(First Quarter - 1996 dollars)

Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Year 2000 Annual Volume[(1)] (acft/yr)	Year 2000 Annual Cost	Year 2000 Unit Cost[(2)] $/acft/yr	Year 2000 Unit Cost[(2)] $/1000 gal	Year 2020 Annual Volume[(1)] (acft/yr)	Year 2020 Annual Cost	Year 2020 Unit Cost[(2)] $/acft/yr	Year 2020 Unit Cost[(2)] $/1000 gal
Springs Hill [(4)] (0.11 mgd)	0	$30,000	[(3)]	[(3)]	123	$37,000	$300	$0.92
Crystal Clear [(4)] (0.43 mgd)	0	$118,000	[(3)]	[(3)]	476	$143,000	$300	$0.92
Marion (0.08 mgd, 4")	56	$38,000	$687	$2.11	87	$43,000	$494	$1.52
Green Valley (1.98 mgd, 4")	362	$251,000	$694	$2.13	1,624	$488,000	$300	$0.92
Cibolo (0.18 mgd, 4")	160	$59,000	$370	$1.14	160	$57,000	$357	$1.10
Garden Ridge (0.51 mgd, 6")	315	$167,000	$530	$1.63	570	$206,000	$362	$1.11
Schertz (2.33 mgd, 12")	1,268	$694,000	$547	$1.68	2,612	$882,000	$338	$1.04
SAWS (13.4 mgd, 30")	12,839	$4,548,000	$354[(5)]	$1.09[(5)]	9,348	$4,049,000	$433[(5)]	$1.33[(5)]
Total	15,000	$5,905,000	$393	$1.21	15,000	$5,905,000	$393	$1.21

(1) Annual volume not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the participant's distribution system
(3) Annual costs for debt service will accrue, even though no water deliveries are projected.
(4) Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.
(5) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to transport the water, may occur before year 2020.
Note: The unit cost to deliver all 15,000 acft/yr to SAWS would be about $386 per acft/yr ($1.18/1,000 gallons).

Table 3.4-11 Summary of Costs by Delivery Location Potential Supply from Canyon Lake Diverted at Lake Dunlap to Regional WTP 15,000 acft/yr, Summer Peaking Delivery (G-37B) (First Quarter - 1996 dollars)								
	Year 2000				Year 2020			
Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft/yr	Unit Cost(2) $/1000 gal	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft/yr	Unit Cost(2) $/1000 gal
Springs Hill (4) (0.22 mgd)	0	$50,000	(3)	(3)	123	$56,000	$458	$1.41
Crystal Clear (4) (0.86 mgd)	0	$193,000	(3)	(3)	476	$218,000	$458	$1.41
Marion (0.16 mgd, 4")	56	$50,000	$890	$2.73	87	$56,000	$647	$1.98
Green Valley (3.06 mgd, 14")	362	$385,000	$1,062	$3.26	1,624	$744,000	$458	$1.41
Cibolo (0.34 mgd, 6")	160	$86,000	$537	$1.65	160	$84,000	$523	$1.60
Garden Ridge (1.02 mgd, 8")	315	$252,000	$799	$2.45	570	$308,000	$541	$1.66
Schertz (4.66 mgd, 18")	1,268	$1,055,000	$832	$2.55	2,612	$1,334,000	$511	$1.57
SAWS (26.8 mgd, 42")	12,839	$6,564,000	$512(5)	$1.57(5)	9,348	$5,835,000	$625(5)	$1.92(5)
Total	15,000	$8,635,000	$576	$1.77	15,000	$8,635,000	$576	$1.77

(1) Annual volume not adjusted for treatment, transmission, and other losses.

(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the participant's distribution system

(3) Annual costs for debt service will accrue, even though no water deliveries are projected.

(4) Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.

(5) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to transport the water, may occur before year 2020.

delivered at a uniform delivery rate varies from $300 per acft per year for Green Valley SUD to $494 per acft per year (Table 3.4-10) delivered to Marion. For a summer peaking pattern, and full usage of the allotted amount, the unit cost of water varies from $458 per acft per year for Green Valley SUD to $647 per acft per year (Table 3.4-11) for Marion.

For the case of all 15,000 acft/yr being delivered to Bexar County at the SAWS Stahl pump Station (as possibly would happen in the early years of project operation), the annual unit cost was estimated to be $386 per acft/yr at a uniform delivery rate and $566 per acft/yr for a summer peaking delivery pattern. These unit costs are inclusive of all system costs (capital and O&M) for all system, components, except lateral pipelines and connections to intermediate delivery points.

<u>Alternative G-37C and G-37D: Delivery of 50,000 acft/yr Diverted at Lake Dunlap to Regional WTP near Marion</u>

Delivery facilities were sized to deliver year 2020 projected shortages to Marion, Cibolo, Schertz, Garden Ridge, and Green Valley SUD. Delivery facilities to Green Valley SUD were sized for Green Valley projected demands plus 599 acft/yr for a potential water trade with Crystal Clear WSC and Springs Hill WSC. Delivery facilities to the San Antonio Water System Stahl pump station were sized to deliver 50,000 acft/yr. Two delivery rate scenarios were considered: a uniform annual delivery rate (Alternative G-37C); and, a summer month peak rate of 2.0 times the uniform annual delivery rate (Alternative G-37D). Table 3.4-12 summarizes the design delivery rate and pipeline sizes at the raw water intake and at each of the delivery locations.

An off-channel storage reservoir could potentially be located near the water treatment plant and could reduce the diversion rate and raw water pipeline size. To reduce the monthly peak diversion rate factor from 2.0 (17 percent of annual total) to 1.4 (11.3 percent of annual total) would require a 5,500 acft storage reservoir. This lower diversion rate would reduce the raw water pipeline diameter from 72 inches to 60 inches. The raw water pipeline would be about eight miles long and the pipeline savings do not offset the cost of the off-channel storage. However, because the off-channel storage also offers advantages of forebay storage, higher plant reliability, and pre-sedimentation treatment and blending, if other raw water sources are located, the option should be left open as other potential water sources are considered and land costs to acquire a storage site (500 acres) have been included in the cost estimate.

Table 3.4-12 Delivery Rates and Pipeline Sizes for Alternatives G-37C and G-37D						
			Design Delivery Rate and Size			
	Annual	Description of	Uniform Annual Delivery (G-37C)		Summer Peak Delivery (G-37D)	
Location	Delivery Amount (acft/yr)	Connection & Capital Cost Item	Delivery Rate (mgd)	Pipeline Diameter	Delivery Rate (mgd)	Pipeline Diameter
Raw Water Intake	50,000	----	44.6	54"	89.3	72"
Springs Hill WSC	123	(1)	0.11	(1)	0.22	(1)
Crystal Clear WSC	476	(1)	0.43	(1)	0.86	(1)
Marion	87	Connection to existing GST	0.08	4"	0.16	4"
Cibolo	160	Connection to existing GST	0.17	4"	0.34	6"
Green Valley SUD	1,624	Connection to existing GST	1.98	12"	4.0	14"
Schertz	2,612	Connection to existing GST	2.33	12"	4.66	18"
Garden Ridge	570	Connection to existing well	0.51	6"	1.02	8"
SAWS-Stahl Pump Station	44,348	New 10 MG GST	44.6	54"	89.3	72"

(1) Spring Hill WSC and Crystal Clear WSC will not be connected to the regional WTP, but would potentially receive their water allocation through a water trade with Green Valley SUD.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water, land, and environmental mitigation. Cost estimates for Alternatives G-37C and G-37D are presented in Table 3.4-13. Table 3.4-13 reports the annual cost to purchase stored water from GBRA to meet the drought average requirement. Although the amount of stored water actually needed each year may be higher or lower, the annual cost is held constant at the drought average amount, as would be the case with a "take-or-pay" type of purchase contract. The total estimated project cost of Alternative G-37C is $75,060,000 (Table 3.4-13), which results in a total annual cost, including operation and maintenance of $13,290,000. The total estimated project cost for Alternative G-37D is $118,780,000 (Table 3.4-13), which results in a total annual cost, including operation and maintenance of $19,995,000. The operating cost was determined for a total static lift from Lake Dunlap to the SAWS Stahl Pump Station of 350 ft and an annual delivery of 50,000 acft.

The estimated cost of each alternative was allocated to each delivery location based on the pro-rata capacity of each component dedicated to meeting potential year 2000 and 2020 demands at the delivery location. Thus, participants would pay a pro-rata share of raw water and

Table 3.4-13 Cost Estimate Summaries for Potential Supply Diverted at Lake Dunlap to Regional WTP 50,000 acft/yr (Alternatives G-37C and G-37D) (First Quarter - 1996 Prices)		
Item	**Alt. G-37C Uniform Annual Delivery**	**Alt. G-37D Summer Peak Delivery**
Capital Costs		
Intake and Treatment Plant	$29,470,000	$48,090,000
Off-Channel Reservoir at WTP	0	0
Transmission Pipelines	20,390,000	33,490,000
Booster Pump Stations	0	0
Interconnects to Participants	4,020,000	4,240,000
Total Capital Cost	$53,880,000	$85,820,000
Engineering, Contingencies, and Legal Costs	17,640,000	28,150,000
Environmental Studies and Mitigation	190,000	190,000
Land Acquisition(1)	1,190,000	1,190,000
Interest During Construction	2,160,000	3,430,000
Total Project Cost	$75,060,000	$118,780,000
Annual Costs		
Annual Debt Service	$ 7,030,000	$11,130,000
Annual Operation and Maintenance		
Water Treatment Plant	2,250,000	4,420,000
Transmission Pipelines	480,000	720,000
Annual Power Cost	1,940,000	1,940,000
Water Purchase(2)	1,590,000(2)	1,785,000(3)
Total Annual Cost	$13,290,000	$19,995,000

(1) Land acquisition cost includes site for future off-channel storage reservoir.
(2) Includes 18,825 acft/yr of stored water purchased from GBRA and 11,129 acft/yr of year 2020 underutilized water rights at an annual cost of $53/acft.
(3) Includes 21,697 acft/yr of stored water purchased from GBRA and 11,129 acft/yr of year 2020 underutilized water rights at an annual cost of $53/acft.

treatment facility costs based solely on the percent of total capacity dedicated to meeting their water demands and the participant's location relative to the water source did not affect calculation of the cost allocation. For transmission and pump station costs, each participant pays a pro-rata share only of the facilities needed to deliver water to them, consequently, costs to participants that are furthest from the water source are proportionately greater.

For Alternatives G-37C and G-37D (annual delivery of 50,000 acft), Tables 3.4-14 and 3.4-15 summarize the total annual cost and the unit cost of water for year 2000 and year 2020. Early in project operation, less water will be delivered to participants and all remaining available water will be delivered to SAWS. The cost of water for year 2020 conditions delivered at a uniform delivery rate varies from $227 per acft for Green Valley SUD to $574 per acft (Table 3.4-14) for Marion. For a summer peaking distribution pattern, and full usage of the allotted amount, the unit cost of water varies from $341 per acft for Green Valley SUD to $690 per acft (Table 3.4-15) for Marion.

For the case of all 50,000 acft/yr being delivered to Bexar County at the SAWS Stahl pump station (as possibly would happen in the early years of project operation), the annual unit cost was estimated to be $263 per acft per year at a uniform delivery rate and $397 per acft per year for a summer peaking delivery pattern. These unit costs are inclusive of all system costs (capital and O&M) for all system components, except lateral pipelines and connections to intermediate delivery points.

3.4.6 Implementation Issues

Implementation steps include:

- Commitment of project participants
- Phasing of project elements
- Negotiate water purchase contracts with GBRA and existing senior water-rights owners
- Financing
- Engineering
- Permitting
- Construction
- Operation and Maintenance

<u>Requirements Specific to Amending the Canyon Lake Permit</u>

1. Alternatives G-37C and G-37D will likely require exceeding the current annual permitted quantity from Canyon Lake of 50,000 acft, and a permit amendment will be necessary. This amendment will require:
   a. Application to the TNRCC.
   b. Hydrologic studies substantiating requested firm yield.
   c. Possibly environmental studies of in-stream flow and bay/estuary effects.
   d. Subordination of hydropower rights.
   e. Management of Edwards Aquifer by a regional agency to achieve the modeled aquifer pumpage/springflow scenario.

Table 3.4-14
Summary of Costs by Delivery Location
Potential Supply Diverted at Lake Dunlap to Regional WTP
50,000 acft/yr, Uniform Annual Delivery (G-37C)
(First Quarter - 1996 dollars)

Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Year 2000 Annual Volume[1] (acft/yr)	Year 2000 Annual Cost	Year 2000 Unit Cost[2] $/acft/yr	Year 2000 Unit Cost[2] $/1000 gal	Year 2020 Annual Volume[1] (acft/yr)	Year 2020 Annual Cost	Year 2020 Unit Cost[2] $/acft/yr	Year 2020 Unit Cost[2] $/1000 gal
Springs Hill [4] (0.11 mgd)	0	$21,000	[3]	[3]	123	$28,000	$227	$0.70
Crystal Clear [4] (0.43 mgd)	0	$83,000	[3]	[3]	476	$108,000	$227	$0.70
Marion (0.08 mgd, 4")	56	$45,000	$804	$2.47	87	$50,000	$574	$1.76
Green Valley (1.98 mgd, 4")	362	$175,000	$483	$1.48	1,624	$369,000	$227	$0.70
Cibolo (0.18 mgd, 4")	160	$44,000	$275	$0.84	160	$44,000	$275	$0.84
Garden Ridge (0.51 mgd, 6")	315	$118,000	$375	$1.15	570	$149,000	$261	$0.80
Schertz (2.33 mgd, 12")	1,268	$506,000	$399	$1.22	2,612	$671,000	$257	$0.79
SAWS-Stahl Pump Station (45 mgd, 30")	47,839	$12,298,000	$257	$0.79	44,348	$11,871,000	$268[5]	$0.82[5]
Total	50,000	$13,290,000	$266	$0.82	50,000	$13,290,000	$266	$0.82

(1) Annual volume not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the participant's distribution system
(3) Annual costs for debt service will accrue, even though no water deliveries are projected.
(4) Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.
(5) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to transport the water, may occur before year 2020.
Note: The unit cost to deliver all 50,000 acft/yr to SAWS would be about $263 per acft/yr ($0.81/1,000 gallons).

Table 3.4-15 Summary of Costs by Delivery Location Potential Supply Diverted at Lake Dunlap to Regional WTP 50,000 acft/yr, Summer Peaking Delivery (G-37D) (First Quarter - 1996 dollars)								
	Year 2000				Year 2020			
Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft/yr	Unit Cost(2) $/1000 gal	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft/yr	Unit Cost(2) $/1000 gal
Springs Hill (4) (0.22 mgd)	0	$35,000	(3)	(3)	123	$42,000	$341	$1.05
Crystal Clear (4) (0.86 mgd)	0	$137,000	(3)	(3)	476	$162,000	$341	$1.05
Marion (0.16 mgd, 4")	56	$53,000	$946	$2.90	87	$60,000	$690	$2.12
Green Valley (3.06 mgd, 14")	362	$266,000	$735	$2.26	1,624	$553,000	$341	$1.05
Cibolo (0.34 mgd, 6")	160	$64,000	$400	$1.23	160	$63,000	$394	$1.21
Garden Ridge (1.02 mgd, 8")	315	$178,000	$565	$1.73	570	$223,000	$391	$1.20
Schertz (4.66 mgd, 18")	1,268	$770,000	$607	$1.86	2,612	$1,004,000	$384	$1.18
SAWS-Stahl Pump Station (89 mgd, 72")	47,839	$18,492,000	$387	$1.19	44,348	$17,888,000	$403(5)	$1.24(5)
Total	50,000	$19,995,000	$400	$1.23	50,000	$19,995,000	$400	$1.23

(1) Annual volume not adjusted for treatment, transmission, and other losses.

(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the participant's distribution system

(3) Annual costs for debt service will accrue, even though no water deliveries are projected.

(4) Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.

(5) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to transport the water, may occur before year 2020.

Lake Dunlap Intake

It will be necessary to obtain these permits:

a. TNRCC Water Right permit.
b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the intake.
c. GLO Easement for use of state-owned land.
d. Coastal Coordinating Council review.
e. GBRA modification or construction permit.

2. Permitting, at a minimum, will require these studies:
   a. Environmental studies.
   b. Cultural resource studies.
3. Land will need to be acquired through either negotiations or condemnation.

Requirements Specific to Diversion of Water from Guadalupe River

To obtain more realistic values of surface water availability, additional in-depth studies of environmental water needs should be performed for affected reaches of the Guadalupe and San Antonio Rivers. These studies are consistent with the Environmental Water Needs Criteria of the Consensus Planning Process which allows the substitution of alternative flow minimums based on stream-specific studies considering indigenous species, habitat, recreational utilization, water quality, and assimilative capacity of individual stream segments.

1. Necessary permits:
   a. Existing water rights permits will need to be amended subsequent to negotiations with each water right owner to allow for an additional point of diversion at Lake Dunlap.
   b. TNRCC permit to divert water.
   c. TNRCC Interbasin Transfer Approval.
2. Permitting will require these studies:
   a. Instream flow issues and impact.
   b. Environmental studies.
   c. Bay and estuary inflow impact.
3. Agreements with water right permit owners including GBRA for use and payment for water diverted under existing permits and for water released from Canyon Lake.

Requirements Specific to Pipelines

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel and Marl Removal permits.

d. Coastal Coordinating Council review may be required.

2. Right-of-way and easement acquisition.
3. Crossings.
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

Requirements Specific to Treatment and Distribution

A detailed study is needed of the cost of pumping and transmission pipeline improvements necessary to effectively integrate the new supply into SAWS water distribution system.

Off-Channel Reservoir (when implemented)

1. It will be necessary to obtain these permits for the off-channel storage reservoir.
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer Approval.
   c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. GLO Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordinating Council review.
   g. TPWD Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Bay and estuary inflow impact.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired either through negotiations or condemnation.
4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Other utilities.

3.5 Guadalupe River Diversion at Gonzales to Mid-Cities and Bexar County with Regional WTP (G-38)

3.5.1 Description of Alternative

This alternative considers diversion of water from the Guadalupe River near Gonzales for treatment at a potential regional water treatment plant near Marion and delivery of treated water on a wholesale basis to several delivery points. Two annual diversion volumes (40,000 acft/yr and 75,000 acft/yr) were studied and Table 3.5-1 summarizes the numbering system for the supply alternatives, diversion quantities, delivery rates (i.e. peaking factors), and delivery locations.

Table 3.5-1
Definition of Alternatives for Guadalupe River Diversion at Gonzales with Regional WTP (G-38)

Alternative	Diversion Quantity (acft/yr)	Delivery Rate	Delivery Location
G-38A	40,000	uniform	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-38B	40,000	summer peaking	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-38C	75,000	uniform	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-38D	75,000	summer peaking	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)

(1) Includes Green Valley SUD, Springs Hill WSC, and Crystal Clear WSC.
(2) Delivery to SAWS Stahl Secondary Pump Station facility.

The water potentially available for diversion near Gonzales would be made up of periodically-available run-of-the-river diversions made firm by allocation of a portion of the firm yield of Canyon Lake and also from use of existing water rights projected to be underutilized in year 2020. A highlight of this alternative is the conjunctive use of multiple water sources to optimize water availability using banked storage in Canyon Lake. (Appendix C describes the use of banked storage and water availability from each source.)

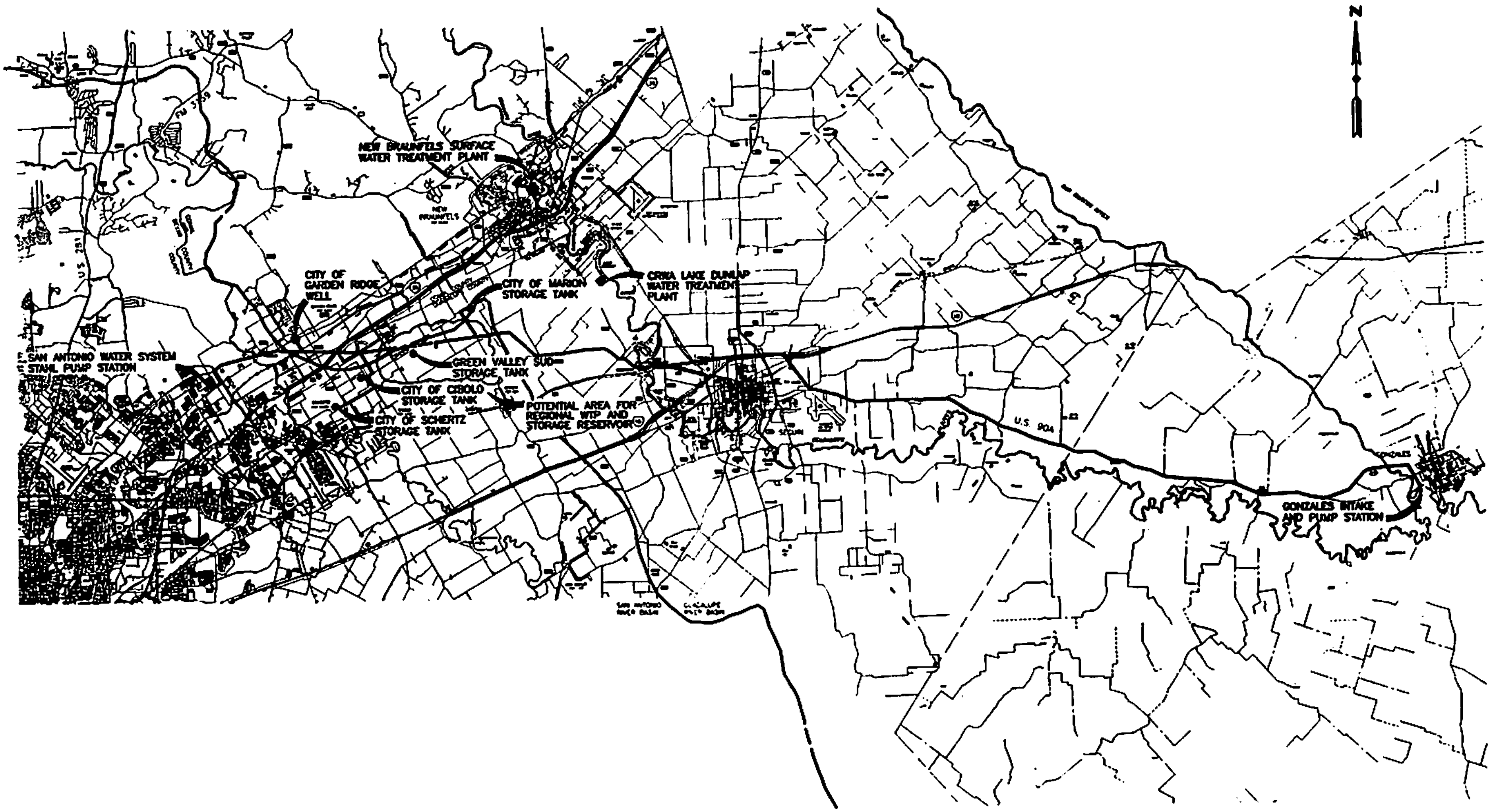
This alternative would involve construction of these facilities: an intake and raw water pump station at Gonzales downstream of the confluence with the San Marcos River; raw water storage facility at the water treatment plant; regional water treatment plant; high service pump station; water transmission pipeline; water delivery pipelines and connections to intermediate delivery locations in Guadalupe County; booster pump stations; and a ground storage tank at SAWS Stahl secondary pump station. The location of these facilities are shown on Figure 3.5-1.

3.5.2 Available Water Supply and Projected Demand

<u>Alternative G-38A and G-38B - Diversion of 40,000 acft/yr from the Guadalupe River at Gonzales</u>

Under Alternatives G-38A and G-38B, water potentially available for diversion at Gonzales would be obtained from the following sources: 1) enhanced springflow resulting from a theoretical reduction in overall Edwards Aquifer pumpage from that observed in calendar year 1989 (543,677 acft) to 400,000 acft/yr; 2) flow committed to large existing water rights (permitted, but projected to be underutilized in calendar year 2020); 3) unappropriated streamflow; and 4) water delivered from Canyon Lake. The term "enhanced springflow" as used throughout this study is defined to be the estimated increase in discharge primarily from Comal and San Marcos Springs into the Guadalupe and San Marcos Rivers which, theoretically, would occur if Edwards Aquifer pumpage were reduced from an annual volume of 543,677 acft to an annual volume of 400,000 acft. For the purposes of this study, it was assumed that this water would first be dedicated to existing water rights (including Canyon Lake) with the remainder available for diversion from the Guadalupe River at Lake Dunlap and/or Gonzales. The procedures and assumptions pertinent to the computation of water potentially available from each of these sources are described in Appendix C, and Table 3.5-2 summarizes estimates of water needed from each source for a total annual diversion of 40,000 acft. A highlight of this alternative is the conjunctive use of multiple water sources to optimize water availability. Using banked storage in Canyon Lake to firm up water availability, conjunctive use is made of enhanced springflow, unappropriated streamflow, and underutilized water rights.

Water availability analyses for Alternative G-38 conclude that 40,000 acft/yr could be diverted from Gonzales without interruption through the historical drought of record subject to either a uniform monthly diversion pattern or a peaked summer diversion pattern. For the



Legend

- Water Treatment Plant
- Connection Point to Existing Distribution System
- Potential Water Transmission Pipeline
- Basin Boundary

2 0 2 4 6

Approximate Scale in Miles

TRANS-TEXAS WATER PROGRAM
WEST CENTRAL STUDY AREA

HDR

HDR Engineering, Inc.

GUADALUPE RIVER DIVERSION AT GONZALES DELIVERED TO REGIONAL WTP, ALTERNATIVE G-38

FIGURE 3.5-1

Table 3.5-2 Water Sources for Diversion of 40,000 acft/yr at Gonzales (Alternatives G-38A and G-38B)				
	Uniform Annual Diversion (G-38A)		Summer Peak Diversion (G-38B)	
Water Source	Average(1) (acft/yr)	Drought(2) (acft/yr)	Average(1) (acft/yr)	Drought(2) (acft/yr)
Enhanced Springflow	34,850	22,760	33,800	20,880
Unappropriated Streamflow	130	230	100	420
Year 2020 Underutilized Rights	3,530	10,080	4,280	10,670
Subtotal	38,510	33,070	38,180	31,970
Canyon Firm Yield(3) (Evaporation on Banked Storage(4))	1,490	8,090 (1,160)	1,820	9,280 (1,250)
Total	40,000	40,000	40,000	40,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage calculated only during the drought and is included in Canyon Firm Yield.

uniform monthly diversion pattern, analyses indicate that a drought average of 22,760 acft/yr could be obtained from enhanced springflow and 10,080 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 8,090 acft/yr would need to be purchased from the yield of Canyon Lake (of which about 1,160 acft/yr is needed to offset increased evaporation from banked storage as described in Appendix C) to ensure availability of 40,000 acft/yr at Gonzales. For the peaked summer diversion pattern, analyses indicate that a drought average of 20,880 acft/yr could be obtained from enhanced springflow and 10,670 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 9,280 acft/yr would need to be purchased from the firm yield of Canyon Lake (of which about 1,250 acft/yr is needed to offset increased evaporation from banked storage) to ensure availability of 40,000 acft/yr at Gonzales. Subject to draft Environmental Water Needs Criteria of the Consensus Planning Process received November 27, 1995, about 230 acft/yr would be available as unappropriated streamflow during drought after considering diversions under enhanced springflow and water rights transfers. Analyses indicate that diversion of enhanced springflow would be significantly greater over the long-term than during drought, while utilization of water purchased from the yield of Canyon Lake would be significantly less.

Delivery facilities for entities in Guadalupe County (GBRA statutory area, see Table 3.4-3, Section 3.4) have been sized for delivery of a pro-rata allotment of 5,652 acft/yr (Alt G-38A and G-38B), to meet projected 2020 shortages for this area. Table 3.5-3 summarizes the water allocation to each of these potential customers.

Table 3.5-3
Allocation of 40,000 acft/yr Diverted at Gonzales and Delivered to Regional WTP (Alternatives G-38A and G-38B)

DELIVERY POINT	1990 DEMAND: DEMAND (acft/yr)	1990 DEMAND: PERCENT OF TOTAL	PROJECTED SHORTAGES(1): YEAR 2020 (acft/yr)	PROJECTED SHORTAGES(1): YEAR 2050 (acft/yr)	ALLOCATION OF NEW SUPPLY(2) (acft/yr)
Entities in GBRA Statutory District:					
Marion	150	2%	87	133	87
Cibolo	204	3%	160	271	160
Schertz	2,140	30%	2,612	7,464	2,612
Garden Ridge	397	5%	570	1,213	570
Crystal Clear WSC	1,042	14%	476	1,194	476
Green Valley SUD	1,804	25%	1,624	3,519	1,624
Springs Hill WSC	1,486	21%	123	1,681	123
GBRA Area Subtotal	7,223	100%	5,652	15,475	5,652
Amount Remaining for Delivery to Bexar County:					34,348

(1) Projected shortages in other areas of Guadalupe and Comal counties not included in this alternative.
(2) Allocations of new water supplies to entities in GBRA Statutory Area are set equal to projected 2020 shortages.

Tables 3.5-3 and 3.5-4 indicate an allocation of 34,348 acft/yr to Bexar County (delivered to SAWS) in year 2020 for Alternative G-38A and G-38B. However, prior to year 2020, more than this amount would be available for delivery to SAWS,[1] and facilities for delivery of potential surface water supplies to Bexar County were sized to deliver 40,000 acft/yr. The transmission pipeline to Bexar County was not stepped down in size at connections to intermediate customers in Guadalupe and Comal counties. Thus, the full 40,000 acft/yr can be delivered to Bexar County in the first year of operation. As water demands of Comal and

[1] With implementation of SB 1477, immediate demands for new water supplies in Bexar County are about 31,000 acft/yr, thereby creating a need for all of the water potentially available from Alternative G-38.

Table 3.5-4 Allocation of 34,348 acft/yr Potential Supply Diverted at Gonzales and Delivered to Bexar County (Alternatives G-38A and G-38B)					
DELIVERY POINT	**1990 DEMAND** **DEMAND (acft/yr)**	**PERCENT OF TOTAL**	**PROJECTED SHORTAGES** **YEAR 2020 (acft/yr)**	**YEAR 2050 (acft/yr)**	**ALLOCATION OF NEW SUPPLY(1) (acft/yr)**
Entities in Bexar County:					
East Central WSC	1,130	0.47%	1,168	2,354	161
BMWD Northeast	3,229	1.33%	4,484	8,024	459
Universal City	2,323	0.96%	2,444	4,458	330
Converse	1,213	0.50%	2,619	5,546	172
Live Oak	1,221	0.50%	302	822	174
Randolph AFB	1,494	0.62%	538	515	212
SAWS/BMWD & Remainder of Bexar County	231,987	95.63%	220,576	380,191	32,840
Bexar County Subtotal	242,597	100%	.232,131	401,910	34,348
(1) Allocations of new water supplies to entities in Bexar County are based on percent distribution of 1990 demand.					

Guadalupe county entities grow, more water would be delivered to them and less water would be transferred to Bexar County. For Alternative G-38A and G-38B, the 2020 delivery quantity to Bexar County would be reduced to about 34,348 acft/yr.

Alternative G-38C and G-38D - Diversion of 75,000 acft/yr from the Guadalupe River at Gonzales

Under Alternative G-38, water potentially available for diversion at Gonzales would be obtained from the following sources: 1) enhanced springflow resulting from a theoretical reduction in overall Edwards Aquifer pumpage from that observed in calendar year 1989 (543,677 acft) to 400,000 acft/yr; 2) flow committed to large existing water rights (permitted, but projected to be underutilized in calendar year 2020); 3) unappropriated streamflow; and 4) water delivered from Canyon Lake. The procedures and assumptions pertinent to the computation of water potentially available from each of these sources are described in Appendix C, and Table 3.5-5 summarizes estimates of water needed from each source for a total annual diversion of 75,000 acft. A highlight of this alternative is the conjunctive use of multiple water sources to enhance water availability. Using banked storage in Canyon Lake to firm up water availability,

Table 3.5-5 Water Sources for Diversion of 75,000 acft/yr at Gonzales (Alternatives G-38C and G-38D)				
	Uniform Annual Diversion (G-37C)		Summer Peak Diversion (G-37D)	
Water Source	Average(1) (acft/yr)	Drought(2) (acft/yr)	Average(1) (acft/yr)	Drought(2) (acft/yr)
Enhanced Springflow	60,960	32,900	57,370	30,670
Unappropriated Streamflow	780	1,170	1,130	1,300
Year 2020 Underutilized Rights	9,100	22,080	11,370	21,990
Subtotal	70,840	56,150	69,870	53,960
Canyon Firm Yield(3) (Evaporation on Banked Storage(4))	4,160	21,930 (3,080)	5,130	24,060 (3,020)
Total	75,000	75,000	75,000	75,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage calculated only during the drought and is included in Canyon Firm Yield.

conjunctive use is made of enhanced springflow, unappropriated streamflow, and underutilized water rights.

Water availability analyses for Alternative G-38 conclude that 75,000 acft/yr could be diverted from Gonzales without interruption through the historical drought of record subject to either a uniform monthly diversion pattern or a peaked summer diversion pattern. For the uniform monthly diversion pattern, analyses indicate that a drought average of 32,900 acft/yr could be obtained from enhanced springflow and 22,080 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 21,930 acft/yr would need to be purchased from the yield of Canyon Lake (of which about 3,080 acft/yr is needed to offset increased evaporation from banked storage as described in Appendix C) to ensure availability of 75,000 acft/yr at Gonzales. For the peaked summer diversion pattern, analyses indicate that a drought average of 30,670 acft/yr could be obtained from enhanced springflow and 21,990 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 24,060 acft/yr would need to be purchased from the firm yield of Canyon Lake (of which about 3,020 acft/yr is needed to offset increased evaporation from banked storage) to ensure availability of 75,000 acft/yr at Gonzales. Subject to draft Environmental Water Needs Criteria of the Consensus Planning Process received November 27, 1995, about 1,170 acft/yr would be available as unappropriated streamflow during drought after considering diversions under enhanced springflow and water rights transfers. Analyses indicate that diversion of enhanced springflow would be significantly greater over the long-term than during drought, while utilization of water purchased from the yield of Canyon Lake would be significantly less.

For delivery of 75,000 acft/yr (Alt G-38C and G-38D), delivery facilities to entities in the GBRA statutory area were sized to deliver the projected year 2020 shortage as shown in Table 3.4-3. Tables 3.5-6 and 3.5-7 summarize the allocation of water supply for Alternatives G-38C and G-38D.

Table 3.5-6
Allocation of 75,000 acft/yr Diverted at Gonzales to Regional WTP
(Alternatives G-38C and G-38D)

DELIVERY POINT	1990 DEMAND		PROJECTED SHORTAGES[1]		ALLOCATION OF NEW SUPPLY[2] (acft/yr)
	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	
Entities in GBRA Statutory District:					
Marion	150	2%	87	133	87
Cibolo	204	3%	160	271	160
Schertz	2,140	30%	2,612	7,464	2,612
Garden Ridge	397	5%	570	1,213	570
Crystal Clear WSC	1,042	14%	476	1,194	476
Green Valley SUD	1,804	25%	1,624	3,519	1,624
Springs Hill WSC	1,486	21%	123	1,681	123
GBRA Area Subtotal	7,223	100%	5,652	15,475	5,652
Amount Remaining for Delivery to Bexar County:					69,348

(1) Projected shortages in other areas of Guadalupe and Comal counties not included in this alternative.
(2) Allocations of new water supplies to entities in GBRA Statutory Area are set equal to projected 2020 shortages.

Table 3.5-7 Allocation of 69,348 acft/yr Potential Supply Diverted at Gonzales and Delivered to Bexar County (Alternatives G-38C and G-38D)					
DELIVERY POINT	**1990 DEMAND**		**PROJECTED SHORTAGES**		**ALLOCATION OF NEW SUPPLY[1] (acft/yr)**
	DEMAND (acft/yr)	**PERCENT OF TOTAL**	**YEAR 2020 (acft/yr)**	**YEAR 2050 (acft/yr)**	
Entities in Bexar County:					
East Central WSC	1,130	0.47%	1,168	2,354	323
BMWD Northeast	3,229	1.33%	4,484	8,024	923
Universal City	2,323	0.96%	2,444	4,458	664
Converse	1,213	0.50%	2,619	5,546	347
Live Oak	1,221	0.50%	302	822	302
Randolph AFB	1,494	0.62%	538	515	427
SAWS/BMWD & Remainder of Bexar County	231,987	95.63%	220,576	380,191	66,362
Bexar County Subtotal	242,597	100%	232,131	401,910	69,348
(1) Allocations of new water supplies to entities in Bexar County are based on percent distribution of 1990 demand.					

Tables 3.5-6 and 3.5-7 indicate an allocation of 69,348 acft/yr to Bexar County (delivered to SAWS) in year 2020 for Alternative G-38C and G-38D. However, prior to year 2020, more than this amount would be available for delivery to SAWS, and facilities for delivery of potential surface water supplies to Bexar County were sized to deliver 75,000 acft/yr. The transmission pipeline to Bexar County was not stepped down in size at connections to intermediate customers in Guadalupe and Comal counties. Thus, the full 75,000 acft/yr can be delivered to Bexar County in the first year of operation. As water demands of Comal and Guadalupe county entities grow, more water would be delivered to them and less water would be transferred to Bexar County. For Alternatives G-38C and D, the 2020 delivery quantity to Bexar County would be reduced to about 69,348 acft/yr.

3.5.3 Environmental Issues

The proposed diversion of water from the Guadalupe River near the City of Gonzales and delivery to the City of Marion, Green Valley SUD Storage Tank, City of Cibolo, City of Schertz and San Antonio Water System's Stahl Pump Station involves a water transmission pipeline similar to that described in Alternative G-28, Volume 3 with minor modifications (Figure 3.5-1).

Alternative G-38 also involves construction of a regional water treatment plant and storage reservoir on an as yet undetermined site (similar to that proposed in Alternative G-37, Section 3.4). The proposed water transmission pipeline uses the same route between the regional WTP and the other delivery locations as that described in Alternatives G-36 and G-37 (Sections 3.3 and 3.4 respectively).

The USDA, Soil Conservation Service has not produced soil maps for the County of Gonzales. In Guadalupe County the proposed pipeline route traverses Crockett-Demona-Windhorst, Sunev-Seguin, Branyon-Barbarosa-Lewisville, Houston Black-Heiden soil associations.[2] Crockett-Demona-Windhorst soils are deep, moderately well drained, gently sloping to sloping, loamy to sandy soils on uplands. The remaining soil associations along the route are described in Alternative G-36 (Section 3.3.3).

The section of the pipeline route between the City of Gonzales and the City of Marion traverses Post Oak Savannah in Gonzales and Guadalupe Counties and Blackland Prairie in the northwestern two-thirds of Guadalupe County.[3] The section of the route between Marion and the other delivery locations (Alternative G-35, Section 3.3) traverses Blackland Prairie and Edwards Plateau Vegetational Areas. These vegetational areas are described in the environmental overview (Section 3.0.4).

In addition to crop, vegetation types along the proposed pipeline route have been classified as Pecan - Elm Forest (located along bottomlands of the Guadalupe River), and Post Oak Woods, Forest, and grassland mosaic.[4] These are most apparent on the sandy soils of the Post Oak Savannah.

The length of the water transmission line from the City of Gonzales to the delivery points in the City of Marion, City of Cibolo, City of Schertz and Stahl Pump Station is about 65.3 miles. A 140 foot wide construction ROW the length of the pipeline would affect a total of 1108.1 acres including 40.7 acres developed (3.7 percent), 799.3 acres crop (72.1 percent), 5.1 acres shrub (0.5 percent), 52.6 acres brush (4.7 percent), 52.6 acres park (4.7 percent), 156.1

[2] Soil Conservation Service. 1977. Soil Survey of Guadalupe County Texas. SCS, USDA, In cooperations with Texas Agricultural Experiment Station.
[3] McMahan, C.A., R.G. Frye and K.L. Brown. 1984. The Vegetation Types of Texas Including Cropland. Texas Parks and Wildlife Department, Austin, Texas.
[4] Ibid.

acres wood (14.1 percent).[5] A mowed maintenance ROW seeded in grass would be required for the lifetime of the project. A 40-ft wide maintenance ROW, 65.3 miles long, would affect a total of 316.6 acres including 11.6 acres developed, 228.4 acres crop, 1.5 acres shrub, 15.0 acres brush, 15.0 acres park, 44.6 acres wood, and 0.5 acres water (e.g., river crossings). However, the large proportion of this ROW that is in crop can be returned to crop following installation of the pipeline. Disturbed areas outside the maintenance ROW presently in brush and shrub can be expected to be invaded by woody vegetation in 5 to 10 years.

Protected species (endangered and threatened) and species which are listed as candidates for protection by USFWS and TPWD for Bexar, Comal, Gonzales and Guadalupe Counties are reported in Appendix D, Tables 1 - 4. Although TNHP[6] reports no threatened or endangered species immediately in the project area, occurrences of important species on USGS quadrant maps covering the project are as follows: Cagle's map turtle (*Graptemys caglei*) and guadalupe bass (*Micropterus treculi*) on the Gonzales South quadrant; smooth blue-star (*Amsonia globerina*) and Cagle's map turtle on the Ottine quadrant; mountain plover (*Charadrius montanus*) on the Seguin quadrant; big red sage (*Salvia pensternoides*) on the Marion quadrant; guadalupe bass on the Schertz quadrant; Texas salamander (*Eurycea neotenes*), fountain darter (*Etheostoma fonticola*), Buckley tridens (*Tridens buckleyanus*), Comal Springs riffle beetle (*Heterelmis comalensis*), and Texas amorpha (*Amorpha roemeriana*) on the New Braunfels West quadrant. Cagle's map turtle, guadalupe bass, mountain plover, Texas salamander, fountain darter and Comal Springs riffle beetle are described briefly in previous sections of this volume.

Texas gourd and Park's jointweed are listed by TOES as occurring in Gonzales and Guadalupe Counties respectively. Additional plant species listed as occurring in Comal and Bexar Counties are reported in Section 3.1.3 (Alternative G-34).

Significant impacts to important species by the project are unlikely. Species associated with Comal Springs (most of those on New Braunfels West) are well upstream of the project area. Other important species and critical habitats can be largely avoided by careful selection of the final pipeline alignment. Habitat surveys in a future phase of project development should be

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[5] These preliminary estimates were based on available Soil Conservation Service Maps and USGS 7.5 minute quadrants: New Braunfels East, McQueeney, Marion, Schertz, New Braunfels West, and should be updated using aerial photographs from the EROS data center in a later phase of project development.

[6] TPWD. 1996. Unpublished maps and data files, Texas Natural Heritage Program, Department of Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

conducted to more accurately assess potential effects and to aid in selecting the final alignment. Cagle's map turtle and Guadalupe bass inhabit the Guadalupe River. Flow changes resulting from Alternative G-38 (discussed below) are not expected to have an adverse effect on Cagle's map turtle or the Guadalupe bass.

The San Antonio Water System, Stahl Pump Station is in the remnant areas of brush, shrub and grassland in northern Bexar County just west of Cibilo Creek.[7] This rapidly urbanizing area which is on the eastern edge of the Balcones Escarpment, is on the Spanish King's Highway, the Camino Real. Comanche Lookout, a new City of San Antonio Park is located in the general vicinity. This 58 acre park contains sites of prehistoric, colonial and modern human activities.[8]

Stream crossings in the proposed corridor are mostly intermittent. Major stream crossings include the Guadalupe River near Seguin and Cibilo Creek, an intermittent stream. Numerous impounded ponds for stock and other agricultural uses dot the Blackland Prairie. Depending on the final alignment, the transmission line may cross the Guadalupe River at Seguin. However, the transmission line corridor is conceptual at this phase of the study. Exact impacts cannot be determined without further study.

The Guadalupe River and the Guadalupe-San Antonio Estuary is described in the Environmental Overview, Section 3.0.4. Assumptions used to estimate instream flows and inflows to the Guadalupe-San Antonio Estuary at Saltwater Barrier included a maximum diversion of 75,000 acft/yr. Additional assumptions were the same as those considered under the Lake Dunlap diversion as described above (Section 3.4.3, Alternative G-37). Based on the 1934-1989 period of record, estimated annual median flow at the City of Gonzales was 552,493 acft/yr. With implementation of Alternative G-38, annual median streamflow was estimated to be 576,255 acft/yr, an increase of 4.3 percent. Monthly median streamflow without Alternative G-38 ranged from 13,667 acft/yr to 48,882 acft/yr. Under the uniform diversion scenario (Alternative G-38C), estimated monthly median streamflow estimates ranged from 15,532 acft/yr to 50,117 acft/yr, monthly increases of from 2.5 percent to 13.6 percent (Figure 3.5-2).

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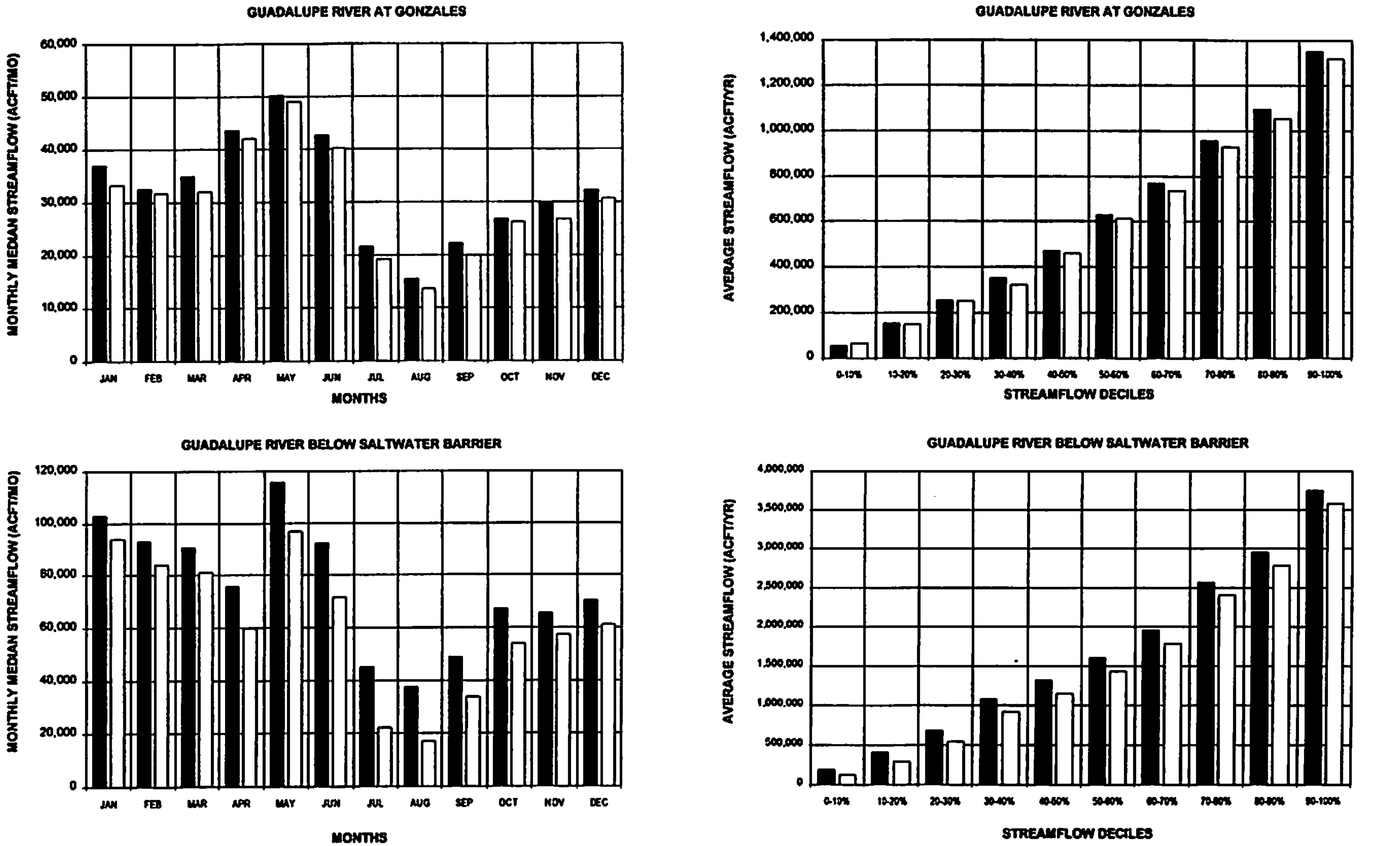
[7] USGS. 1990. NAPP Series 2434, EROS Data Center, Sioux Falls, South Dakota.
[8] TPWD. 1996. op. cit.



LEGEND:

■ WITH PROJECT

□ WITHOUT PROJECT

NOTES:

1. ANNUAL DIVERSION RATE = 75,000 ACFT
2. STATISTICS BASED ON 1934-89 HISTORICAL PERIOD
3. WITH PROJECT STREAMFLOWS BASED ON EDWARDS AQUIFER PUMPAGE = 400,000 ACFT/YR
4. WITHOUT PROJECT STREAMFLOWS BASED ON EDWARDS AQUIFER PUMPAGE = 543,677 ACFT/YR

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TRANS TEXAS WATER PROGRAM /
WEST CENTRAL STUDY AREA

CHANGES IN STREAMFLOW
UNIFORM DIVERSION
GUADALUPE RIVER-GONZALES
ALTERNATIVE G- 38C

FIGURE 3.5-2

Comparing average streamflow deciles at the City of Gonzales without Alternative G-38 to those with the project indicated a decrease of 18.4 percent in the lowest decile and small, probably insignificant increases (0.6 percent to 9.1 percent) in all other deciles (Figure 3.5-2).

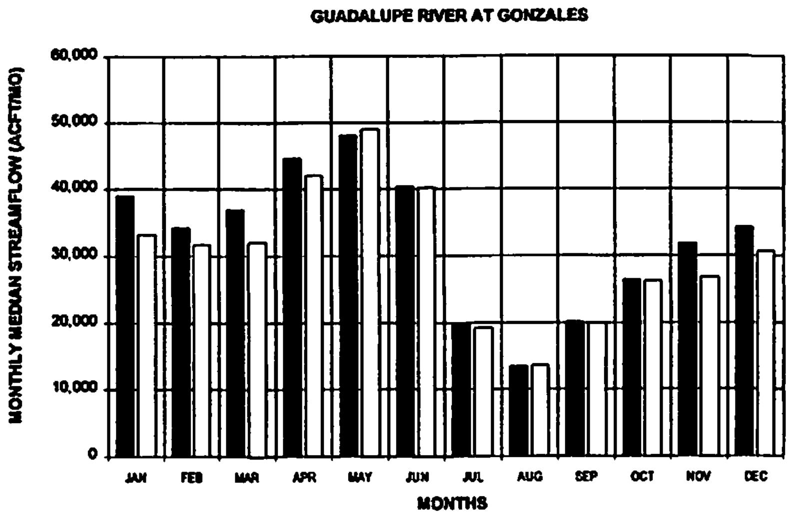
The increased flows at Gonzales with the diversion of 75,000 acft/yr of water from the Guadalupe river is a result of decreased withdrawals from the Edwards Aquifer. The summer peaked diversion scenario shifts more of the increased flows to the winter months in comparison to the uniform diversion. Increased streamflow in the Guadalupe River would be considered to be beneficial regardless of the diversion scenario implemented. The summer peaked diversion increases monthly flow variability in addition to increasing streamflow. Increased variability in streamflow should produce greater variability in the relative abundance of habitats and species dependent upon those habitats. The relative abundance of fish species collected in a study of the Guadalupe River appeared to be affected by instream flows.[9] However, the merits of relatively uniform versus variable flows is probably more of a concern with respect to how riverine habitat should be managed than with impacts on a particular species. It seems unlikely that project implementation as described herein would eliminate sensitive species inhabiting the Guadalupe River.

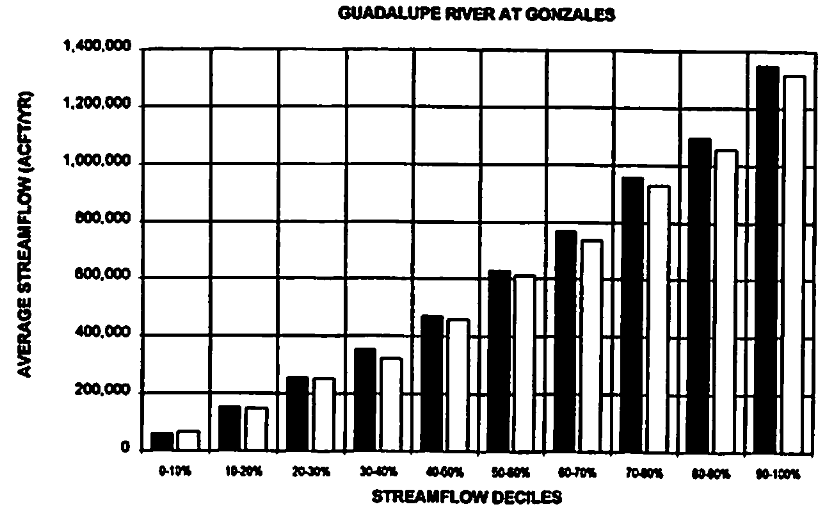
As noted above (Section 3.4.3, Alternative G-37) "without project" annual median flow at Saltwater Barrier was 1,220,927 acft/yr and monthly medians ranged from 16,960 acft/yr to 96,754 acft/yr. Under the uniform diversion scenario annual median flow with implementation of Alternative G-38 was an estimated to be 1,410,242 acft/yr, a 15.5 percent increase in freshwater inflow to the Guadalupe-San Antonio Estuary. Monthly median estimates with project implementation ranged from 37,543 acft/yr to 115,491 acft/yr, which represented monthly increases ranging from 9.5 percent to 121.4 percent (Figure 3.5-2).

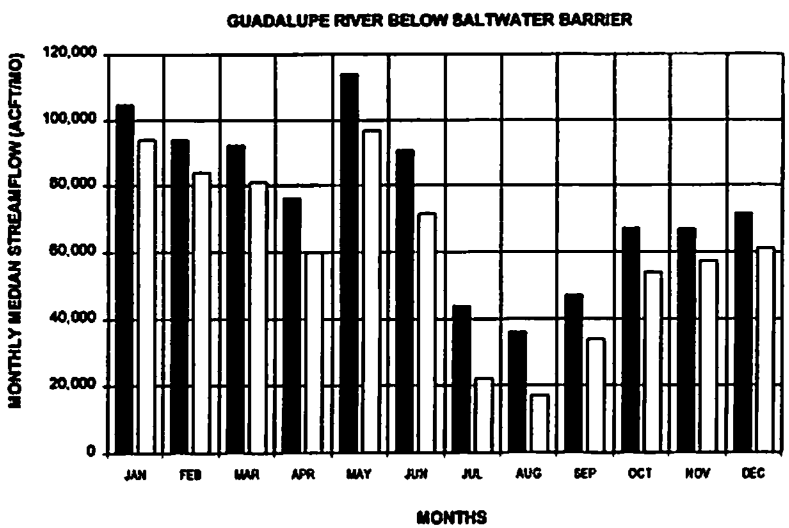
Comparing estimated annual average flows at Saltwater Barrier without Alternative G-38 to flows with project implementation by deciles indicated increased flows in all deciles. Percent increases ranged from 54.6 percent in the lowest flow decile to 4.8 in the highest decile (Figure 3.5-2).

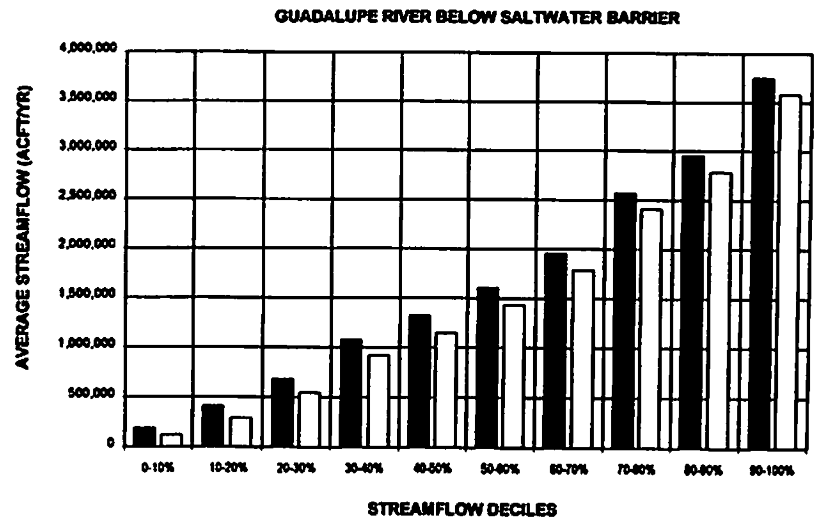
Under the summer peaked diversion scenario (Alternative G-38D), monthly median streamflows at the City of Gonzales ranged from 13,432 acft/yr to 48,017 acft/yr (Figure 3.5-3). Monthly median percent change ranged from a decrease of 1.8 percent to an increase of 18.5

[9] Academy of Natural Sciences, Philadelphia. 1991. Report No. 91-27. Philadelphia, Pennsylvania.









LEGEND:

■ WITH PROJECT

□ WITHOUT PROJECT

NOTES:
1. ANNUAL DIVERSION RATE = 75,000 ACFT
2. STATISTICS BASED ON 1934-89 HISTORICAL PERIOD
3. WITH PROJECT STREAMFLOWS BASED ON EDWARDS AQUIFER PUMPAGE = 400,000 ACFT/YR
4. WITHOUT PROJECT STREAMFLOWS BASED ON EDWARDS AQUIFER PUMPAGE = 543,677 ACFT/YR

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CHANGES IN STREAMFLOW SUMMER PEAKED DIVERSION GUADALUPE RIVER-GONZALES ALTERNATIVE G-38D

FIGURE 3.5-3

percent. Implementation of Alternative G-38 resulted in decreased estimated flows in the lowest decile of average annual flows. Small percent increases (1.8 percent to 9.2 percent) were indicated in the remaining deciles (Figure 3.5-3).

At Saltwater Barrier with implementation of the summer peaked diversion, monthly median flows ranged from 35,988 acft/yr to 113,803 acft/yr (Figure 3.5-3). Monthly increases ranged from 11.3 to 112.2 percent. At Saltwater Barrier differences between uniform and summer-peaked diversions at the City of Gonzales are unlikely to be ecologically signifcant. The decile statistics for the uniform and summer-peaked diversions are nearly identical. Implementation of Alternative G-38 indicated increased inflows ranging from 56.4 percent in the lowest flow decile to 4.8 percent in the highest decile (Figure 3.5-3). Because inflows are positively correlated with the abundance of several commercially important estuarine species, increased freshwater inflows are generally considered to have favorable effects in terms of estuarine ecology.

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction will be first surveyed by qualified professionals for the presence of significant cultural resources.

3.5.4 Water Quality and Treatability

[To be completed in subsequent phases of the study.]

3.5.5 Engineering and Costing

For this alternative, raw water diverted at Gonzales would be treated at a potential regional water treatment plant near Marion and treated water would be supplied on a wholesale basis to Green Valley SUD, Marion, Cibolo, Schertz, Garden Ridge, and San Antonio Water System. Figure 3.5-1 shows the general location of the potential water treatment plant and potential pipeline routes, however, pipeline routes may be adjusted once route studies and on-the-ground surveys have been performed in subsequent project phases.

Springs Hill WSC and Crystal Clear WSC currently receive treated water from the CRWA treatment plant at Lake Dunlap. Construction of a treated waterline from the regional

WTP eastward to the existing CRWA WTP would not be economical. Therefore, Springs Hill WSC and Crystal Clear WSC would not be connected to the regional WTP, but would potentially receive their water allocation by trading an equivalent amount of treated water with Green Valley SUD. For this arrangement, Springs Hill WSC would receive 123 acft/yr and Crystal Clear WSC would receive 476 acft/yr more water from the CRWA WTP than currently allocated and Green Valley SUD would receive 599 acft/yr less water from the CRWA WTP than currently allocated.

Raw water would be diverted at a new water intake to be located on the Guadalupe River downstream of the confluence with the San Marcos River and be pumped to a forebay storage facility near the treatment plant. For alternatives G-38A and G-38C (uniform delivery alternatives) the forebay storage facility provides for enhanced raw water quality by allowing selective pumping during periods of high river flows and possible lower water quality. Another benefit of the forebay storage is improved reliability of the surface water system by allowing continuing plant operation during raw water pipeline maintenance or unscheduled outages. For Alternative G-38A (40,000 acft/yr, uniform diversion), the forebay storage volume chosen for costing is about 1,700 acft, or about 15 days of storage. For Alternative G-38C (75,000 acft/yr, uniform diversion), the forebay storage volume chosen for costing is about 3,000 acft, also about 15 days of storage.

For the summer peak flowrate alternatives (G-38B and G-38D), the storage volume was set large enough to allow reducing the peak summer raw water diversion rate and meet part of the peak month needs from storage, and thereby reduce the size of the raw water transmission pipeline. Use of forebay storage results in an overall cost savings by reducing the raw water pipeline size. To reduce the summer peak diversion rate from 2.0 times annual average to 1.4 (i.e. a reduction in the peak month diversion from 17 percent of the annual total to 11 percent) would require a storage volume of about 4,400 acft/yr for Alternative G-38B, and 8,250 acft/yr for Alternative G-38D.

Water treatment would consist of conventional surface water treatment (flocculation, settling, filtration, and chlorine disinfection).

The major facilities required to implement this alternative are:

- Reservoir Intake and Pump Station
- Raw Water Pipeline to Off-Channel Storage
- Off-Channel Storage Facility

- Water Treatment Plant Expansion
- Treated Water Pump Station
- Transmission Pipeline
- Interconnections to:
  - > Marion
  - > Cibolo
  - > Schertz
  - > Green Valley SUD
  - > SAWS Stahl Secondary Pump Station
- Booster Pump Stations

Alternative G-38A and G-38B: Delivery of 40,000 acft/yr Diverted at Gonzales to Regional WTP near Marion

Delivery facilities were sized to deliver a pro-rata allocation of 2020 projected shortages to Marion, Cibolo, Schertz, Garden Ridge and Green Valley SUD. Delivery facilities to Green Valley SUD were sized for Green Valley projected demands plus 599 acft/yr for the potential water trade with Crystal Clear and Spring Hill WSCs. Delivery facilities to the SAWS Stahl Pump Station were sized to deliver 40,000 acft/yr.

Two delivery rate scenarios were considered: a uniform annual delivery rate (Alternative G-38A); and, a summer month peak rate of 2.0 times the uniform annual delivery rate (Alternative G-38B). The raw water diversion rate was reduced to 1.4 times the uniform annual rate by providing sufficient forebay storage at the treatment plant to meet a portion of peak month needs. Table 3.5-8 summarizes the design delivery rate and pipeline sizes at the raw water intake and at each of the delivery locations.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water, land, and environmental mitigation. Cost estimates for Alternatives G-38A and G-38B are presented in Table 3.5-9. Table 3.5-9 reports the annual cost to purchase stored water from GBRA to meet the drought average requirement. Although the amount of stored water actually needed each year may be higher or lower, the annual cost is held constant at the drought average amount, as would be the case with a "take-or-pay" type of purchase contract. The total estimated project cost of Alternative G-38A is $109,240,000 (Table 3.5-9), which results in a total annual cost, including operation and maintenance and purchase of stored water, of $17,380,000. The total estimated project cost for Alternative G-38B is $149,310,000 (Table 3.5-9), which results in a total annual cost, including

Table 3.5-8 Delivery Rates and Pipeline Sizes for Alternatives G-38A and G-38B						
			Design Delivery Rate and Size			
			Uniform Annual Delivery (G-38A)		Summer Peak Delivery (G-38B)	
Location	**Annual Delivery Amount (acft/yr)**	**Description of Connection & Capital Cost Item**	**Delivery Rate (mgd)**	**Pipeline Diameter**	**Delivery Rate (mgd)**	**Pipeline Diameter**
Raw Water Intake	40,000	----	35.7	48"	48	54"
Springs Hill WSC	123	(1)	0.11	(1)	0.22	(1)
Crystal Clear WSC	476	(1)	0.43	(1)	0.86	(1)
Marion	87	Connection to existing GST	0.08	4"	0.16	4"
Cibolo	160	Connection to existing GST	0.17	4"	0.34	6"
Green Valley SUD	1,624	Connection to existing GST	1.98	12"	4.0	14"
Schertz	2,612	Connection to existing GST	2.33	12"	4.66	18"
Garden Ridge	570	Connection to existing well	0.51	6"	1.02	8"
SAWS-Stahl Pump Station	34,348	New 10 MG GST	35.7	48"	71	66"
(1) Springs Hill WSC and Crystal Clear WSC will not be connected to the regional WTP, but would potentially receive their water allocation through a water trade with Green Valley SUD.						

operation and maintenance and purchase of stored water, of $23,250,000. The operating cost was determined for a total static lift from Gonzales to the Stahl Pump Station well of 690 ft. and an annual delivery of 40,000 acft.

The estimated cost of each alternative was allocated to each delivery location based on the pro-rata capacity of each component dedicated to meeting potential year 2000 and 2020 demands at the delivery location. Thus, for raw water and treatment facility costs, participants would pay a pro-rata share based solely on the percent of total capacity dedicated to meeting their water demands, and the participant's location relative to the water source did not affect the cost allocation for treatment. For transmission and pump station costs, allocation was made on a pro-rata allocation only of the facilities needed to deliver water to them, consequently, costs to participants that are furthest from the water source are proportionately greater.

For Alternatives G-38A and G-38B (annual delivery of 40,000 acft), Tables 3.5-10 and 3.5-11 summarize the total annual cost and the annual unit cost of treated water for year 2000 and year 2020. Early in project operation, small quantities of water will be delivered to participants and all remaining water will be delivered to SAWS. The cost of water for year 2020

Table 3.5-9 Cost Estimate Summaries for Potential Supply from Guadalupe River Diverted at Gonzales to Regional WTP 40,000 acft/yr (Alternatives G-38A and G-38B) (First Quarter - 1996 Prices)		
Item	**Alt. G-38A Uniform Annual Delivery**	**Alt. G-38B Summer Peak Delivery**
Capital Costs		
Intake and Treatment Plant	$26,130,000	$41,270,000
Off-Channel Storage Facility	3,000,000	5,150,000
Transmission Pipelines	38,860,00	49,350,000
Booster Pump Stations	6,900,000	8,160,000
Interconnects to Participants	4,020,000	4,240,000
Total Capital Cost	$78,910,000	$108,170,000
Engineering, Contingencies, and Legal Costs	25,130,000	34,770,000
Environmental Studies and Mitigation	520,000	520,000
Land Acquisition	1,520,000	1,520,000
Interest During Construction	3,160,000	4,330,000
Total Project Cost	$109,240,000	$149,310,000
Annual Costs		
Annual Debt Service	$10,240,000	$13,990,000
Annual Operation and Maintenance		
Water Treatment Plant	1,810,000	3,680,000
Transmission Pipelines	890,000	1,040,000
Power Cost	3,480,000	3,480,000
Purchase of Water	960,000(1)	1,060,000(2)
Total Annual Cost	$17,380,000	$23,250,000
(1) Includes 8,090 acft/yr of stored water purchased from GBRA and 10,080 acft/yr of year 2020 underutilized water rights at an annual cost of $53/acft. (2) Includes 9,280 acft/yr of stored water purchased from GBRA and 10,670 acft/yr of year 2020 underutilized water rights at an annual cost of $53/acft		

conditions delivered at a uniform delivery rate varies from $391 per acft per year for Green Valley SUD[10] to $747 per acft per year (Table 3.5-10) delivered to Marion. For a summer peaking distribution pattern, and full usage of the allotted amount, the unit cost of water varies from $517 per acft per year for Green Valley SUD to $874 per acft per year (Table 3.5-11) for

[10] This would also be the unit cost of water for Springs Hill WSC and Crystal Clear WSC for a potential water trade with Green Valley.

Table 3.5-10
Summary of Costs by Delivery Location
Potential Supply Diverted at Gonzales to Regional WTP
40,000 acft/yr, Uniform Annual Delivery (G-38A)
(First Quarter - 1996 dollars)

Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Year 2000 Annual Volume[1] (acft/yr)	Year 2000 Annual Cost	Year 2000 Unit Cost[2] $/acft/yr	Year 2000 Unit Cost[2] $/1000 gal	Year 2020 Annual Volume[1] (acft/yr)	Year 2020 Annual Cost	Year 2020 Unit Cost[2] $/acft/yr	Year 2020 Unit Cost[2] $/1000 gal
Springs Hill[4] (0.11 mgd)	0	$42,000	[3]	[3]	123	$48,000	$391	$1.20
Crystal Clear[4] (0.43 mgd)	0	$161,000	[3]	[3]	476	$186,000	$391	$1.20
Marion (0.08 mgd, 4")	56	$57,000	$1,018	$3.13	87	$65,000	$747	$2.29
Green Valley (1.98 mgd, 4")	362	$339,000	$936	$2.88	1,624	$635,000	$391	$1.20
Cibolo (0.18 mgd, 4")	160	$70,000	$438	$1.34	160	$70,000	$438	$1.34
Garden Ridge (0.51 mgd, 6")	315	$198,000	$629	$1.94	570	$244,000	$428	$1.31
Schertz (2.33 mgd, 12")	1,268	$861,000	$679	$2.09	2,612	$1,100,000	$421	$1.29
SAWS-Stahl Pump Station (35.7 mgd, 48")	37,839	$15,652,000	$414	$1.27	34,348	$15,032,000	$438[5]	$1.34[5]
Total	40,000	$17,380,000	$435	$1.33	40,000	$17,380,000	$435	$1.33

[1] Annual volume not adjusted for treatment, transmission, and other losses.
[2] Cost of treated water delivered on a wholesale basis and does not include operating costs of the distribution system
[3] Annual costs for debt service will accrue, even though no water deliveries are projected.
[4] Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.
[5] Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to transport the water, may occur before year 2020.
Note: The unit cost to deliver all 40,000 acft/yr to SAWS would be about $431 per acft/yr ($1.32/1,000 gallons).

Table 3.5-11 Summary of Costs by Delivery Location Potential Supply Diverted at Gonzales to Regional WTP 40,000 acft/yr, Summer Peaking Delivery (G-38B) (First Quarter - 1996 dollars)								
	Year 2000				Year 2020			
Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft/yr	Unit Cost(2) $/1000 gal	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2) $/acft/yr	Unit Cost(2) $/1000 gal
Springs Hill (4) (0.22 mgd)	0	$57,000	(3)	(3)	123	$64,000	$517	$1.59
Crystal Clear (4) (0.86 mgd)	0	$221,000	(3)	(3)	476	$246,000	$517	$1.59
Marion (0.16 mgd, 4")	56	$66,000	$1,179	$3.62	87	$76,000	$874	$2.68
Green Valley (3.06 mgd, 14")	362	$447,000	$1,235	$3.79	1,624	$839,000	$517	$1.59
Cibolo (0.34 mgd, 6")	160	$92,000	$574	$1.76	160	$92,000	$575	$1.76
Garden Ridge (1.02 mgd, 8")	315	$266,000	$845	$2.59	570	$325,000	$570	$1.75
Schertz (4.66 mgd, 18")	1,268	$1,154,000	$910	$2.79	2,612	$1,465,000	$561	$1.72
SAWS (26.8 mgd, 42")	37,839	$20,947,000	$554(5)	$1.70(5)	34,348	$20,143,000	$586(5)	$1.80(5)
Total	40,000	$23,250,000	$581	$1.78	40,000	$23,250,000	$581	$1.78

(1) Annual volume not adjusted for treatment, transmission, and other losses.

(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the distribution system

(3) Annual costs for debt service will accrue, even though no water deliveries are projected.

(4) Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.

(5) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to transport the water, may occur before year 2020.

Table 3.5-12 Delivery Rates and Pipeline Sizes for Alternatives G-38C and G-38D						
			Design Delivery Rate and Size			
			Uniform Annual Delivery (G-38C)		Summer Peak Delivery (G-38D)	
Location	Annual Delivery Amount (acft/yr)	Description of Connection & Capital Cost Item	Delivery Rate (mgd)	Pipeline Diameter	Delivery Rate (mgd)	Pipeline Diameter
Raw Water Intake	75,000	----	67	66"	91	72"
Springs Hill WSC	123	(1)	0.11	(1)	0.22	(1)
Crystal Clear WSC	476	(1)	0.43	(1)	0.86	(1)
Marion	87	Connection to existing GST	0.08	4"	0.16	4"
Cibolo	160	Connection to existing GST	0.17	4"	0.34	6"
Green Valley SUD	1,624	Connection to existing GST	1.98	12"	4.0	14"
Schertz	2,612	Connection to existing GST	2.33	12"	4.66	18"
Garden Ridge	570	Connection to existing well	0.51	6"	1.02	8"
SAWS-Stahl Pump Station	69,348	New 10 MG GST	67	66"	134	90"
(1) Springs Hill WSC and Crystal Clear WSC will not be connected to the regional WTP, but would potentially receive their water allocation through a water trade with Green Valley SUD.						

Marion. For the case of all 40,000 acft/yr being delivered to Bexar County at the SAWS Stahl pump station (as possibly would happen in the early year of project operation), the annual unit cost was estimated to be $431 per acft/yr at a uniform delivery rate, and $577 per acft/yr for a summer peaking delivery pattern.

Alternative G-38C and G-38D: Delivery of 75,000 acft/yr Diverted at Gonzales to Regional WTP near Marion

Delivery facilities were sized to deliver year 2020 projected shortages to Marion, Cibolo, Schertz, Garden Ridge, and Green Valley SUD. Delivery facilities to Green Valley SUD were sized for Green Valley projected demands plus 599 acft/yr for a potential water trade with Crystal Clear WSC and Springs Hill WSC. Delivery facilities to the San Antonio Water System Stahl pump station were sized to deliver 75,000 acft/yr. Two delivery rate scenarios were considered: a uniform annual delivery rate (Alternative G-38C); and, a summer month peak rate of 2.0 times the uniform annual delivery rate (Alternative G-38D). Table 3.5-12 summarizes the design delivery rate and pipeline sizes at the raw water intake and at each of the delivery locations.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water, land, and environmental mitigation. Cost estimates for Alternatives G-38C and G-38D are presented in Table 3.5-13. Table 3.5-13 reports the annual cost to purchase stored water from GBRA to meet the drought average requirement. Although the amount of stored water actually needed each year may be higher or lower, the annual cost is held constant at the drought average amount, as would be the case with a "take-or-pay" type of purchase contract. The total estimated project cost of Alternative G-38C is $165,990,000 (Table 3.5-13), which results in a total annual cost, including operation and maintenance of $28,553,000. The total estimated project cost for Alternative G-38D is $244,210,000 (Table 3.5-13), which results in a total annual cost, including operation and maintenance of $38,830,000. The operating cost was determined for a total static lift from Gonzales to the SAWS Stahl Pump Station of 690 ft and an annual delivery of 75,000 acft.

The estimated cost of each alternative was allocated to each delivery location based on the pro-rata capacity of each component dedicated to meeting potential year 2000 and 2020 demands at the delivery location. Thus, participants would pay a pro-rata share of raw water and treatment facility costs based solely on the percent of total capacity dedicated to meeting their water demands and the participant's location relative to the water source did not affect calculation of the cost allocation. For transmission and pump station costs, each participant pays a pro-rata share only of the facilities needed to deliver water to them, consequently, costs to participants that are furthest from the water source are proportionately greater.

For Alternatives G-38C and G-38D (annual delivery of 75,000 acft), Tables 3.5-14 and 3.5-15 summarize the total annual cost and the unit cost of water for year 2000 and year 2020. Early in project operation, less water will be delivered to participants and all remaining available water will be delivered to SAWS. The cost of water for year 2020 conditions delivered at a uniform delivery rate varies from $349 per acft for Green Valley SUD[11] to $701 per acft (Table 3.5-14) for Marion. For a summer peaking distribution pattern, and full usage of the allotted

[11] This would also be the unit cost of water for Springs Hill WSC and Crystal Clear WSC for a potential water trade with Green Valley.

Table 3.5-13 Cost Estimate Summaries for Potential Supply from Guadalupe River Diverted at Gonzales to Regional WTP 75,000 acft/yr (Alternatives G-38C and G-38D) (First Quarter - 1996 Prices)		
Item	**Alt. G-38C Uniform Annual Delivery**	**Alt. G-38D Summer Peak Delivery**
Capital Costs		
Intake and Treatment Plant	$41,460,000	$75,550,000
Off-Channel Storage Facility	4,000,000	10,000,000
Transmission Pipelines	62,090,000	77,620,000
Booster Pump Stations	9,080,000	10,120,000
Interconnects to Participants	4,240,000	4,240,000
Total Capital Cost	$120,650,000	$177,530,000
Engineering, Contingencies, and Legal Costs	38,470,000	57,540,000
Environmental Studies and Mitigation	520,000	520,000
Land Acquisition	1,520,000	1,520,000
Interest During Construction	4,830,000	7,100,000
Total Project Cost	$165,990,000	$244,210,000
Annual Costs		
Annual Debt Service	$15,550,000	$22,880,000
Annual Operation and Maintenance		
Water Treatment Plant	3,520,000	6,170,000
Transmission Pipelines	1,290,000	1,480,000
Power Cost	5,860,000	5,860,000
Purchase of Water	2,333,000(1)	2,440,000(2)
Total Annual Cost	$28,553,000	$38,830,000

(1) Includes 21,930 acft/yr of stored water purchased from GBRA and 22,080 acft/yr of year 2020 underutilized water rights at an annual cost of $53/acft.
(2) Includes 24,060 acft/yr of stored water purchased from GBRA and 21,990 acft/yr of year 2020 underutilized water rights at an annual cost of $53/acft

amount, the unit cost of water varies from $473 per acft for Green Valley to $827 per acft (Table 3.5-15) for Marion.

For the case of all 75,000 acft/yr being delivered to Bexar County at the SAWS Stahl pump station (as possibly would happen in the early years of project operation), the annual unit

Table 3.5-14
Summary of Costs by Delivery Location
Potential Supply Diverted at Gonzales to Regional WTP
75,000 acft/yr, Uniform Annual Delivery (G-38C)
(First Quarter - 1996 dollars)

	Year 2000				Year 2020			
Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	**Annual Volume[1] (acft/yr)**	**Annual Cost**	**Unit Cost[2] $/acft/yr**	**Unit Cost[2] $/1000 gal**	**Annual Volume[1] (acft/yr)**	**Annual Cost**	**Unit Cost[2] $/acft/yr**	**Unit Cost[2] $/1000 gal**
Springs Hill [4] (0.11 mgd)	0	$36,000	[3]	[3]	123	$43,000	$349	$1.07
Crystal Clear [4] (0.43 mgd)	0	$141,000	[3]	[3]	476	$166,000	$349	$1.07
Marion (0.08 mgd, 4")	56	$53,000	$946	$2.90	87	$61,000	$701	$2.15
Green Valley (1.98 mgd, 4")	362	$279,000	$771	$2.37	1,624	$566,000	$349	$1.07
Cibolo (0.18 mgd, 4")	160	$63,000	$394	$1.21	160	$64,000	$400	$1.23
Garden Ridge (0.51 mgd, 6")	315	$173,000	$549	$1.69	570	$217,000	$381	$1.17
Schertz (2.33 mgd, 12")	1,268	$752,000	$596	$1.83	2,612	$987,000	$378	$1.16
SAWS-Stahl Pump Station (67 mgd, 66")	72,839	$27,056,000	$371[5]	$1.14[5]	69,348	$26,449,000	$381[5]	$1.17[5]
Total	75,000	$28,553,000	$381	$1.17	75,000	$28,553,000	$381	$1.17

[1] Annual volume not adjusted for treatment, transmission, and other losses.
[2] Cost of treated water delivered on a wholesale basis and does not include operating costs of the distribution system
[3] Annual costs for debt service will accrue, even though no water deliveries are projected.
[4] Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.
[5] Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to bring the water, may occur before year 2020.
Note: The unit cost to deliver all 75,000 acft/yr to SAWS would be about $379 per acft/yr ($1.16/1,000 gallons).

Table 3.5-15 Summary of Costs by Delivery Location Potential Supply Diverted at Gonzales to Regional WTP 75,000 acft/yr, Summer Peaking Delivery (G-38D) (First Quarter - 1996 dollars)								
	Year 2000				Year 2020			
Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2)		Annual Volume(1) (acft/yr)	Annual Cost	Unit Cost(2)	
			$/acft/yr	$/1000 gal			$/acft/yr	$/1000 gal
Springs Hill (4) (0.22 mgd)	0	$52,000	(3)	(3)	123	$58,000	$473	$1.45
Crystal Clear (4) (0.86 mgd)	0	$200,000	(3)	(3)	476	$225,000	$473	$1.45
Marion (0.16 mgd, 4")	56	$63,000	$1,128	$3.46	87	$72,000	$827	$2.54
Green Valley (3.06 mgd, 14")	362	$408,000	$1,126	$3.46	1,624	$768,000	$473	$1.45
Cibolo (0.34 mgd, 6")	160	$84,000	$527	$1.62	160	$84,000	$525	$1.61
Garden Ridge (1.02 mgd, 8")	315	$240,000	$764	$2.35	570	$295,000	$519	$1.59
Schertz (4.66 mgd, 18")	1,268	$1,055,000	$832	$2.55	2,612	$1,344,000	$515	$1.58
SAWS Stahl Pump Station (134 mgd, 72")	72,839	$36,728,000	$504(5)	$1.55(5)	69,348	$35,984,000	$519(5)	$1.59(5)
Total	75,000	$38,830,000	$518	$1.59	75,000	$38,830,000	$518	$1.59

(1) Annual volume not adjusted for treatment, transmission, and other losses.

(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the distribution system

(3) Annual costs for debt service will accrue, even though no water deliveries are projected.

(4) Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.

(5) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to bring the water, may occur before year 2020.

cost was estimated to be $379 per acft per year at a uniform delivery rate and $515 per acft per year for a summer peaking delivery pattern.

3.5.6 Implementation Issues

Implementation steps include:

- Commitment of project participants
- Phasing of project elements
- Negotiate water purchase contracts with GBRA and existing water rights owners
- Financing
- Engineering
- Permitting
- Construction
- Operation and Maintenance

<u>Requirements Specific to Amending the Canyon Lake Permit</u>

1. Alternatives G-38C and G-38D will likely require exceeding the current annual permitted quantity from Canyon Lake of 50,000 acft, and a permit amendment will be necessary. This amendment will require:
   a. Application to the TNRCC.
   b. Hydrologic studies substantiating requested firm yield.
   c. Possibly environmental studies of in-stream flow and bay/estuary effects.
   d. Subordination of hydropower rights.
   e. Management of Edwards Aquifer by a regional agency to achieve the modeled aquifer pumpage/springflow scenario.

<u>Gonzales Intake</u>

It will be necessary to obtain these permits:
   a. TNRCC Water Right permit.
   b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the intake.
   c. GLO Easement for use of state-owned land.
   d. Coastal Coordinating Council review.
2. Permitting, at a minimum, will require these studies:
   a. Environmental studies.
   b. Cultural resource studies.
3. Land will need to be acquired through either negotiations or condemnation.

<u>Requirements Specific to Diversion of Water from Guadalupe River</u>

To obtain more realistic values of surface water availability, additional in-depth studies of environmental water needs should be performed for affected reaches of the Guadalupe and San Antonio Rivers. These studies are consistent with the Environmental Water Needs Criteria of the

Consensus Planning Process which allows the substitution of alternative flow minimums based on stream-specific studies considering indigenous species, habitat, recreational utilization, water quality, and assimilative capacity of individual stream segments.

1. Necessary permits:
    a. Existing water rights permits will need to be amended subsequent to negotiations with each water right owner to allow for an additional point of diversion at Gonzales.
    b. TNRCC permit to divert water.
    c. TNRCC Interbasin Transfer Approval.
2. Permitting will require these studies:
    a. Instream flow issues and impact.
    b. Environmental studies.
    c. Bay and estuary inflow impact.
3. Agreements with water right permit owners including GBRA for use and payment for water diverted under existing permits and for water released from Canyon Lake.

Requirements Specific to Pipelines

1. Necessary permits:
    a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
    b. GLO Sand and Gravel Removal permits.
    c. TPWD Sand, Gravel and Marl Removal permits.
    d. Coastal Coordinating Council review may be required.
2. Right-of-way and easement acquisition.
3. Crossings.
    a. Highways and railroads.
    b. Creeks and rivers.
    c. Other utilities.

Requirements Specific to Treatment and Distribution

A detailed study is needed of the cost of pumping and transmission pipeline improvements necessary to effectively integrate the new supply into SAWS water distribution system.

Off-Channel Reservoir

1. It will be necessary to obtain these permits for the off-channel storage reservoir.
    a. TNRCC Water Right and Storage permits.
    b. TNRCC Interbasin Transfer Approval.

c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
d. GLO Sand and Gravel Removal permits.
e. GLO Easement for use of state-owned land.
f. Coastal Coordinating Council review.
g. TPWD Sand, Gravel, and Marl permit.

2. Permitting, at a minimum, will require these studies:
   a. Bay and estuary inflow impact.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired either through negotiations or condemnation.
4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Other utilities.

3.6 Guadalupe River Diversion at Lake Dunlap and near Gonzales to Mid-Cities and Bexar County with Regional WTP (G-39)

3.6.1 Description of Alternative

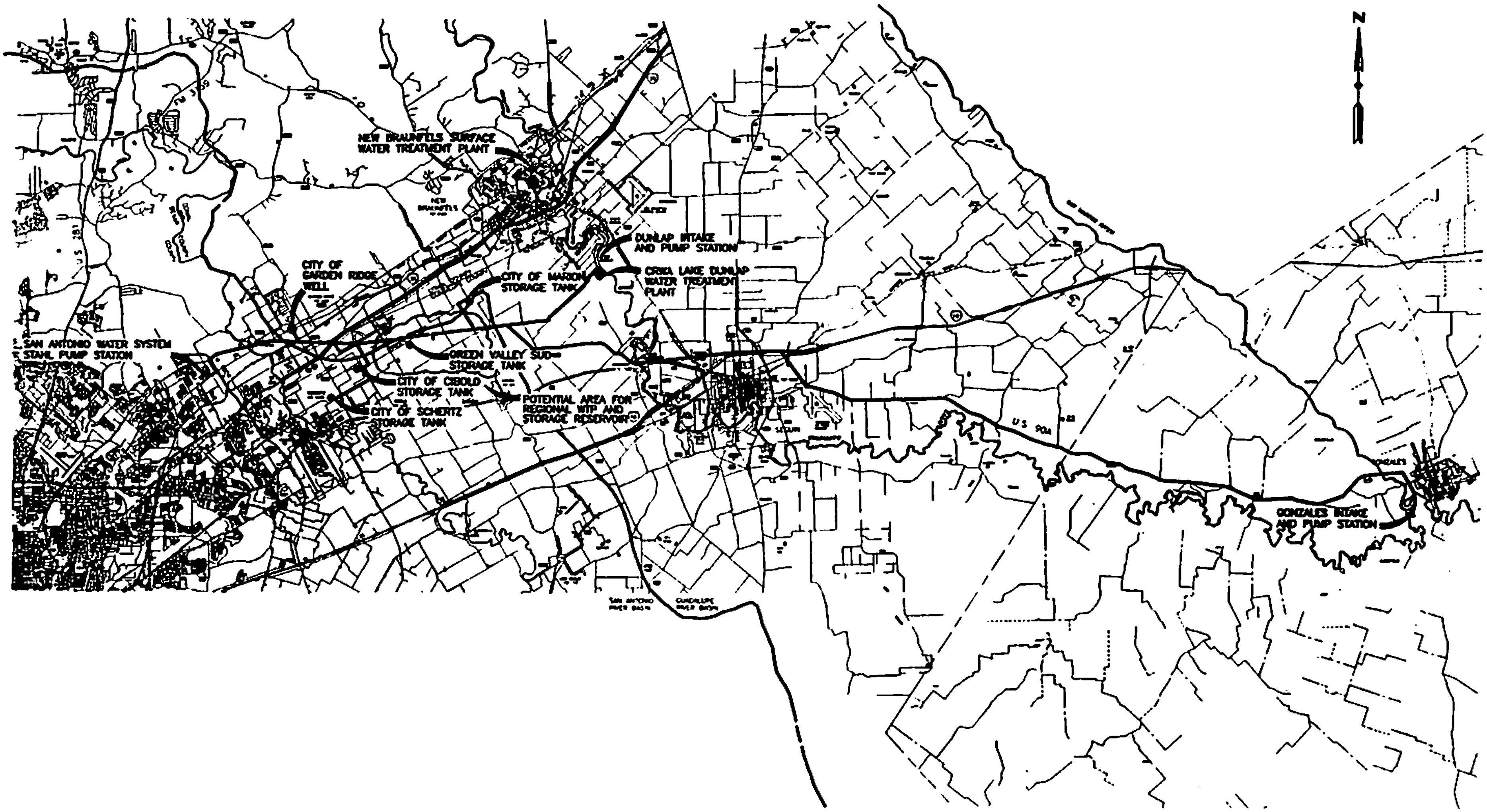
This alternative considers diversion of water from two points on the Guadalupe River combined for treatment at a single potential regional water treatment plant near Marion and delivery of treated water on a wholesale basis. The points of diversion would be near Lake Dunlap and near Gonzales. Two annual diversion volumes (40,000 acft/yr and 75,000 acft/yr) were studied and Table 3.6-1 summarizes the numbering system for the supply alternatives, diversion quantities, delivery rates (i.e. peaking factors), and delivery locations.

Table 3.6-1
Definition of Alternatives for Guadalupe River Diversion at Lake Dunlap and Gonzales with Regional WTP (G-39)

Alternative	Diversion Quantity (acft/yr)	Delivery Rate	Delivery Location
G-39A	5,000 @ Dunlap 35,000 @ Gonzales	uniform	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-39B	5,000 @ Dunlap 35,000 @ Gonzales	summer peaking	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-39C	15,000 @ Dunlap 60,000 @ Gonzales	uniform	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)
G-39D	15,000 @ Dunlap 60,000 @ Gonzales	summer peaking	Marion, Cibolo, Schertz, Garden Ridge, CRWA Entities in Guadalupe County(1), SAWS(2)

(1) Includes Green Valley SUD, Springs Hill WSC, and Crystal Clear WSC.
(2) Delivery to SAWS Stahl Secondary Pump Station facility.

This alternative would involve construction of these facilities: an intake and raw water pump station at Gonzales; a raw water pipeline from the Gonzales diversion; an intake and raw water pump station at Lake Dunlap; a raw water pipeline from Lake Dunlap that joins the pipeline from Gonzales; forebay storage facility at the water treatment plant; regional water treatment plant near Marion; high service pump station; water transmission pipeline; water delivery pipelines and connections to intermediate delivery locations in Guadalupe County; booster pump stations; and a ground storage tank at SAWS Stahl secondary pump station. The location of these facilities are shown on Figure 3.6-1.



Legend

- ■ Water Treatment Plant
- ● Connection Point to Existing Distribution System
- — Potential Water Transmission Pipeline
- ⁀ Basin Boundary

2 0 2 4 6

Approximate Scale in Miles

TRANS-TEXAS WATER PROGRAM
WEST CENTRAL STUDY AREA

HDR

HDR Engineering, Inc.

GUADALUPE RIVER DIVERSION AT GONZALES & LAKE DUNLAP DELIVERED TO REGIONAL WTP, ALTERNATIVE G-39

FIGURE 3.6-1

3.6.2 Available Water Supply and Projected Demand

Alternative G-39A and G-39B - Diversion of 40,000 acft/yr from the Guadalupe River

Water potentially available at Lake Dunlap would include purchase of stored water in Canyon Lake from GBRA. The water potentially available for diversion at Gonzales would be made up of periodically-available run-of-the-river water made firm by allocation of a portion of the firm yield of Canyon Lake and also from use of existing water rights projected to be underutilized in year 2020.

Dunlap Diversion - 5,000 acft/yr

The Dunlap diversion requires the purchase of 5,000 acft/yr of Canyon Lake water from GBRA. This water would be released from Canyon Lake to a new intake located on Lake Dunlap.

Gonzales Diversion - 35,000 acft/yr

Water potentially available for diversion at Gonzales would be obtained from the following sources: 1) enhanced springflow resulting from a theoretical reduction in overall Edwards Aquifer pumpage from that observed in calendar year 1989 (543,677 acft) to 400,000 acft/yr; 2) flow permitted to large existing water rights (permitted, but projected to be underutilized in calendar year 2020); 3) unappropriated streamflow; and 4) stored water delivered from Canyon Lake. The term "enhanced springflow" as used throughout this study is defined to be the estimated increase in discharge primarily from Comal and San Marcos Springs into the Guadalupe and San Marcos Rivers which, theoretically, would occur if Edwards Aquifer pumpage were reduced from an annual volume of 543,677 acft to an annual volume of 400,000 acft. For the purposes of this study, it was assumed that this water would first be dedicated to existing water rights (including Canyon Lake) with the remainder available for diversion from the Guadalupe River at Lake Dunlap and/or Gonzales. The procedures and assumptions pertinent to the computation of water potentially available from each of these sources are described in Appendix C. Table 3.6-2 summarizes estimates of water available from each source for a total annual diversion of 35,000 acft from Gonzales.

Water availability analyses for Alternative G-39 show that 35,000 acft/yr could be diverted near Gonzales without interruption through the historical drought of record subject to either a uniform monthly diversion pattern or a peaked summer diversion pattern. For the uniform monthly diversion pattern, analyses indicate that a drought average of 20,430 acft/yr

Table 3.6-2 Water Sources for Diversion of 35,000 acft/yr at Gonzales (Alternatives G-39A and G-39B)				
	Uniform Annual Diversion (G-39A)		Summer Peak Diversion (G-39B)	
Water Source	Average(1) (acft/yr)	Drought(2) (acft/yr)	Average(1) (acft/yr)	Drought(2) (acft/yr)
Enhanced Springflow	30,620	20,430	29,700	18,670
Unappropriated Streamflow	100	160	60	220
Year 2020 Underutilized Rights	2,970	8,300	3,630	8,980
Subtotal	33,690	28,890	33,390	27,870
Canyon Firm Yield(3) (Evaporation on Banked Storage(4))	1,310	7,140 (1,030)	1,610	8,240 (1,110)
Total	35,000	35,000	35,000	35,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(3) Evaporation on banked storage calculated only during the drought and is included in Canyon Firm Yield.

could be obtained from enhanced springflow and 8,310 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 7,140 acft/yr would need to be purchased from the yield of Canyon Lake (of which about 1,040 acft/yr is needed to offset increased evaporation from banked storage as described in Appendix C) to ensure availability of 35,000 acft/yr at Gonzales. For the peaked summer diversion pattern, analyses indicate that a drought average of 18,670 acft/yr could be obtained from enhanced springflow and 8,980 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 8,240 acft/yr would need to be purchased from the firm yield of Canyon Lake (of which about 1,110 acft/yr is needed to offset increased evaporation from banked storage) to ensure availability of 35,000 acft/yr at Gonzales. Subject to draft Environmental Water Needs Criteria of the Consensus Planning Process received November 27, 1995, between 160 acft/yr and 220 acft/yr would be available as unappropriated streamflow during drought after considering diversions under enhanced springflow and water rights transfers. Analyses indicate that diversion of enhanced springflow would be significantly greater over the long-term than during drought, while utilization of water purchased from the yield of Canyon Lake would be significantly less.

Combined Diversion - 40,000 acft/yr

Delivery facilities for entities in Guadalupe County (GBRA statutory area) have been sized for delivery of a pro-rata allotment of 5,652 acft/yr, to meet projected 2020 shortages for this area. Table 3.6-3 summarizes the water allocation to each of the potential customers for Alternatives G-39A and G-39B.

Table 3.6-3
Allocation of 40,000 acft/yr Diverted at Lake Dunlap and Gonzales and Delivered to Regional WTP (Alternatives G-39A and G-39B)

DELIVERY POINT	1990 DEMAND: DEMAND (acft/yr)	1990 DEMAND: PERCENT OF TOTAL	PROJECTED SHORTAGES(1): YEAR 2020 (acft/yr)	PROJECTED SHORTAGES(1): YEAR 2050 (acft/yr)	ALLOCATION OF NEW SUPPLY(2) (acft/yr)
Entities in GBRA Statutory Service Area:					
Marion	150	2%	87	133	87
Cibolo	204	3%	160	271	160
Schertz	2,140	30%	2,612	7,464	2,612
Garden Ridge	397	5%	570	1,213	570
Crystal Clear WSC	1,042	14%	476	1,194	476
Green Valley SUD	1,804	25%	1,624	3,519	1,624
Springs Hill WSC	1,486	21%	123	1,681	123
GBRA Area Subtotal	7,223	100%	5,652	15,475	5,652
Amount Remaining for Delivery to Bexar County:					34,348

(1) Projected shortages in other areas of Guadalupe and Comal counties not included in this alternative.
(2) Allocations of new water supplies to entities in GBRA Statutory Area are set equal to projected 2020 shortages.

Table 3.6-4 indicates an allocation of 34,348 acft/yr to Bexar County (delivered to SAWS) in year 2020 for Alternative G-39A and G-39B. However, prior to year 2020, more than this amount would be available for delivery to SAWS[1], and facilities for delivery of potential surface water supplies to Bexar County were sized to deliver 40,000 acft/yr. The transmission pipeline to

[1] With implementation of SB 1477, immediate demands for new water supplies in Bexar County are about 31,000 acft/yr, thereby creating a need for all of the water potentially available from Alternative G-37.

Table 3.6-4 Allocation of 34,348 acft/yr Potential Supply Diverted at Lake Dunlap and Gonzales and Delivered to Bexar County (Alternatives G-39A and G-39B)					
	1990 DEMAND		PROJECTED SHORTAGES		ALLOCATION OF NEW SUPPLY(1) (acft/yr)
DELIVERY POINT	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	
Entities in Bexar County:					
East Central WSC	1,130	0.47%	1,168	2,354	161
BMWD Northeast	3,229	1.33%	4,484	8,024	459
Universal City	2,323	0.96%	2,444	4,458	330
Converse	1,213	0.50%	2,619	5,546	172
Live Oak	1,221	0.50%	302	822	174
Randolph AFB	1,494	0.62%	538	515	212
SAWS/BMWD & Remainder of Bexar County	231,987	95.63%	220,576	380,191	32,840
Bexar County Subtotal	242,597	100%	232,131	401,910	34,348
(1) Allocations of new water supplies to entities in Bexar County are based on percent distribution of 1990 demand.					

Bexar County was not stepped down in size at connections to intermediate customers in Guadalupe and Comal counties. Thus, the full 40,000 acft/yr can be delivered to Bexar County in the first year of operation. As water demands of Comal and Guadalupe county entities grow, more water would be delivered to them and less water would be transferred to Bexar County. For Alternative G-39A and G-39B, the 2020 delivery quantity to Bexar County would be about 34,348 acft/yr.

Alternative G-39C and G-39D - Diversion of 75,000 acft/yr from the Guadalupe River

Dunlap Diversion - 15,000 acft/yr

The Dunlap diversion requires the purchase of 15,000 acft/yr of Canyon Lake water from GBRA. This water would be released from Canyon Lake to a new intake located on Lake Dunlap.

Gonzales Diversion - 60,000 acft/yr

Under Alternative G-39C and G-39D, water potentially available for diversion at Gonzales would be obtained from the following sources: 1) enhanced springflow resulting from a theoretical reduction in overall Edwards Aquifer pumpage from that observed in calendar year 1989 (543,677 acft) to 400,000 acft/yr; 2) flow committed to large existing water rights (permitted, but projected to be underutilized in calendar year 2020); 3) unappropriated streamflow; and 4) water delivered from Canyon Lake. The procedures and assumptions pertinent to the computation of water potentially available from each of these sources are described in Appendix C, and Table 3.6-5 summarizes estimates of water needed from each source for a total annual diversion of 60,000 acft at Gonzales.

Table 3.6-5
Water Sources for Diversion of 60,000 acft/yr near Gonzales
(Alternatives G-39C and G-39D)

Water Source	Uniform Annual Diversion (G-39C)		Summer Peak Diversion (G-39D)	
	Average[1] (acft/yr)	Drought[2] (acft/yr)	Average[1] (acft/yr)	Drought[2] (acft/yr)
Enhanced Springflow	50,220	28,840	48,000	26,730
Unappropriated Streamflow	390	790	580	950
Year 2020 Underutilized Rights	5,980	15,280	7,220	15,330
Subtotal	56,590	44,910	55,800	43,010
Canyon Firm Yield[3]	3,410	17,600	4,200	19,490
(Evaporation on Banked Storage[4])		(2,510)		(2,500)
Total	60,000	60,000	60,000	60,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(3) Evaporation on banked storage calculated only during the drought and is included in Canyon Firm Yield.

Water availability analyses for Alternative G-39 conclude that 60,000 acft/yr could be diverted near Gonzales without interruption through the historical drought of record subject to either a uniform monthly diversion pattern or a peaked summer diversion pattern. For the uniform monthly diversion pattern, analyses indicate that a drought average of 28,840 acft/yr could be obtained from enhanced springflow and 15,280 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 17,600 acft/yr would need to be purchased from the yield of Canyon Lake (of which about 2,510 acft/yr is needed to offset increased evaporation from banked storage as described in Appendix C) to ensure availability of 60,000 acft/yr at Gonzales. For the peaked summer diversion pattern, analyses indicate that a drought average of 26,730 acft/yr could be obtained from enhanced springflow and 15,330 acft/yr obtained by purchase or lease of water rights projected to be underutilized in 2020. In addition, an average of 19,490 acft/yr would need to be purchased from the firm yield of Canyon Lake (of which about 2,500 acft/yr is needed to offset increased evaporation from banked storage) to ensure availability of 60,000 acft/yr near Gonzales. Subject to draft Environmental Water Needs Criteria of the Consensus Planning Process received November 27, 1995, about 790 acft/yr would be available as unappropriated streamflow during drought after considering diversions under enhanced springflow and water rights transfers. Analyses indicate that diversion of enhanced springflow would be significantly greater over the long-term than during drought, while utilization of water purchased from the yield of Canyon Lake would be significantly less.

Combined Diversion - 75,000 acft/yr

For delivery of 75,000 acft/yr (Alt G-39C and G-39D), delivery facilities to entities in the GBRA statutory area were sized to deliver the projected year 2020 shortage as shown in Table 3.6-6. Tables 3.6-6 and 3.6-7 summarize the allocation of water supply for Alternatives G-39C and G-39D.

Tables 3.6-6 and 3.6-7 indicate an allocation of 69,348 acft/yr to Bexar County (delivered to SAWS) in year 2020 for Alternative G-39C and G-39D. However, prior to year 2020, more than this amount would be available for delivery to SAWS, and facilities for delivery of potential surface water supplies to Bexar County were sized to deliver 75,000 acft/yr. The transmission pipeline to Bexar County was not stepped down in size at connections to intermediate customers in Guadalupe and Comal counties. Thus, the full 75,000 acft/yr can be delivered to Bexar County in the first year of operation. As water demands of Comal and Guadalupe county entities grow, more water would be delivered to them and less water would be transferred to Bexar County. For Alternative G-39C and G-39D, the 2020 delivery quantity to Bexar County would be about 69,348 acft/yr.

3.6.3 Environmental Issues

The proposed diversions of water from Lake Dunlap and the Guadalupe River near Gonzales and delivery to the City of Marion, Green Valley SUD Storage Tank, City of Cibolo, City of Schertz and San Antonio Water System's Stahl Pump Station involves a water transmission pipeline the same as that described in Alternative G-38 with the addition of the section of pipeline between the City of Marion Storage Tank and Lake Dunlap described in Alternative G-36 (Figure 3.6-1).

Table 3.6-6
Allocation of 75,000 acft/yr Diverted at Lake Dunlap and Gonzales to Regional WTP
(Alternatives G-39C and G-39D)

DELIVERY POINT	1990 DEMAND		PROJECTED SHORTAGES[1]		ALLOCATION OF NEW SUPPLY[2] (acft/yr)
	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	
Entities in GBRA Statutory Service Area:					
Marion	150	2%	87	133	87
Cibolo	204	3%	160	271	160
Schertz	2,140	30%	2,612	7,464	2,612
Garden Ridge	397	5%	570	1,213	570
Crystal Clear WSC	1,042	14%	476	1,194	476
Green Valley SUD	1,804	25%	1,624	3,519	1,624
Springs Hill WSC	1,486	21%	123	1,681	123
GBRA Area Subtotal	7,223	100%	5,652	15,475	5,652
Amount Remaining for Delivery to Bexar County:					69,348

(1) Projected shortages in other areas of Guadalupe and Comal counties not included in this alternative.
(2) Allocations of new water supplies to entities in GBRA Statutory Area are set equal to projected 2020 shortages.

Table 3.6-7
Allocation of 69,348 acft/yr Potential Supply Diverted at Lake Dunlap and Gonzales
and Delivered to Bexar County (Alternatives G-39C and G-39D)

DELIVERY POINT	1990 DEMAND		PROJECTED SHORTAGES		ALLOCATION OF NEW SUPPLY[1] (acft/yr)
	DEMAND (acft/yr)	PERCENT OF TOTAL	YEAR 2020 (acft/yr)	YEAR 2050 (acft/yr)	
Entities in Bexar County:					
East Central WSC	1,130	0.47%	1,168	2,354	323
BMWD Northeast	3,229	1.33%	4,484	8,024	923
Universal City	2,323	0.96%	2,444	4,458	664
Converse	1,213	0.50%	2,619	5,546	347
Live Oak	1,221	0.50%	302	822	302
Randolph AFB	1,494	0.62%	538	515	427
SAWS/BMWD & Remainder of Bexar County	231,987	95.63%	220,576	380,191	66,362
Bexar County Subtotal	242,597	100%	232,131	401,910	69,348

(1) Allocations of new water supplies to entities in Bexar County are based on percent distribution of 1990 demand.

Soil associations, vegetational habitats and sensitive species for Alternative G-39 are qualitatively the same as those described in Sections 3.3 and 3.5 (Alternatives G-36 and G-38). The proposed pipeline route from the diversions near Gonzales and Lake Dunlap to the delivery points would be about 70.5 miles long and, assuming a 140 foot wide construction ROW, would affect a total of 1196.4 acres including 49.2 acres developed (4.1 percent), 875.6 acres crop (73.2 percent), 5.1 acres shrub (0.4 percent), 56 acres brush (4.7 percent), 52.6 acres park (4.4 percent), 156.1 acres wood (13.0 percent), and 1.7 acres water (0.1 percent). A 40 foot wide mowed ROW maintained for the life of the project would affect 341.8 acres including 14.1 acres developed, 250.2 acres crop, 1.5 acres shrub, 16 acres brush, 15.0 acres park and 44.6 acres wood.

The proposed diversions at Lake Dunlap and near Gonzales considered above in sections 3.4.3 (Alternative G-37) and 3.5.3 (Alternative G-38) are maximum diversion scenarios and represent maximum potential impacts in terms of aquatic impacts. The potential impacts of the combined diversion on freshwater and estuarine habitats would be less than the separate diversions already considered above (please refer the environmental issues sections 3.4.3 and 3.5.3 above).

Cultural resources protection on public lands in Texas is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction will be first surveyed by qualified professionals for the presence of significant cultural resources.

3.6.4 Water Quality and Treatability

[To be completed in subsequent phases of the study.]

3.6.5 Engineering and Costing

For this alternative, raw water diverted at Lake Dunlap and at Gonzales would be treated at a potential regional water treatment plant near Marion and treated water would be supplied on a wholesale basis to Green Valley SUD, Marion, Cibolo, Schertz, Garden Ridge, and San Antonio Water System. Figure 3.6-1 shows the general location of the potential water treatment plant and potential pipeline routes, however, pipeline routes may be adjusted once route studies and on-the-ground surveys have been performed in subsequent project phases.

Springs Hill WSC and Crystal Clear WSC currently receive treated water from the CRWA treatment plant at Lake Dunlap. Construction of a treated waterline from the regional WTP eastward to the existing CRWA WTP would not be economical. Therefore, Springs Hill WSC and Crystal Clear WSC would not be connected to the regional WTP, but potentially receive their water allocation by trading an equivalent amount of treated water with Green Valley SUD. For this arrangement, Springs Hill WSC would receive 123 acft/yr and Crystal Clear WSC would receive 476 acft/yr more water from the CRWA WTP than currently allocated and Green Valley SUD would receive 599 acft/yr less water from the CRWA WTP than currently allocated.

At the diversion near Gonzales, raw water would be diverted at a new water intake to be located on the Guadalupe River downstream of the confluence with the San Marcos River and be pumped to a forebay storage facility near the treatment plant. At the Lake Dunlap diversion, raw water would be pumped from a new water intake to be located adjacent to the existing CRWA intake at Lake Dunlap to a connection with the raw water pipeline from Gonzales and the combined flow would be transported by pipeline to the forebay storage facility. Treatment would consist of conventional surface water treatment (flocculation, settling, filtration, and chlorine disinfection). The forebay storage facility would provide for enhanced raw water quality by allowing for pre-sedimentation of raw water. Another benefit of the forebay storage would be improved reliability of the surface water system by allowing continuing plant operation during raw water pipeline maintenance or unscheduled outages. For Alternatives G-39A (40,000 acft/yr, uniform diversion), the forebay storage volume chosen for costing is about 1,700 acft, or about 15 days of storage. For Altemtive G-39C (75,000 acft/yr, uniform diversion), the forebay storage volume chosen for costing is about 3,000 acft/yr, also about 15 days of storage.

For the summer peak flowrate alternatives (G-39B and G-39D), the storage volume was set large enough to allow reducing the peak summer raw water diversion rate and meet part of the peak month needs from storage, and thereby reduce the size of the raw water transmission pipeline. Use of forebay storage results in an overall cost savings by reducing the raw water pipeline size. To reduce the summer peak diversion rate from 2.0 times annual average to 1.4 (i.e. a reduction in the peak month diversion from 17 percent of the annual total to 11 percent) would require a storage volume of about 4,400 acft/yr for Alternative G-39B, and 8,250 acft/yr for Alternative G-39D.

The major facilities required to implement this alternative are:

- River Intake and Pump Station near Gonzale
- River Intake and Pump Station near Lake Dunlap

- Raw Water Pipeline from Gonzales and Pump Stations
- Raw Water Pipeline from Lake Dunlap
- Combined Raw Water Pipeline to Treatment Plant
- Water Treatment Plant near Marion
- Treated Water Pump Station
- Transmission Pipeline
- Interconnections to:
  - > Marion
  - > Cibolo
  - > Schertz
  - > Green Valley SUD
  - > SAWS Stahl Secondary Pump Station
- Booster Pump Station

Alternative G-39A and G-39B: Delivery of 40,000 acft/yr of Guadalupe River Water to Regional WTP near Marion

Delivery facilities were sized to deliver a pro-rata allocation of 2020 projected shortages to Marion, Cibolo, Schertz, Garden Ridge and Green Valley SUD. Delivery facilities to Green Valley SUD were sized for Green Valley projected demands plus 599 acft/yr for the potential water trade with Crystal Clear and Spring Hill WSCs. Delivery facilities to the SAWS Stahl Pump Station were sized to deliver 40,000 acft/yr.

Two delivery rate scenarios were considered: a uniform annual delivery rate (Alternative G-39A); and, a summer month peak rate of 2.0 times the uniform annual delivery rate (Alternative G-39B). Table 3.6-8 summarizes the design delivery rate and pipeline sizes at the raw water intake and at each of the delivery locations.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water, land, and environmental mitigation. Cost estimates for Alternatives G-39A and G-39B are presented in Table 3.6-9. The total estimated project cost of Alternative G-39A is $107,630,000 (Table 3.6-9), which results in a total annual cost, including operation and maintenance and purchase of stored water, of $17,420,000. The total estimated project cost for Alternative G-39B is $146,660,000 (Table 3.6-9), which results in a total annual cost, including operation and maintenance and purchase of stored water, of $23,100,000. The operating cost was determined for a total static lift from Gonzales to the Stahl Pump Station well of 694 ft and an annual delivery of 40,000 acft (5,000 acft/yr diverted at Lake Dunlap and 35,000 acft/yr at Gonzales).

Table 3.6-8 Delivery Rates and Pipeline Sizes for Alternatives G-39A and G-39B						
			Design Delivery Rate and Size			
			Uniform Annual Delivery (G-39A)		Summer Peak Delivery (G-39B)	
Location	Annual Delivery Amount (acft/yr)	Description of Connection & Capital Cost Item	Delivery Rate (mgd)	Pipeline Diameter	Delivery Rate (mgd)	Pipeline Diameter
Raw Water Intake - Lake Dunlap	5,000	-----	4.5	18"	6.3	18"
Raw Water Intake - Gonzales	35,000	-----	31.3	42"	43.8	48"
Raw Water Pipeline - Combined	40,000	-----	35.7	48"	50.0	48"
Springs Hill WSC	123	(1)	0.11	(1)	0.22	(1)
Crystal Clear WSC	476	(1)	0.43	(1)	0.86	(1)
Marion	87	Connection to existing GST	0.08	4"	0.16	4"
Cibolo	160	Connection to existing GST	0.17	4"	0.34	6"
Green Valley SUD	1,624	Connection to existing GST	1.98	12"	4.0	14"
Schertz	2,612	Connection to existing GST	2.33	12"	4.66	18"
Garden Ridge	570	Connection to existing well	0.51	6"	1.02	8"
SAWS-Stahl Pump Station	34,348	New 10 MG GST	35.7	48"	71.4	66"

(1) Spring Hill WSC and Crystal Clear WSC will not be connected to the regional WTP, but would potentially receive their water allocation through a water trade with Green Valley SUD.

The estimated cost of each alternative was allocated to each delivery location based on the pro-rata capacity of each component dedicated to meeting potential year 2000 and 2020 demands at the delivery location. Thus, for raw water and treatment facility costs, participants would pay a pro-rata share based solely on the percent of total capacity dedicated to meeting their water demands, and the participant's location relative to the water source did not affect the cost allocation for treatment. For transmission and pump station costs, allocation was made on a pro-rata allocation only of the facilities needed to deliver water to them, consequently, costs to participants that are furthest from the water source are proportionately greater.

For Alternatives G-39A and G-39B (annual delivery of 40,000 acft), Tables 3.6-10 and 3.6-11 summarize the total annual cost and the annual unit cost of water for year 2000 and year 2020. Early in project operation, small quantities of water will be delivered to participants and all available water will be delivered to SAWS. The cost of water for year 2020 conditions delivered at a uniform delivery rate varies from $392 per acft per year for Green Valley SUD to $747 per acft

Table 3.6-9 Cost Estimate Summaries for Potential Supply from Guadalupe River Diverted at Lake Dunlap and Gonzales to Regional WTP 40,000 acft/yr (Alternatives G-39A and G-39B) (First Quarter - 1996 Prices)		
Item	**Alt. G-39A Uniform Annual Delivery**	**Alt. G-39B Summer Peak Delivery**
Capital Costs		
Intake and Treatment Plant	$27,120,000	$42,440,000
Off-Channel Storage	3,000,000	5,150,000
Transmission Pipelines	36,550,000	46,530,000
Booster Pump Stations	6,900,000	7,700,000
Interconnects to Participants	4,020,000	4,240,000
Total Capital Cost	$77,590,000	$106,060,000
Engineering, Contingencies, and Legal Costs	24,780,000	34,200,000
Environmental Studies and Mitigation	580,000	580,000
Land Acquisition	1,580,000	1,580,000
Interest During Construction	3,100,000	4,240,000
Total Project Cost	$107,630,000	$146,660,000
Annual Costs		
Annual Debt Service	$10,080,000	$13,740,000
Annual Operation and Maintenance		
Water Treatment Plant	1,810,000	3,680,000
Transmission Pipelines	870,000	1,020,000
Annual Power Cost	3,580,000	3,480,000
Annual Cost of Water	1,080,000(1)	1,180,000(2)
Total Annual Cost	$17,420,000	$23,100,000
(1) Includes 12,140 acft/yr of stored water purchased from GBRA and 8,300 acft/yr of year 2020 underutilized water rights at an annual cost of $53/acft. (2) Includes 13,240 acft/yr of stored water purchased from GBRA and 8,980 acft/yr of year 2020 underutilized water rights at an annual cost of $53/acft.		

per year (Table 3.6-10) delivered to Marion. For a summer peaking distribution pattern, and full usage of the allotted amount, the unit cost of water varies from $512 per acft per year for Green Valley SUD to $862 per acft per year (Table 3.6-11) for Marion.

For the case of all 40,000 acft/yr being delivered to Bexar County at the SAWS Stahl pump Station (as possibly would happen in the early years of project operation), the annual unit cost was estimated to be $433 per acft/yr at a uniform delivery rate and $573 per acft/yr for a summer

Table 3.6-10
Summary of Costs by Delivery Location
Potential Supply Diverted at Lake Dunlap and Gonzales to Regional WTP
40,000 acft/yr, Uniform Annual Delivery (G-39A)
(First Quarter - 1996 dollars)

	Year 2000				Year 2020			
Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	**Annual Volume[1] (acft/yr)**	**Annual Cost**	**Unit Cost[2] $/acft/yr**	**Unit Cost[2] $/1000 gal**	**Annual Volume[1] (acft/yr)**	**Annual Cost**	**Unit Cost[2] $/acft/yr**	**Unit Cost[2] $/1000 gal**
Springs Hill [4] (0.11 mgd)	0	$42,000	[3]	[3]	123	$48,000	$392	$1.20
Crystal Clear [4] (0.43 mgd)	0	$161,000	[3]	[3]	476	$187,000	$392	$1.20
Marion (0.08 mgd, 4")	56	$57,000	$1,018	$3.12	87	$65,000	$747	$2.29
Green Valley (1.98 mgd, 4")	362	$332,000	$917	$2.82	1,624	$637,000	$392	$1.20
Cibolo (0.18 mgd, 4")	160	$70,000	$438	$1.34	160	$71,000	$444	$1.36
Garden Ridge (0.51 mgd, 6")	315	$198,000	$629	$1.93	570	$244,000	$428	$1.31
Schertz (2.33 mgd, 12")	1,268	$857,000	$676	$2.07	2,612	$1,100,000	$421	$1.29
SAWS-Stahl Pump Station (35.7 mgd, 48")	37,839	$15,703,000	$415	$1.27	34,348	$15,068,000	$439[5]	$1.35[5]
Total	40,000	$17,420,000	$436	$1.34	40,000	$17,420,000	$436	$1.34

(1) Annual volume not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the distribution system
(3) Annual costs for debt service will accrue, even though no water deliveries are projected.
(4) Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.
(5) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to transport the water, may occur before year 2020.
Note: The unit cost to deliver all 40,000 acft/yr to SAWS would be about $433 per acft/yr ($1.33/1,000 gallons).

Table 3.6-11
Summary of Costs by Delivery Location
Potential Supply Diverted at Lake Dunlap and Gonzales to Regional WTP
40,000 acft/yr, Summer Peaking Delivery (G-39B)
(First Quarter - 1996 dollars)

Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Year 2000 Annual Volume[1] (acft/yr)	Year 2000 Annual Cost	Year 2000 Unit Cost[2] $/acft/yr	Year 2000 Unit Cost[2] $/1000 gal	Year 2020 Annual Volume[1] (acft/yr)	Year 2020 Annual Cost	Year 2020 Unit Cost[2] $/acft/yr	Year 2020 Unit Cost[2] $/1000 gal
Springs Hill [4] (0.22 mgd)	0	$57,000	[3]	[3]	123	$63,000	$512	$1.57
Crystal Clear [4] (0.86 mgd)	0	$219,000	[3]	[3]	476	$244,000	$512	$1.57
Marion (0.16 mgd, 4")	56	$66,000	$1,179	$3.62	87	$75,000	$862	$2.65
Green Valley (3.06 mgd, 14")	362	$436,000	$1,204	$3.70	1,624	$832,000	$512	$1.57
Cibolo (0.34 mgd, 6")	160	$91,000	$569	$1.75	160	$91,000	$569	$1.75
Garden Ridge (1.02 mgd, 8")	315	$263,000	$835	$2.56	570	$322,000	$565	$1.73
Schertz (4.66 mgd, 18")	1,268	$1,141,000	$900	$2.76	2,612	$1,454,000	$557	$1.71
SAWS (71.4 mgd, 66")	37,839	$20,827,000	$550[5]	$1.69[5]	34,348	$20,019,000	$583[5]	$1.79[5]
Total	40,000	$23,100,000	$578	$1.77	40,000	$23,100,000	$578	$1.77

(1) Annual volume not adjusted for treatment, transmission, and other losses.
(2) Cost of treated water delivered on a wholesale basis and does not include operating costs of the distribution system
(3) Annual costs for debt service will accrue, even though no water deliveries are projected.
(4) Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.
(5) Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to transport the water, may occur before year 2020.

peaking delivery pattern. These unit costs are inclusive of all system costs (capital and O&M) for all system components, except lateral pipelines and connections to intermediate delivery points.

Alternative G-39C and G-39D: Delivery of 75,000 acft/yr Diverted at Lake Dunlap and Gonzales to Regional WTP near Marion

Delivery facilities were sized to deliver year 2020 projected shortages to Marion, Cibolo, Schertz, Garden Ridge, and Green Valley SUD. Delivery facilities to Green Valley SUD were sized for Green Valley projected demands plus 599 acft/yr for a potential water trade with Crystal Clear WSC and Springs Hill WSC. Delivery facilities to the San Antonio Water System Stahl pump station were sized to deliver 75,000 acft/yr. Two delivery rate scenarios were considered: a uniform annual delivery rate (Alternative G-39C); and, a summer month peak rate of 2.0 times the uniform annual delivery rate (Alternative G-39D). Table 3.6-12 summarizes the design delivery rate and pipeline sizes at the raw water intake and at each of the delivery locations.

Table 3.6-12
Delivery Rates and Pipeline Sizes for Alternatives G-39C and G-39D

Location	Annual Delivery Amount (acft/yr)	Description of Connection & Capital Cost Item	Design Delivery Rate and Size: Uniform Annual Delivery (G-38C) Delivery Rate (mgd)	Uniform Annual Delivery (G-38C) Pipeline Diameter	Summer Peak Delivery (G-38D) Delivery Rate (mgd)	Summer Peak Delivery (G-38D) Pipeline Diameter
Raw Water Intake - Lake Dunlap	15,000	----	13.6	30"	19	30"
Raw Water Intake - Gonzales	60,000	----	53.6	54"	75.0	66"
Raw Water Pipeline - Combined	75,000	----	67.0	66"	91	72"
Springs Hill WSC	123	(1)	0.11	(1)	0.22	(1)
Crystal Clear WSC	476	(1)	0.43	(1)	0.86	(1)
Marion	87	Connection to existing GST	0.08	4"	0.16	4"
Cibolo	160	Connection to existing GST	0.17	4"	0.34	6"
Green Valley SUD	1,624	Connection to existing GST	1.98	12"	4.0	14"
Schertz	2,612	Connection to existing GST	2.33	12"	4.66	18"
Garden Ridge	570	Connection to existing well	0.51	6"	1.02	8"
SAWS-Stahl Pump Station	69,348	New 10 MG GST	67	66"	134	90"

(1) Springs Hill WSC and Crystal Clear WSC will not be connected to the regional WTP, but would potentially receive their water allocation through a water trade with Green Valley SUD.

Cost estimates were computed for capital costs, annual debt service, operation and maintenance costs, power, purchase of stored water, land, and environmental mitigation. Cost estimates for Alternatives G-39C and G-39D are presented in Table 3.6-13. The total estimated project cost of Alternative G-39C is $154,820,000 (Table 3.6-13), which results in a total annual cost, including operation and maintenance of $27,820,000. The total estimated project cost for Alternative G-39D is $239,180,000 (Table 3.6-13), which results in a total annual cost, including operation and maintenance of $38,710,000. The operating cost was determined for a total static lift from Gonzales to the SAWS Stahl Pump Station of 694 ft and an annual delivery of 75,000 acft (15,000 acft/yr at Lake Dunlap and 60,000 acft/yr at Gonzales).

The estimated cost of each alternative was allocated to each delivery location based on the pro-rata capacity of each component dedicated to meeting potential year 2000 and 2020 demands

at the delivery location. Thus, participants would pay a pro-rata share of raw water and treatment facility costs based solely on the percent of total capacity dedicated to meeting their water demands and the participant's location relative to the water source did not affect calculation of the cost allocation. For transmission and pump station costs, each participant pays a pro-rata share only of the facilities needed to deliver water to them, consequently, costs to participants that are furthest from the water source are proportionately greater.

For Alternatives G-39C and G-39D (annual delivery of 75,000 acft), Tables 3.6-14 and 3.6-15 summarize the total annual cost and the unit cost of water for year 2000 and year 2020. Early in project operation, less water will be delivered to participants and all remaining available water will be delivered to SAWS. The cost of water for year 2020 conditions delivered at a uniform delivery rate varies from $338 per acft for Green Valley SUD[2] to $691 per acft (Table 3.6-14) for Marion. For a summer peaking distribution pattern, and full usage of the allotted amount, the unit cost of water varies from $471 per acft for Green Valley to $828 per acft (Table 3.5-15) for Marion.

For the case of all 75,000 acft/yr being delivered to Bexar County at the SAWS Stahl pump station (as possibly would happen in the early years of project operation), the annual unit

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[2] This would also be the unit cost of water for Springs Hill WSC and Crystal Clear WSC for a potential water trade with Green Valley.

Table 3.6-13 Cost Estimate Summaries for Potential Supply from Guadalupe River Diverted at Lake Dunlap and Gonzales to Regional WTP 75,000 acft/yr (Alternatives G-39C and G-39D) (First Quarter - 1996 Prices)		
Item	**Alt. G-39C Uniform Annual Delivery**	**Alt. G-39D Summer Peak Delivery**
Capital Costs		
Intake and Treatment Plant	$43,320,000	$77,540,000
Off-Channel Storage Facility	4,000,000	10,020,000
Transmission Pipelines	52,190,000	72,520,000
Booster Pump Stations	8,630,000	9,300,000
Interconnects to Participants	4,020,000	4,240,000
Total Capital Cost	$112,160,000	$173,620,000
Engineering, Contingencies, and Legal Costs	36,010,000	56,460,000
Environmental Studies and Mitigation	580,000	580,000
Land Acquisition	1,580,000	1,580,000
Interest During Construction	4,490,000	6,940,000
Total Project Cost	$154,820,000	$239,180,000
Annual Costs		
Annual Debt Service	$14,510,000	$22,410,000
Annual Operation and Maintenance		
Water Treatment Plant	3,520,000	6,170,000
Transmission Pipelines	1,200,000	1,440,000
Power Cost	6,050,000	6,050,000
Purchase of Water	2,540,000(1)	2,640,000(2)
Total Annual Cost	$27,820,000	$38,710,000

(1) Includes 32,600 acft/yr of stored water purchased from GBRA and 15,280 acft/yr of year 2020 underutilized water rights at an annual cost of $53/acft.
(1) Includes 34,490 acft/yr of stored water purchased from GBRA and 15,330 acft/yr of year 2020 underutilized water rights at an annual cost of $53/acft

cost was estimated to be $369 per acft per year at a uniform delivery rate and $514 per acft per year for a summer peaking delivery pattern.

Table 3.6-14 Summary of Costs by Delivery Location Potential Supply Diverted at Lake Dunlap and Gonzales to Regional WTP 75,000 acft/yr, Uniform Annual Delivery (G-39C) (First Quarter - 1996 dollars)								
	Year 2000				Year 2020			
Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Annual Volume[1] (acft/yr)	Annual Cost	Unit Cost[2]		Annual Volume[1] (acft/yr)	Annual Cost	Unit Cost[2]	
			$/acft/yr	$/1000 gal			$/acft/yr	$/1000 gal
Springs Hill [4] (0.11 mgd)	0	$35,000	[3]	[3]	123	$42,000	$338	$1.04
Crystal Clear [4] (0.43 mgd)	0	$136,000	[3]	[3]	476	$161,000	$338	$1.04
Marion (0.08 mgd, 4")	56	$52,000	$929	$2.85	87	$60,000	$691	$2.12
Green Valley (1.98 mgd, 4")	362	$255,000	$704	$2.16	1,624	$549,000	$338	$1.04
Cibolo (0.18 mgd, 4")	160	$62,000	$388	$1.19	160	$62,000	$387	$1.19
Garden Ridge (0.51 mgd, 6")	315	$166,000	$528	$1.62	570	$211,000	$371	$1.14
Schertz (2.33 mgd, 12")	1,268	$720,000	$568	$1.74	2,612	$960,000	$367	$1.13
SAWS-Stahl Pump Station (67 mgd, 66")	72,839	$26,394,000	$362[5]	$1.11[5]	69,348	$25,775,000	$372[5]	$1.14[5]
Total	75,000	$27,820,000	$371	$1.14	75,000	$27,820,000	$371	$1.14

[1] Annual volume not adjusted for treatment, transmission, and other losses.
[2] Cost of treated water delivered on a wholesale basis and does not include operating costs of the distribution system
[3] Annual costs for debt service will accrue, even though no water deliveries are projected.
[4] Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.
[5] Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to bring the water, may occur before year 2020.
Note: The unit cost to deliver all 75,000 acft/yr to SAWS would be about $369 per acft/yr ($1.13/1,000 gallons).

Table 3.6-15
Summary of Costs by Delivery Location
Potential Supply Diverted at Lake Dunlap and Gonzales to Regional WTP
75,000 acft/yr, Summer Peaking Delivery (G-39D)
(First Quarter - 1996 dollars)

Delivery Location (Max. Delivery Rate, mgd; connection pipe size, in)	Year 2000 Annual Volume[1] (acft/yr)	Year 2000 Annual Cost	Year 2000 Unit Cost[2] $/acft/yr	Year 2000 Unit Cost[2] $/1000 gal	Year 2020 Annual Volume[1] (acft/yr)	Year 2020 Annual Cost	Year 2020 Unit Cost[2] $/acft/yr	Year 2020 Unit Cost[2] $/1000 gal
Springs Hill[4] (0.22 mgd)	0	$51,000	[3]	[3]	123	$58,000	$471	$1.44
Crystal Clear[4] (0.86 mgd)	0	$199,000	[3]	[3]	476	$224,000	$471	$1.44
Marion (0.16 mgd, 4")	56	$63,000	$1,120	$3.44	87	$72,000	$828	$2.54
Green Valley (3.06 mgd, 14")	362	$396,000	$1,095	$3.36	1,624	$765,000	$471	$1.44
Cibolo (0.34 mgd, 6")	160	$84,000	$523	$1.60	160	$84,000	$525	$1.61
Garden Ridge (1.02 mgd, 8")	315	$238,000	$755	$2.32	570	$294,000	$516	$1.58
Schertz (4.66 mgd, 18")	1,268	$1,044,000	$823	$2.53	2,612	$1,338,000	$512	$1.57
SAWS Stahl Pump Station (134 mgd, 72")	72,839	$36,635,000	$503[5]	$1.54[5]	69,348	$35,875,000	$517[5]	$1.59[5]
Total	75,000	$38,710,000	$516	$1.58	75,000	$38,710,000	$516	$1.58

[1] Annual volume not adjusted for treatment, transmission, and other losses.
[2] Cost of treated water delivered on a wholesale basis and does not include operating costs of the distribution system
[3] Annual costs for debt service will accrue, even though no water deliveries are projected.
[4] Springs Hill and Crystal Clear WSCs will not be connected to the regional WTP, but will receive their water allocation by trading an equivalent amount of water delivery with Green Valley SUD. Springs Hill WSC will receive 123 acft/yr and Crystal Clear WSC will receive 476 acft/yr more water from the CRWA WTP than currently allocated. Green Valley SUD will receive 599 acft/yr less water from the CRWA WTP than currently allocated.
[5] Cost to bring replacement water into the Guadalupe River Basin is not included. The need for replacement water and the cost to bring the water, may occur before year 2020.

3.6.6 Implementation Issues

Implementation steps include:

- Commitment of project participants
- Phasing of project elements
- Negotiate water purchase contracts with GBRA and existing water rights owners
- Financing
- Engineering
- Permitting
- Construction
- Operation and Maintenance

Requirements Specific to Amending the Canyon Lake Permit

1. Alternatives G-39C and G-39D will likely require exceeding the current annual permitted quantity from Canyon Lake of 50,000 acft, and a permit amendment will be necessary. This amendment will require:
    a. Application to the TNRCC.
    b. Hydrologic studies substantiating requested firm yield.
    c. Possible environmental studies of in-stream flow and bay/estuary effects.
    d. Subordination of hydropower rights.
    e. Management of Edwards Aquifer by a regional agency to achieve the modeled aquifer pumpage/springflow scenario.

Gonzales Intake

It will be necessary to obtain these permits:
    a. TNRCC Water Right permit.
    b. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the intake.
    c. GLO Easement for use of state-owned land.
    d. Coastal Coordinating Council review.
2. Permitting, at a minimum, will require these studies:
    a. Environmental studies.
    b. Cultural resource studies.
3. Land will need to acquired through either negotiations or condemnation.

Requirements Specific to Diversion of Water from Guadalupe River

To obtain more realistic values of surface water availability, additional in-depth studies of environmental water needs should be performed for affected reaches of the Guadalupe and San Antonio Rivers. These studies are consistent with the Environmental Water Needs Criteria of the Consensus Planning Process which allows the substitution of alternative flow minimums based on stream-specific studies considering indigenous species, habitat, recreational utilization, water quality, and assimilative capacity of individual stream segments.

1. Necessary permits:
   a. Existing water rights permits will need to be amended subsequent to negotiations with each water right owner to allow for an additional point of diversion at Gonzales.
   b. TNRCC permit to divert water.
   c. TNRCC Interbasin Transfer Approval.
2. Permitting will require these studies:
   a. Instream flow issues and impact.
   b. Environmental studies.
   c. Bay and estuary inflow impact.
3. Agreements with water right permit owners including GBRA for use and payment for water diverted under existing permits and for water released from Canyon Lake.

Requirements Specific to Pipelines

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. GLO Sand and Gravel Removal permits.
   c. TPWD Sand, Gravel and Marl Removal permits.
   d. Coastal Coordinating Council review may be required.
2. Right-of-way and easement acquisition.
3. Crossings.
   a. Highways and railroads.
   b. Creeks and rivers.
   c. Other utilities.

Requirements Specific to Treatment and Distribution

Detailed study needed of the cost of pumping and transmission pipeline improvements necessary to effectively integrate the new supply into SAWS water distribution system.

Off-Channel Reservoir

1. It will be necessary to obtain these permits for the off-channel storage reservoir.
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer Approval.
   c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. GLO Sand and Gravel Removal permits.

e. GLO Easement for use of state-owned land.
f. Coastal Coordinating Council review.
g. TPWD Sand, Gravel, and Marl permit.

2. Permitting, at a minimum, will require these studies:
   a. Bay and estuary inflow impact.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired either through negotiations or condemnation.
4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Other utilities.

APPENDIX A

POPULATION AND WATER DEMAND PROJECTIONS

APPENDIX A
LIST OF TABLES

Appendix A: Table 1		
Municipal Water Use - 1990*		
Bexar, Comal, and Guadalupe Counties		
San Antonio River Basin		
Trans-Texas Water Program		
County/Water Utility		Total Use 1990 ac-ft
BEXAR COUNTY		
San Antonio	*	166,616
Balcones Heights	*	538
Terrell Hills	*	817
Olmos Park	*	385
Helotes	*	310
Leon Valley	*	1,715
Alamo Heights	*	2,210
Converse	*	1,213
FairOaks Ranch (Bexar Co.)	*	617
Kirby	*	1,080
Live Oak Water Public Utility Dept.	*	1,221
Schertz (Part)	*	60
Schertz (Outside City)	*	607
Shavano Park-City of	*	840
St. Hedwig	*	187
Universal City	*	2,323
Windcrest (WC&ID No. 10)	*	1,329
Castle Hills(BMWD)	*	1,311
Somerset(BMWD)	*	215
Hill Country(BMWD)	*	460
BMWD (Southside)		13,586
BMWD (Northwest)		3,229
BMWD (Northeast)		3,372
BMWD (Texas Research Park)		9
BMWD (Cagnon Road)		0
BMWD (Chaparral)		60
BMWD (Hickory)		9
BMWD (Kings Point).		52
BMWD (Palo Alto Park)		11
BMWD (Pleasant Oaks)		50
BMWD (Silver Mountain)		14
BMWD (South Oaks)		8
BMWD (Twin Valley)		40
BMWD (Waterwood)		34
BMWD (Windy's)		265
St. Anthony High School		82

* As reported to Texas Water Development Board by each respective water utility listed. Includes only quantities supplied by the utility to its customers and does not include individual household wells in some subdivisions that are not fully served by a public water system. Since water use surveys have not been made of individual households that are not supplied by public water systems, estimates of water use are made for the population not served by a public supplier and are included at the end of the list for each county listed as "other".

BEXAR COUNTY	(cont')		
East Central WSC			1,016
San Antonio Ranch MUD			53
Palm Park Water Company			87
Brooks AFB			623
St. Marys Univ.			177
Austin Highway WSC			55
Baptist Children's Home			6
Cadillac WSC			57
Lakeside Water Co			32
Lakeview Gardens No. 2			6
Lazy Acres MHP			5
Military--Ft. Sam Houston			4,340
Military--Kelly AFB			3,566
Military --Lackland AFB			3,300
North Breeze MHP			3
Oak Hills MHP			6
San Fernando Water Co.			418
Shady Acres MHP			17
Trailer City Water Co.			15
Valley Ridge Estates MHP			40
VFW Post 4700 Trailer Park			3
AAA Lookout Trailer Park			3
Air Force Village II			140
Atascosa Rural WSC			602
Aum Sat Tat Ranch			22
Bavarian Hills Subdvision			24
Brookdale MHP			12
Coolcrest Water Co.(Haskin)			80
Cordi Marin Villa			3
Country Oaks MHP			24
Country Springs Water Co.			100
Elm Valley Water Co.			45
Elmendorf-City of			108
Enchanted Oaks Water Supply			12
Estates Utility Co.			41
Evetts Apartments			4
G&G MHP			2
Geronimo Forest Subdvision			63
Green Valley SUD			125
Helotes School			1
Hillbrook Apartments			7
Hollywood Park(HCWW)			1,714
Latin American Bible Institute			2
Leon Springs Villa Water Co.			65
Little Joe's Ice House & Trailer Park			3
Meadow Acres WSC			58
Military-Camp Bullis			83
Military- Camp Stanley			47

BEXAR COUNTY (cont')		
Military-Randolph AFB		1,494
Mobile City Estates		22
Moore's MHP		3
Nico-Tyme Water Co-op		3
North San Antonio Hills		55
Oak Hills Acres MH Subdvision		6
Oaks North MH Estates (Haskin)		74
Pioneer Estates(Rio Medina Water Corp.)		33
S&S Hills WSC (Scenic Hills & SS Serene		8
Scenic Oaks Water Syatem		145
Selma-City of		125
Stage Coach Hills WaterSystem (Haskin)		60
Timberwood Park Subdivision (Haskin)		175
Vail's MHP		1
Voss Water Co.		40
Western Trails WSC		18
Others		945
BEXAR COUNTY TOTAL		225,295
COMAL COUNTY		
FairOaks Ranch	*	19
Schertz (Part)	*	19
Green Valley SUD		46
North Point Homeowners Assn.		1
Oak Valley Water		8
Siesta Village Subdivision		5
The Oaks (Canyon Lake WSC)		36
Woodlands Golf&CountryClub(CL)		37
Other		1,586
COMAL COUNTY TOTAL		1,756
GUADALUPE COUNTY		
Green Valley SUD		712
East Central WSC		112
Cibolo		198
Marion		151
Garden Oaks Subdivision		24
Oak Hills Ranch Estates		7
Schertz (Part)		1437
Other		15
GUADALUPE COUNTY TOTAL		2,656
BEXAR/COMAL/GUADALUPE TOTAL		229,707

Appendix A: Table 2
Industrial Water Use -- 1990 and Industrial Water Demand Projections
Bexar, Comal, and Guadalupe Counties
San Antonio River Basin
Trans-Texas Water Program*

Number of Wells**	Use in 1990 ac-ft	Source of Supply (acre-feet) SAWS ac-ft	Own Wells	SAWS & OwnWells	Other Source	Source	
PG	5.34	5.34					SAN ANTONIO
PG	651.35	651.35					SAN ANTONIO
PG	63.83	63.83					SAN ANTONIO/WELLS ALSO
PG 3	137.76			137.76			USED GW FROM SAN ANTONIO ALSO
PG	1.66	1.66					SAN ANTONIO
PG	2.07	2.07					SAN ANTONIO
PG	4.79	4.79					SAN ANTONIO
SG 1	68.94		68.94				
PG	50.64	50.64					SAN ANTONIO
SG	19.82		19.82				
PG	1.92	1.92					SAN ANTONIO/OWN WELL ALSO
SG 1	80.38		80.38				USED GW FROM SAN ANTONIO ALSO
PG	11.43				11.43		BEXAR MET/OWN WELL
SG 4	158.25		158.25				GW FROM BEXAR MET ALSO
SG 1	0.49			0.49			PLANT IDLE 98 % OF TIME
PG	84.14	84.14					SAN ANTONIO
PG	2.23	2.23					SAN ANTONIO
PG	6.84				6.84		CONVERSE
SG	2.06		2.06				
SS	124.25				124.25		OWN RESERVOIR/OWN WELLS ALSO
PG	3.37	3.37					SAN ANTONIO
SG 3	336.74		336.74				
PG	1.84				1.84		BEXAR METRO/OWN WELLS ALSO
SG 1	231.65				231.65		BEXAR MET
PG	59.59	59.59					SAN ANTONIO
PG	53.71	53.71					SAN ANTONIO
PG	326.83	326.83					SAN ANTONIO
PG	40.66	40.66					SAN ANTONIO
PG	28.13	28.13					SAN ANTONIO
PG	33.76	33.76					SAN ANTONIO
PG	11.65	11.65					SAN ANTONIO
PG	25.44	25.44					SAN ANTONIO
PG	195.65	195.65					SAN ANTONIO
PG	36.62	36.62					SAN ANTONIO
PG	49.64	49.64					SAN ANTONIO
PG	108.31	108.31					SAN ANTONIO
SG 1	1.10		1.10				
PG	3.22	3.22					SAN ANTONIO
PG	8.11	8.11					SAN ANTONIO

Table 2 (cont')							
Number of Wells**	Use in 1990 ac-ft	Source of Supply (acre-feet) SAWS ac-ft	Own Wells	SAWS & OwnWells	Other Source	Source	
PG	32.33	32.33					SAN ANTONIO
PG	250.06	250.06					SAN ANTONIO
PG	18.28	18.28					
PG	12.77	12.77					SAN ANTONIO
PG	739.15	739.15					
PG	1.78	1.78					SAN ANTONIO
PG	20.80	20.80					SAN ANTONIO
PG	88.87	88.87					SAN ANTONIO
PG	102.50	102.50					SAN ANTONIO
PG	19.71	19.71					SAN ANTONIO
PG	1.63	1.63					SAN ANTONIO
PG	22.71	22.71					SAN ANTONIO
SG 1	9.57		9.57				
PG	2.28	2.28					SAN ANTONIO
PG	88.99	88.99					SAN ANTONIO
PG	21.64				21.64		BEXAR MET
SG 1	248.63		248.63				
PG	17.82	17.82					SAN ANTONIO
PG	757.96	757.96					SAN ANTONIO
PG	16.68	16.68					SAN ANTONIO
PG	124.29	124.29					SAN ANTONIO/OWN GW ALSO
SG 3	549.94			549.94			GW FROM SAN ANTONIO ALSO
SG 24	5,289.78		5,289.78				FROM EDWARDS DISTRICT REPORTS
PG	4.99	4.99					SAN ANTONIO
PG	33.13	33.13					SAN ANTONIO
PG	61.54	61.54					SAN ANTONIO
PG	2.28			2.28			SAN ANTONIO/OWN WELLS ALSO
SG 1	0.26			0.26			SAN ANTONIO ALSO
PG	25.32	25.32					SAN ANTONIO
PG	253.11	253.11					SAN ANTONIO
PG	0.01	0.01					SAN ANTONIO/OWN WELLS ALSO
SG 2	372.65			372.65			GW FROM SAN ANTONIO ALSO
PG	2.26			2.26			SAN ANTONIO/OWN WELL ALSO
SG 3	66.20			66.20			GW FROM SAN ANTONIO ALSO
PG	260.59	260.59					SAN ANTONIO
PG	41.58	41.58					SAN ANTONIO
PG	4.30	4.30					SAN ANTONIO
PG	5.74				5.74		EAST CENTRAL WSC
SG 1	12.37		12.37				
SG	67.08		67.08				
PG	0.75	0.75					SAN ANTONIO
PG	23.00	23.00					SAN ANTONIO
SG 1	68.68		68.68				

Table 2 (cont')								
Number of Wells**	Use in 1990 ac-ft	Source of Supply (acre-feet) SAWS ac-ft	Own Wells	SAWS & OwnWells	Other Source	Source		
PG	10.37	10.37					SAN ANTONIO	
PG	0.34				0.34		SCHERTZ	
SG	62.28		62.28					
PG	51.40	51.40					SAN ANTONIO	
PG	4.06	4.06					SAN ANTONIO	
PG	0.38	0.38					SAN ANTONIO	
SG 1	21.03		21.03					
PG	70.85	70.85					SAN ANTONIO	
PG	35.50	35.50					SAN ANTONIO	
PG	0.79	0.79					SAN ANTONIO	
	1,013.78	1,013.78					ALL OTHERS	
Total	18,029.00	6,066.72	6,446.71	1,131.84	403.73			

* There was no reported industrial water use in Comal or Guadalupe County areas of the San Antonio River Basin in 1990, and no projections are made for industrial water demands in these areas.

** PG = Purchased Groundwater
SG = Self Supplied Groundwater
SS = Self Supplied Surface Water.

Projected Demands (2000 to 2050)

2000	2010	2020	2030	2040	2050
16,805	19,682	22,359	24,935	28,264	31,697

Source: Texas Water Development Board, 1996 Concensus Water Plan Projections.

Appendix A: Table 3

Steam-Electric Power Water Demand Projections

Bexar, Comal, and Guadalupe Counties

San Antonio River Basin

Trans-Texas Water Program*

Number of Wells**	Use in 1980 ac-ft	SAWS ac-ft	Source of Supply (acre-feet) Own Wells	SAWS & OwnWells	Other Source	Source	
SG 5	348.87		348.87				CITY PUBLIC SERVICE BOARD
PG	242.10				242.10		SAN ANTONIO/OWN SW ALSO
SS	6,858.30				6,858.30		SAN ANTONIO RIVER/GW ALSO
PG	470.10				470.10		SAN ANTONIO/OWN SW ALSO
SS	21,180.50				21,180.50		CALAVERAS LAKE/GW ALSO
	31,089.87		348.87				

* There is no projected demand for steam-electric power water in Comal and Guadalupe Counties in the San Antonio River Basin area.

** PG = Purchased Groundwater
SG = Self Supplied Groundwater
SS = Self Supplied Surface Water.

Projected Demands (2000 to 2050)***

2000	2010	2020	2030	2040	2050
36,000	36,000	40,000	45,000	50,000	56,000

Source: Texas Water Development Board 1996 Concensus Water Plan Projections.

*** Totals are not included in Bexar County totals of Table 2.1-8, since most of this is reclaimed wastewater.

Appendix A: Table 4A

Nursery & Stockyard Water Demand Projections
Bexar, Comal, and Guadalupe Counties
San Antonio River Basin
Trans-Texas Water Program*

Number of Wells**	Use in 1990 ac-ft	SAWS ac-ft	Source of Supply (acre-feet) Own Wells	SAWS & OwnWells	Other Source	Source		
SG 2	2,706.79		2,706.79				Nursery	
SG 3	224.03		224.03				Stockyards	
	2,930.82		2,930.82					

* There is no projected demand for nursery and stockyard water in Comal and Guadalupe Counties in the San Antonio River Basin area.

** PG = Purchased Groundwater
SG = Self Supplied Groundwater
SS = Self Supplied Surface Water.

Projected Demands (2000 to 2050) Included in Table 4B,below.

2000	2010	2020	2030	2040	2050
3,000	3,000	3,000	3,000	3,000	3,000

Appendix A: Table 4B

Irrigation Water Demand Projections
Bexar, Comal, and Guadalupe Counties
San Antonio River Basin
Trans-Texas Water Program*

County	Use in 1990 ac-ft	Projections 2000 ac-ft	2010 ac-ft	2020 ac-ft	2030 ac-ft	2040 ac-ft	2050 ac-ft
Bexar	33,638	35,080	32,313	30,946	29,638	28,385	27,184
Comal	70	66	63	61	58	56	53
Guadalupe	343	324	306	289	273	258	244
	34,051	35,470	32,682	31,296	29,969	28,699	27,481

Source: Texas Water Development Board 1996 Concensus Water Plan Projections.

Appendix A: Table 5							
Mining Water Demand Projections							
Bexar, Comal, and Guadalupe Counties							
San Antonio River Basin							
Trans-Texas Water Program*							
Number	Use in		Source of Supply (acre-feet)				
of	1990	SAWS	Own	SAWS &	Other		
Wells**	ac-ft	ac-ft	Wells	OwnWells	Source	Source	
SG 1	0.31		0.31				SW ALSO
SS	260.45				260.45		RECIRCULATED FROM MEDINA RIVER/GW
SG 2	215.24		215.24				SW FROM PRIVATE RESERVOIR ALSO
SG 4	1,048.73		1,048.73				
SG 6	198.22		198.22				
	1,722.95		1,462.50				

* There is no projected demand for mining water in Comal County in the San Antonio River Basin area.

** PG = Purchased Groundwater
SG = Self Supplied Groundwater
SS = Self Supplied Surface Water.

Projected Demands (2000 to 2050)						
2000	2010	2020	2030	2040	2050	
4,781	4,758	5,018	5,217	5,451	5,763	Bexar
8	10	10	10	10	10	Guadalupe
4,791	4,768	5,028	5,227	5,461	5,773	Total

Source: Texas Water Development Board 1996 Concensus Water Plan Projections.

Appendix A: Table 6 Livestock Water Demand Projections Bexar, Comal, and Guadalupe Counties San Antonio River Basin Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
Bexar	1,353	1,461	1,461	1,461	1,461	1,461	1,461
Comal	45	50	50	50	50	50	50
Guadalupe	258	284	284	284	284	284	284
Total	1,656	1,795	1,795	1,795	1,795	1,795	1,795
Source: Texas Water Development Board 1996 Concensus Water Plan Projections.							

Appendix A: Table 7 Total Water Demand and Supply Projections Bexar, Comal, and Guadalupe Counties San Antonio River Basin Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
Bexar*							
Demand	276,050	363,160	395,613	439,348	499,240	555,209	595,946
Supply							
Edwards Aquifer**	258,588	222,386	193,941	193,941	193,941	193,941	193,941
Other Aquifers	7,725	19,125	19,125	19,125	19,125	19,125	19,125
Surface Sources[1]	9,737	10,037	10,037	10,037	10,037	10,037	10,037
Total Supply	276,050	251,548	223,103	223,103	223,103	223,103	223,103
Shortage	0	111,612	172,510	216,245	276,137	332,106	372,843
Comal							
Demand	1,871	2,221	2,726	3,520	4,495	5,556	6,689
Supply							
Edwards Aquifer**	337	290	253	253	253	253	253
Other Aquifers[2]	1,534	270	270	270	270	270	270
Surface Sources[3]	0	18	18	18	18	18	18
Total Supply	1,871	578	541	541	541	541	541
Shortage	0	1,643	2,185	2,979	3,954	5,015	6,148
Guadalupe							
Demand	3,265	5,413	6,392	7,410	9,237	11,109	13,513
Supply							
Edwards Aquifer**	3,048	2,621	2,286	2,286	2,286	2,286	2,286
Other Aquifers[4]	46	2,516	2,516	2,516	2,516	2,516	2,516
Surface Sources[5]	171	1,176	1,176	1,176	1,176	1,176	1,176
Total Supply	3,265	6,313	5,978	5,978	5,978	5,978	5,978
Shortage	0	-900	414	1,432	3,259	5,131	7,535
Total							
Demand	281,186	370,794	404,731	450,278	512,972	571,874	616,148
Supply							
Edwards Aquifer**	261,973	225,297	196,480	196,480	196,480	196,480	196,480
Other Aquifers	9,305	21,911	21,911	21,911	21,911	21,911	21,911
Surface Sources	9,908	11,231	11,231	11,231	11,231	11,231	11,231
Total Supply	281,186	258,439	229,622	229,622	229,622	229,622	229,622
Shortage	0	112,355	175,109	220,656	283,350	342,252	386,526

Source: Texas Water Development Board 1996 Concensus Water Plan Projections.

* Steam-Electric Power generation water demands of Appendix A:Table 3 are not included, since most of this demand is met with reclaimed wastewater.

** Projections are based upon provisions of SB 1477, 1993 Texas Legislature, as ammended.

[1] Includes 9,737acft of local surface water and 300 acft of Guadalupe River Water (East Central WSC).

[2] Projected supplies include 15% of county's annually available groundwater, as reported by TWDB.

[3] Includes 18 acft of Guadalupe River Water (Green Valley WSC).

[4] Includes 46 acft of local groundwater and 210 acft of Carrizo Aquifer Water (Springs Hill WSC @ 30% of present Carrizo Aquifer Supply for 1990. Projected @ 20% of County's annually available Groundwater, as reported by TWDB.

[5] Includes Guadalupe River Water through Green Valley and Springs Hill WSCs @ 40% of 2,940acft of present supply available.

Appendix A: Table 8	
Municipal Water Use - 1990*	
Comal and Guadalupe Counties	
Guadalupe River Basin	
Trans-Texas Water Program	
Water Supply Entity	**Total Use in 1990 ac-ft**
Comal County	
At Canyon Lake	
Canyon Lake Water Supply Corporation	
Lakeview Park	36
Rolling Hills	62
Astro Hills/CL Hills 1,2,3	66
Canyon Lake Hills 4,5,6	45
Waterfront Park	22
Canyon Lake Forest	73
Subtotal	304
Triple Peak	9
Canyon Lake Village & Village West	250
Summit	50
Riverside	12
Horseshoe Falls	46
Crystal Heights	2
Subtotal	369
North Lake Estates	3
Cougar Ridge	3
The Point	5
DBH/Hillcrest	7
Canyon Lake Acres	16
Scenic Terrace	4
Hancock Canyon	6
Tanglewood & Tamarack Shores	56
Canyon Lake Island	1
Canyon Lake Shores	22
Subtotal	123
Deer River	18
Lake of the Hills	17
Riverwood (Guadalupe River Estates)	21
Subtotal	56
Total	852

* As reported to Texas Water Development Board by each respective water utility listed. Includes only quantities supplied by the utility to its customers and does not include individual household wells in some subdivisions that are not fully served by a public water system. Since water use surveys have not been made of individual households that are not supplied by public water systems, estimates of water use are made for the population not served by a public supplier and are included at the end of the list for each county listed as "other".

Table 8 (cont')	
Water Supply Entity	Total Use in 1990 ac-ft
Remainder of County	0
Scenic River&Little Ponderosa(CLWSC)	43
Arrowhead Village	1
Balcones Supply Inc.	32
Canyon Lake Estates WSC	2
Canyon Springs Water Co.	58
Canyon Lake Villas	1
Indian Hills Water Co.	9
Clear Water Estates	31
Comal Co. FWSD No. 1	69
Comal Ind. School Dist.(Bulv. Primary)	2
Comal Ind. School Dist.(Bulv. Elem.)	2
Comal Hills WSC	3
Comal ISD (Mountain Valley School)	3
Country Hills Water System	21
Cypress Cove Maintenance Assn.	47
Cypress Lake Gardens Property	13
Deep River	25
Devils Backbone Heights	26
3-G W.C. Inc.	15
Wingert Water Supply	12
Garden Ridge	397
Gruene River Development	2
Hancock Oak Hills Subdivision	4
Spring Branch Indian Hills	46
HART-N-HART MHP	1
Haskin Water Supply, Inc.	109
Hill Country Resort	20
Hunter Oaks Water Supply	6
W&W Water Co.	4
Lakeside Utilities	22
New Braunfels Utilities	6,199
Northwoods Water System	25
Mountain Oaks Subdivision	0
Rancho Del Lago	13
Rockford Place MHP	9
Log Cabin Creek Water System	1
R&W Water Co.	12
Scenic Terrace Water System	1
Comal Ind. School Dist.(Middle School)	7
Comal Ind. School Dist.(High School)	17
Stallion Springs	9
Canyon Lake MH Estates	59
TAMIGA Acres MHP	4
T Bar M Tennis Villas	4

Table 8 (cont')	
Water Supply Entity	Total Use in 1990 ac-ft
Remainder of County	0
TPWL Dept.(Guadalupe River State Park)	17
US Army (Canyon Lake Recreation Area)	15
US Air Force(Canyon Lake Rec. Area)	3
USCOE (Canyon Lake Rec. Areas)	7
Westhaven Assoc.,Inc.	47
Whitewate Sports, Inc.	3
Other	329
Subtotal	7,807
Total	8,659
Guadalupe County	
Breeze Addition Water Works, Inc.	4
Green Valley SUD	1,036
GUADCO M.U.D. No 1	26
Lago Vista Water System	5
Lake McQueeny Estates	65
Lakeside Mobile Living	4
New Braunfels	55
City of Seguin	3,604
Springs Hill WSC	1,036
USAF(Seguin Auxillary Airfield)	1
Other	1,135
Total	6,971

Appendix A: Table 9				
Industrial Water Use--1990				
Comal and Guadalupe Counties				
Guadalupe River Basin				
Trans-Texas Water Program				
Number of Wells	**Total Use 1990 ac-ft**	**Source of Supply**		
		Own Wells ac-ft	**Other ac-ft**	**Source**
Comal				
SG 1	19.64	19.64		
PG	14.53		14.53	New Braunfels
PG	16.08		16.08	New Braunfels
PG	3.30		3.30	New Braunfels
PG	6.36		6.36	Marion
SG 1	217.29		217.29	Marion
SG 15	941.95	941.95		
PG	2.57		2.57	New Braunfels
SG 1	154.75	154.75		
PG	3.46		3.46	Green Valley
SG 3	626.88	626.88		
PG	95.69		95.69	New Braunfels
SS	2,010.78		2,010.78	Guadalupe River
PG	76.43		76.43	New Braunfels
Total	4,189.71	1,743.22	2,446.49	
Surface	2,010.78			
Ground	2,178.93			
Guadalupe				
SS	7.37		7.37	Guadalupe River
PS	46.01		46.01	Seguin
PS	526.88		526.88	Seguin
SG 2	92.07	92.07		
PS	34.11		34.11	Seguin
PG	379.00		379.00	GBRA &Springs Hill
PG	94.00		94.00	GBRA & Springs Hill
TE	13.20		13.20	Treated Effluent
PS	13.13		13.13	Seguin
PG	1.08		1.08	Crystal Clear
PG	0.48		0.48	Crystal Clear
PS	89.63		89.63	GBRA
Total	1,296.96	92.07	1,204.89	
Surface	717.13			
Ground	566.63			
SS = Self Supplied Surface Water			PG = Purchased Groundwater	
PS = Purchased Surface Water			TE = Treated Effluent	
SG =Self Supplied Groundwater				

Appendix A: Table 10							
Municipal Water Demand Projections							
Guadalupe-Blanco River Authority Counties							
Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
Caldwell	4,931	5,802	6,106	6,388	6,787	6,709	6,648
Calhoun	3,916	4,411	4,456	4,554	4,895	5,273	5,746
Comal	10,415	18,587	22,780	28,687	36,569	43,590	51,227
DeWitt	3,556	3,614	3,470	3,400	3,535	3,688	3,841
Gonzales	3,832	3,879	3,729	3,613	3,589	3,628	3,684
Guadalupe	9,627	15,357	17,802	20,696	25,780	29,447	34,088
Hays	11,644	16,652	19,661	22,428	27,207	32,695	37,279
Kendall	2,130	2,571	2,697	2,836	3,136	3,476	3,855
Refugio	1,227	1,328	1,275	1,220	1,198	1,177	1,150
Victoria	11,545	13,013	13,146	13,382	14,178	15,056	16,116
Total	62,823	85,214	95,122	107,204	126,874	144,739	163,634
Texas Water Development Board 1996 Concensus Water Plan Projections.							

Appendix A: Table 11							
Industrial Water Demand Projections							
Guadalupe-Blanco River Authority Counties							
Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
Caldwell	0	0	0	0	0	0	0
Calhoun	24,539	63,026	77,588	85,949	95,240	105,236	115,958
Comal	3,248	3,450	3,487	3,548	3,799	4,071	4,351
DeWitt	91	108	126	146	170	195	223
Gonzales	865	929	992	1,043	1,083	1,160	1,231
Guadalupe	1,661	1,883	2,102	2,248	2,385	2,590	2,797
Hays	293	381	445	507	564	620	677
Kendall	2	2	3	4	4	5	6
Refugio	0	0	0	0	0	0	0
Victoria	20,032	24,115	28,446	31,157	33,670	37,900	42,201
Total	50,731	93,894	113,189	124,602	136,915	151,777	167,444
Texas Water Development Board 1996 Concensus Water Plan Projections							

Appendix A: Table 12								
Steam-Electric Power Generation Water Demand Projections								
Guadalupe-Blanco River Authority Counties								
Trans-Texas Water Program								
		Use in	**Projections**					
County		**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
		ac-ft	**ac-ft**	**ac-ft**	**ac-ft**	**ac-ft**	**ac-ft**	**ac-ft**
Caldwell		0	0	0	0	0	0	0
Calhoun		62	100	100	100	100	100	100
Comal		0	0	0	0	0	0	0
Dewitt		0	0	0	0	0	0	0
Gonzales		0	0	0	0	0	0	0
Guadalupe		0	0	0	0	0	0	0
Hays		0	0	0	0	0	0	0
Kendall		0	0	0	0	0	0	0
Refugio		0	0	0	0	0	0	0
Victoria		887	8,000	10,000	10,000	10,000	10,000	10,000
Total		949	8,100	10,100	10,100	10,100	10,100	10,100
Texas Water Development Board 1996 Concensus Water Plan Projections.								

Appendix A: Table 13 Irrigation Water Demand Projections Guadalupe-Blanco River Authority Counties Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
Caldwell	1,375	1,215	1,073	948	837	739	653
Calhoun	35,421	19,777	14,683	11,187	8,341	6,415	5,035
Comal	479	459	440	421	404	387	370
DeWitt	285	256	229	206	185	166	148
Gonzales	3,540	3,019	2,574	2,195	1,871	1,596	1,361
Guadalupe	2,646	2,501	2,364	2,234	2,111	1,996	1,886
Hays	320	316	312	308	305	301	297
Kendall	380	364	348	333	319	305	292
Refugio	0	0	0	0	0	0	0
Victoria	13,699	13,478	10,610	8,351	6,573	5,175	4,074
Total	58,145	41,385	32,633	26,183	20,946	17,080	14,116

Texas Water Development Board 1996 Concensus Water Plan Projections.

Appendix A: Table 14							
Mining Water Demand Projections							
Guadalupe-Blanco River Authority Counties							
Trans-Texas Water Program							
	Use in	**Projections**					
County	**1990**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
	ac-ft	**ac-ft**	**ac-ft**	**ac-ft**	**ac-ft**	**ac-ft**	**ac-ft**
Caldwell	27	21	16	10	4	0	0
Calhoun	1	28	21	12	6	3	3
Comal	946	5,570	5,464	5,628	5,796	3,590	2,224
Dewitt	129	161	106	70	50	44	44
Gonzales	21	41	37	33	29	29	30
Guadalupe	8	196	198	200	202	207	213
Hays	0	96	90	72	56	37	28
Kendall	0	13	9	5	1	0	0
Refugio	77	44	26	19	11	4	4
Victoria	2,409	2,578	2,028	1,732	1,714	1,720	1,862
Total	3,618	8,748	7,995	7,781	7,869	5,634	4,408
Texas Water Development Board 1996 Concensus Water Plan Projections.							

Appendix A: Table 15 Livestock Water Demand Projections Guadalupe-Blanco River Authority Counties Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
Caldwell	816	835	835	835	835	835	835
Calhoun	291	304	304	304	304	304	304
Comal	316	356	356	356	356	356	356
Dewitt	1,840	1,896	1,896	1,896	1,896	1,896	1,896
Gonzales	4,108	5,064	5,064	5,064	5,064	5,064	5,064
Guadalupe	1,031	1,132	1,132	1,132	1,132	1,132	1,132
Hays	676	484	484	484	484	484	484
Kendall	389	512	512	512	512	512	512
Refugio	563	407	407	407	407	407	407
Victoria	1,274	1,398	1,398	1,398	1,398	1,398	1,398
Total	.11,304	12,388	12,388	12,388	12,388	12,388	12,388
Texas Water Development Board 1996 Concensus Water Plan Projections.							

Appendix A: Table 16							
Municipal Water Demand Projections							
Guadalupe River Basin							
Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
HIGH							
Kerr	5,712	7,656	7,772	7,829	8,219	8,306	8,383
Gillespie	9	10	10	10	11	12	13
Bandera	16	21	22	24	27	29	33
Blanco	427	547	557	571	604	612	590
Subtotal	6,164	8,234	8,361	8,434	8,861	8,959	9,019
UPPER							
Kendall	746	761	752	765	816	891	973
Comal	8,659	16,482	20,167	25,278	32,182	38,140	44,641
Hays	9,740	13,754	16,012	18,171	21,896	26,248	30,175
Guadalupe	6,971	10,562	12,010	13,869	17,110	18,890	21,113
Caldwell	4,715	5,681	5,973	6,243	6,630	6,552	6,490
Bastrop	31	70	93	119	153	176	169
Travis	66	123	128	139	158	168	180
Subtotal	30,928	47,433	55,135	64,584	78,945	91,065	103,741
MIDDLE							
Gonzales	3,824	3,865	3,716	3,600	3,576	3,615	3,671
DeWitt	2,883	2,913	2,796	2,740	2,845	2,967	3,085
Wilson	68	113	118	123	129	137	150
Karnes	14	27	25	25	26	28	28
Fayette	386	427	435	450	494	542	600
Lavaca	15	12	11	11	11	11	12
Subtotal	7,190	7,357	7,101	6,949	7,081	7,300	7,546
LOWER							
Goliad	184	182	172	164	164	165	174
Victoria	8,489	9,540	9,674	9,869	10,452	11,110	11,875
Subtotal	8,673	9,722	9,846	10,033	10,616	11,275	12,049
Calhoun	3	9	9	10	11	11	13
Grand Total	52,958	72,755	80,452	90,010	105,514	118,610	132,368
* Texas Water Development Board, 1996 Consensus Texas Water Plan Projections.							
Below normal rainfall condition with advanced conservation.							

Appendix A: Table 17							
Industrial Water Demand Projections							
Guadalupe River Basin							
Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
HIGH							
Kerr	28	30	33	36	38	41	44
Gillespie	0	0	0	0	0	0	0
Bandera	0	0	0	0	0	0	0
Blanco	0	0	0	0	0	0	0
Subtotal	28	30	33	36	38	41	44
UPPER							
Kendall	0	0	0	0	0	0	0
Comal	3,248	3,450	3,487	3,548	3,799	4,071	4,351
Hays	57	93	105	118	129	142	154
Guadalupe	1,661	1,883	2,102	2,248	2,385	2,590	2,797
Caldwell	0	0	0	0	0	0	0
Bastrop	0	0	0	0	0	0	0
Travis	0	0	0	0	0	0	0
Subtotal	4,966	5,426	5,694	5,914	6,313	6,803	7,302
MIDDLE							
Gonzales	865	929	992	1,043	1,083	1,160	1,231
DeWitt	91	108	126	146	170	195	223
Wilson	48	59	69	81	95	110	128
Karnes	0	0	0	0	0	0	0
Fayette	0	0	0	0	0	0	0
Lavaca	0	0	0	0	0	0	0
Subtotal	1,004	1,096	1,187	1,270	1,348	1,465	1,582
LOWER							
Goliad	0	0	0	0	0	0	0
Victoria	20,032	24,115	28,446	31,157	33,670	37,900	42,201
Subtotal	20,032	24,115	28,446	31,157	33,670	37,900	42,201
Calhoun	233	419	493	546	601	662	726
Grand Total	26,263	31,086	35,853	38,923	41,970	46,871	51,855
* Texas Water Development Board, 1996 Consensus Water Plan Projections							
Oil base prices with conservation.							

Appendix A: Table 18							
Steam-Electric Power Generation Water Demand Projections							
Guadadupe River Basin							
Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
HIGH							
Kerr	0	0	0	0	0	0	0
Gillespie	0	0	0	0	0	0	0
Bandera	0	0	0	0	0	0	0
Blanco	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0
UPPER							
Kendall	0	0	0	0	0	0	0
Comal	0	0	0	0	0	0	0
Hays	0	0	0	0	0	0	0
Guadalupe	0	0	0	0	0	0	0
Caldwell	0	0	0	0	0	0	0
Bastrop	0	0	0	0	0	0	0
Travis	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0
MIDDLE							
Gonzales	0	0	0	0	0	0	0
DeWitt	0	0	0	0	0	0	0
Wilson	0	0	0	0	0	0	0
Karnes	0	0	0	0	0	0	0
Fayette	0	0	0	0	0	0	0
Lavaca	0	0	0	0	0	0	0
Subtotal	0	0	0	0	0	0	0
LOWER							
Goliad	12,165	15,000	15,000	20,000	20,000	20,000	20,000
Victoria	887	8,000	10,000	10,000	10,000	10,000	10,000
Subtotal	13,052	23,000	25,000	30,000	30,000	30,000	30,000
Calhoun	0	0	0	0	0	0	0
Grand Total	13,052	23,000	25,000	30,000	30,000	30,000	30,000
* Texas Water Development Board, 1996 Consensus Water Plan Projections							
TWDB High Series.							

Appendix A: Table 19							
Irrigation Water Demand Projections							
Guadalupe River Basin							
Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
HIGH							
Kerr	850	822	796	770	745	721	697
Gillespie	0	0	0	0	0	0	0
Bandera	0	0	0	0	0	0	0
Blanco	105	98	93	88	83	79	74
Subtotal	955	920	889	858	828	800	771
UPPER							
Kendall	380	364	348	333	319	305	292
Comal	409	393	377	360	346	331	317
Hays	298	294	290	286	283	280	276
Guadalupe	2,303	2,177	2,058	1,945	1,838	1,738	1,642
Caldwell	1,355	1,197	1,057	934	824	728	643
Bastrop	0	0	0	0	0	0	0
Travis	0	0	0	0	0	0	0
Subtotal	4,745	4,425	4,130	3,858	3,610	3,382	3,170
MIDDLE							
Gonzales	3,540	3,019	2,574	2,195	1,871	1,596	1,361
DeWitt	263	236	211	190	171	153	137
Wilson	116	103	90	80	70	62	55
Karnes	0	0	0	0	0	0	0
Fayette	0	0	0	0	0	0	0
Lavaca	0	0	0	0	0	0	0
Subtotal	3,919	3,358	2,875	2,465	2,112	1,811	1,553
LOWER							
Goliad	0	0	0	0	0	0	0
Victoria	1,995	1,571	1,237	974	766	603	475
Subtotal	1,995	1,571	1,237	974	766	603	475
Calhoun	0	0	0	0	0	0	0
Grand Total	11,614	10,274	9,131	8,155	7,316	6,596	5,969
* Texas Water Development Board, 1996 Consensus Water Plan Projections							
TWDB Series, with aggressive adoption of conservation technology, and a reduction in Federal Farm							
Programs by one-half.							

Appendix A: Table 20 Mining Water Demand Projections Guadalupe River Basin Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
HIGH							
Kerr	73	163	113	105	102	102	105
Gillespie	0	0	0	0	0	0	0
Bandera	0	0	0	0	0	0	0
Blanco	0	0	0	0	0	0	0
Subtotal	73	163	113	105	102	102	105
UPPER							
Kendall	0	0	0	0	0	0	0
Comal	946	5,570	5,464	5,628	5,796	3,590	2,224
Hays	0	84	82	68	55	37	28
Guadalupe	0	186	188	190	192	197	203
Caldwell	27	8	7	5	2	0	0
Bastrop	0	12	8	5	2	0	0
Travis	0	0	0	0	0	0	0
Subtotal	973	5,860	5,749	5,896	6,047	3,824	2,455
MIDDLE							
Gonzales	21	37	34	32	29	29	30
DeWitt	21	24	24	25	26	27	28
Wilson	0	11	8	4	1	0	0
Karnes	0	11	8	4	1	0	0
Fayette	0	16	12	7	4	2	0
Lavaca	0	0	0	0	0	0	0
Subtotal	42	99	86	72	61	58	58
LOWER							
Goliad	0	12	9	5	2	0	0
Victoria	2,398	1,938	1,302	904	783	675	688
Subtotal	2,398	1,950	1,311	909	785	675	688
Calhoun	0	13	9	5	2	0	0
Grand Total	3,486	8,085	7,268	6,987	6,997	4,659	3,306
* Texas Water Development Board, 1996 Consensus Water Plan Projections							

Appendix A: Table 21 Livestock Water Demand Projections Guadalupe River Basin Trans-Texas Water Program							
	Use in	Projections					
County	1990	2000	2010	2020	2030	2040	2050
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
HIGH							
Kerr	257	350	350	350	350	350	350
Gillespie	26	32	32	32	32	32	32
Bandera	5	6	6	6	6	6	6
Blanco	130	157	157	157	157	157	157
Subtotal	418	545	545	545	545	545	545
UPPER							
Kendall	307	404	404	404	404	404	404
Comal	271	306	306	306	306	306	306
Hays	378	271	271	271	271	271	271
Guadalupe	773	848	848	848	848	848	848
Caldwell	681	696	696	696	696	696	696
Bastrop	61	65	65	65	65	65	65
Travis	36	36	36	36	36	36	36
Subtotal	2,507	2,626	2,626	2,626	2,626	2,626	2,626
MIDDLE							
Gonzales	4,072	5,018	5,018	5,018	5,018	5,018	5,018
DeWitt	1,378	1,419	1,419	1,419	1,419	1,419	1,419
Wilson	61	64	64	64	64	64	64
Karnes	94	92	92	92	92	92	92
Fayette	130	168	168	168	168	168	168
Lavaca	35	39	39	39	39	39	39
Subtotal	5,770	6,800	6,800	6,800	6,800	6,800	6,800
LOWER							
Goliad	195	267	267	267	267	267	267
Victoria	595	653	653	653	653	653	653
Subtotal	790	920	920	920	920	920	920
Calhoun	0	2	2	2	2	2	2
Grand Total	9,485	10,893	10,893	10,893	10,893	10,893	10,893
* Texas Water Development Board, 1996 Consensus Water Plan Projections							
TWDB High Series.							

Appendix A: Table 22									
Projected Year 2020 Water Demand and Supply Comparisons									
Guadalupe River Basin/Guadalupe Blanco River Authority Service Area									
Trans-Texas Water Program									
			2020	Surface	Surface Water Supplies in 2020				
County	Use in 1990 ac-ft	2020 Projected Demand ac-ft	2020 Ground Water Supply* ac-ft	Water Needed in 2020 ac-ft	Other than Canyon ac-ft	Source	Canyon Lake ac-ft	Canyon Contracts 1995 ac-ft	Comments Re: Surface Water Needs/Sources
Kerr[1]	6,920	9,090	6,867	2,223	10,664	------	1,000	0	One-sixth of 6,100 ac-ft of junior rights upstream of Canyon.
Gillespie[2]	35	42	554	0	0	------	0	0	
Bandera[2]	21	30	233	0	0	------	0	0	
Blanco[2]	662	816	1,547	0	0	------	0	0	
Subtotal	7,638	9,978	9,201	2,223	0		1,000	0	
Kendall**	2,901	3,690	4,840	1,000	0	------	1,000	0	
Comal**[3]	15,404	38,640	7,912	30,728	14,721	ror rights	16,007	16,007	
Hays**[3]	12,933	23,799	9,177	14,622	5,622	SM River	9,000	5,500	5,000 San Marcos; 500 SWTSU; & 3,500 future uses in Hays Co.
Guadalupe**	14,976	26,510	16,105	10,405	4,221	ror rights	6,184	4,992	4,992 existing contracts; 1,192 for new users.
Caldwell**[3]	7,149	8,181	10,688	2,164	1,164	SM River	1,000	0	Luling,Martindale, Maxwell & other WSC's.
Bastrop[2]	92	189	1,661	0	0	----	0	0	
Travis[2]	102	175	88	0	0	----	0	0	
Subtotal	53,557	101,184	50,471	58,919	25,728		33,191	26,499	
Gonzales**	12,366	11,948	46,560	1,564	782	ror rights	391	0	One-half Gonzales projected 2020 demand.
DeWitt**	5,901	5,718	15,866	1,684	842	------	421	5	One-half Cuero's projected 2020 demand.
Wilson[2]	293	352	3,635	0	0	------	0	0	
Karnes[2]	108	121	563	0	0	------	0	0	
Fayette[2]	516	625	1,513	0	0	------	0	0	
Lavaca[2]	50	50	381	0	0	------	0	0	
Subtotal	19,234	18,814	68,518	3,248	1,624		812	5	

Table 22 (cont'd)

Goliad	12,544	20,436	2,578	7,627	12,500	ror rights	6,000	6,000	Coletto Creek average annual demand.
Refugio**[2]	1,867	1,646	7,768	0	0	------	0	0	
Victoria**	49,843	66,020	41,130	24,890	17,188	ror rights	5,702	0	To firm up ror rights for industrial users.
Calhoun**[4]	64,230	113,106	2,940	78,166	72,230	ror rights	7,934	0	To firm up ror rights for industrial users.
Subtotal	128,484	201,208	54,416	110,683	101,918		19,636	6,000	
Total	208,913	331,184	182,606	175,073			54,639	32,504	

* Source: Groundwater Availibility Data for Texas Counties; Unpublished Planning Data ; Texas Water Development Board ; 1993. Groundwater from Edwards Aquifer based on assumption of pumpage limits of 400,000 ac-ft per year.

** Guadalupe-Blanco River Authority Counties (Data for whole county.); For all other counties, data for only that part of county located in Guadalupe Basin.

[1] Present surface water supply from Guadalupe River senior water rights of 4,564 ac-ft for Kerr County is not counted against Canyon Lake yield.

[2] Estimated to be supplied from local groundwater.

[3] Groundwater from Edwards Aquifer for Comal, Hays, Guadalupe, and Caldwell Counties based on pumpage limits of 400,000 ac-ft per year.

[4] 32,000 ac-ft of supply is obtained from Lake Texana of the Lavaca Basin. Demand includes 11,000 ac-ft of canal conveyance losses.

APPENDIX B

COST ESTIMATING PROCEDURES

Cost Estimating Procedures

Introduction

This study includes preparation of construction cost estimates, total project cost estimates, and estimates of operation and maintenance costs for a variety of project elements. Major structural and non-structural cost elements included in the estimates are listed below:

Structural Costs	Non-Structural Costs
1. Off-Channel Reservoirs	1. Engineering - Design, Bidding and Construction Phase Services, Geotechnical, and Surveying
2. Pump stations	2. Legal Services
3. Pipelines	3. Contingencies
4. Water Treatment Plants	4. Permits
5. Interconnects to existing distribution systems	5. Environmental - Studies & Mitigation
6. Water Storage Tanks	6. Archaeology - Studies & Mitigation
	7. Interest During Construction
	8. Operations and Maintenance
	9. Land and Rights-of-Way
	10. Financing

The methods used in estimating costs are as follows:

Structural Costs

1. Off-Channel Reservoirs. The construction costs for these elements were handled individually. Since each reservoir site is unique, costs were based on the specific requirements of the project for the site. Items included in the estimate consisted of the construction cost and the non-structural costs listed above.

2. Pump Stations. Pump stations vary in cost according to the discharge and pumping head requirements and structure requirements for housing the equipment and providing proper flow conditions to the pump suction intake. The costs of pumps, motors, and electrical controls were estimated using a generalized cost data related to station horsepower derived from actual construction costs of equipment previously installed, escalated to first-quarter 1996 prices.

3. Pipeline. Pipeline construction costs are influenced by pipe materials, bedding requirements, geologic conditions, urbanization, terrain, and special crossings. Most pipelines in the present study areas will be constructed in rural areas with subsurface material consisting of soil (non-rock). Table B-1 includes estimated base pipeline costs per foot for pipeline sizes ranging from 12-inch to 120-inch diameter. The table includes costs based on soil construction (without rock) and rural environment. The costs shown represent the minimum cost range for pipelines. Costs for specific applications are estimated by adding the increased cost of installation to the

Table B-1 Pipeline Costs	
Size (inches)	Base Pipeline Cost[1] including Appurtenances ($/LF)
12	25
18	36
24	43
30	55
36	73
42	89
48	112
54	118
60	136
66	168
72	201
78	220
84	236
90	249
96	292
102	336
108	380
114	426
120	479

[1] Base pipeline cost is for normal operating pressure pipe installed in a soil trench, rural environment. For other conditions (i.e., rock trench, high pressure pipe class, and urban environment) costs were determined for the increased material and installation components, resulting in a cost factor multiplier to be applied to the base pipeline cost. Cost factors ranged from 1.0 to 2.25. Base pipeline costs obtained from Trans-Texas Corpus Christi Service Area Phase I Report, inflated to first-quarter 1996. ENR CCI = 5542.

cost per foot shown in the table to compensate for geologic conditions such as rock and urbanization. Both of these items will also increase the time for construction. The cost estimates pertain to installed cost of pipeline and appurtenances, such as markers, valves, thrust restraint system, corrosion monitoring and control equipment, air and vacuum control valves, blow-off valves, revegetation, rights-of-way, fencing, and gates. Costs of special crossings such as railroads, highways, and rivers were estimated on an individual basis.

4. Water Treatment. It is not the intent of the cost estimating methodology to establish an exact treatment process, but rather to estimate the cost of a general treatment process appropriate for bringing the source water quality to the required standard. Conventional treatment process,

including alum and polymer addition, rapid mix, flocculation, settling, filtration, and disinfection with chlorine is costed. Treatment plant costs include processes, site work, buildings, storage tanks, sludge handling and disposal, clearwell, pumps, and equipment. Finished water pumping (high service pumping) is also included in the costs. Operation and maintenance costs include labor, materials, replacement of equipment, process energy, building energy, chemicals, and high service pumping energy.

5. Interconnects to Existing Distribution Systems. Interconnects to existing distribution system were costed for connection to existing storage tanks where possible. For connection to existing tanks, connection cost included site piping, control valves, and a simple radio telemetry control system. At interconnects where no storage tank exists, the interconnect cost included the cost of constructing a ground storage tank or medium height standpipe.

Construction Cost Indices

Updates of previous cost estimates to first-quarter 1996 price levels and trending of unit costs were performed using an ENR Construction Cost Index (CCI) of 5542.

Non-Structural Costs

The costs for engineering, administration, legal, environment, land, O&M and interest during construction must be added to the construction costs to obtain the project capital cost. The following guides were used for estimating the costs of non-structural items and are common to all alternatives:

1. Engineering, contingencies, financial and legal services were lumped together and estimated as 30% of total construction costs for pipelines and 35% for all other facilities. Construction costs include only the cost of building the project facilities and any relocations requiring construction contracts including labor and materials. Costs for land and rights-of-way, permits, environmental and archaeological studies, and mitigation were estimated separately.

2. Land costs vary significantly with location and economic factors. Land costs for reservoirs and canals were estimated by using appropriate costs per acre as obtained from local appraisal districts and include costs for legal services, sales commissions, and surveys in the cost per acre used.

3. Land costs for pipelines include a permanent easement plus a temporary construction easement plus rights to enter the easement for maintenance and repairs. For estimating pipeline right-of-way cost, the cost was the full land value per acre based on purchase of the land as determined from discussions with the local appraisal districts plus legal, sales, and surveying costs. This full value was applied to a 40-foot permanent

easement width for the length of the pipeline. This cost covers the cost of the permanent and temporary easement.

4. Permits, environmental studies and mitigation, and archaeological studies and mitigation costs were estimated on an individual project basis utilizing information available and judgment of qualified professionals. In the case of reservoir projects, the mitigation costs are based on acreages of inundation times the cost per acre to purchase an equal land area.

5. Debt service and interest during construction. Debt service for all projects was calculated assuming an interest rate of 8% for 25 years (i.e., debt service factor of 0.0937) applied to total estimated project costs including interest during construction. Interest during construction was calculated assuming the total estimated project cost (excluding interest during construction) will be drawn down at a constant rate per month during the construction period. Interest during construction is the total of interest accrued at the end of the construction period using an 8 percent annual interest rate less 4 percent for investment of available funds. Interest during construction was calculated as the average project cost for the construction period times the net annual interest rate of 4 percent times the number of years required to construct the facilities.

6. Operations and maintenance costs (O&M) (not including power costs for pumping). Annual O&M costs were calculated as 1.0 percent of the total estimated construction cost for pipelines, as 2.5 percent of total estimated construction costs for pump stations, and as 1.5 percent of total estimated construction costs for dams. These costs include labor and materials required to maintain the project and regular replacement of equipment. In addition to these costs, power costs were calculated on an annual basis using calculated horsepower input and a power purchase cost of $0.06 per kwhr.

7. Presentation of Estimates. Cost estimates were prepared to show annual total cost and annual cost per acft of water supplied by each alternative.

APPENDIX C

WATER AVAILABILITY ANALYSES

APPENDIX C
WATER AVAILABILITY ANALYSES

INTRODUCTION

Each of the alternatives presented in this report considers the diversion of water from the Guadalupe River to provide additional water supplies ranging from 5,000 acft/yr up to 75,000 acft/yr for entities located in the watersheds of both the Guadalupe River and the San Antonio River. It was assumed that annual diversions less than or equal to 15,000 acft/yr would be supplied in the form of a new contractual obligation from the presently uncommitted firm yield of Canyon Lake and, therefore, would not necessitate water availability analyses. Alternatives G-37, G-38, and G-39 include proposed diversions of 40,000 acft/yr to 75,000 acft/yr from the Guadalupe River at Gonzales and/or Lake Dunlap which can not be supplied from the presently uncommitted firm yield of Canyon Lake alone and must include the consideration of water potentially available from a range of sources. Sources of water for these alternatives include: 1) Enhanced springflow (as defined on page C-5) resulting from a theoretical reduction in overall Edwards Aquifer pumpage from that observed in calendar year 1989 (543,677 acft) to 400,000 acft/yr; 2) Flows committed to existing water rights which are projected to be underutilized in year 2020; 3) Unappropriated streamflow; and 4) Allocations from the uncommitted firm yield of Canyon Lake used to "firm up" supplies periodically available from the other sources. Methods and assumptions applied and results obtained in the quantification of firm water availability from the combined utilization of the four potential water sources listed above are presented in this Appendix C.

River Basin Model and Database Enhancements

Draft Environmental Water Needs Criteria for New Project Direct Diversions from the Consensus Planning Process received November 27, 1995 were used in estimating unappropriated streamflows potentially available for diversion from the Guadalupe River at Gonzales and/or Lake Dunlap. These environmental criteria are applied in three "zones" based on flow regime at the proposed point of diversion and are defined as follows:

1) When flow at the point of diversion is greater than the median natural daily flow for the current month, the median natural daily flow for the current month must be passed.

2) When the flow at the point of diversion is greater than the lower quartile (25th percentile) and is less than the median natural daily flow for the current month, the lower quartile natural daily flow must be passed.
3) When the flow at the point of diversion is less than the lower quartile natural daily flow for the current month, flow up to the water quality standard or 2-year, 7-day low flow (7Q2) must be passed.

The Guadalupe - San Antonio River Basin Model (GSA Model)[1] was modified to facilitate calculation of water available on a daily basis subject to this draft environmental criteria after accounting for required flow passage for downstream water rights on a monthly basis. Incorporation of the draft environmental criteria provided an opportunity to enhance the GSA Model facilitating water availability computation on a daily timestep with explicit consideration of proposed maximum diversion rate constraints and daily flow variations within a month.

On days when flow at the point of diversion exceeds the median, a portion of the flow must also be passed to provide for desired freshwater inflows to the Guadalupe Estuary. The draft environmental criteria suggest that the appropriate desired minimum freshwater inflow to the receiving estuary should be between the MaxH (maximum harvest) and MinQ (minimum freshwater inflow necessary to satisfy all constraints) monthly values established by joint analyses conducted by the Texas Parks and Wildlife Department (TPWD) and Texas Water Development Board (TWDB). As the MinQ values for the Guadalupe Estuary have yet to be finalized for the Guadalupe Estuary, monthly MaxH values provided by TPWD have been used in this study. Monthly estimates of MaxH inflows to the Guadalupe Estuary range from 52,420 acft in March, April, September, October, and November up to 222,600 acft in May and total 1,147,320 acft on an annual basis. As the most downstream control point in the GSA Model is located at the Saltwater Barrier on the Guadalupe River near Tivoli (USGS #1888), monthly MaxH values for the entire estuary were prorated to the Saltwater Barrier based on the ratio of average annual natural streamflow at the Saltwater Barrier to estuarine inflow estimated by the TWDB for the 1941-87 period.

In order to implement the draft environmental criteria, it was necessary to estimate daily natural streamflows at Lake Dunlap and Gonzales for the 1934-89 historical period from monthly natural streamflows previously developed. Note that the monthly natural streamflows were

[1] HDR Engineering, Inc., "Guadalupe - San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September, 1993.

derived by adjusting historical gaged streamflows to account for reported diversions and return flows and to account for upstream impoundments. Hence, the monthly natural streamflows were derived using historical pumpage and resultant springflow from the Edwards Aquifer. Natural daily streamflows at Lake Dunlap for the entire 1934-89 period were estimated by prorating the sum of the natural monthly streamflows for the Guadalupe River above the Comal River (USGS #1685) and the Comal River (USGS #1690) based on the sum of the daily gaged streamflows divided by the sum of the monthly gaged streamflows at these two locations. Natural daily streamflows at Gonzales were estimated by prorating the sum of the natural monthly streamflows for the Guadalupe River at Lake Wood (H-5), San Marcos River at Luling (USGS #1720), and Plum Creek at Luling (USGS #1730) based on the sum of the daily gaged streamflows divided by the sum of the monthly gaged streamflows at USGS #1685, USGS #1690, USGS #1720, and USGS #1730 for the 1940-89 period and at USGS #1685 and USGS #1690 prior to 1940.

Estimated natural daily streamflows for the full 1934-89 period were then used to compute applicable medians and quartiles for each month of the year and to compute the 7Q2 streamflow for the Guadalupe River at Gonzales and Lake Dunlap. These flow statistics represent the minimum flow passage requirements for diversions subject to the draft environmental criteria and are summarized in Table C-1. For the five months of July through November at each location, the 7Q2 flow exceeds the quartile flow and, therefore, replaces the quartile flow under the draft environmental criteria. The relatively high values for the 7Q2 at Gonzales (514 cfs) and Lake Dunlap (363 cfs) are primarily the result of significant baseflows contributed by the discharges from Comal and/or San Marcos Springs which are the two largest springs in Texas. On the basis of a permit recently issued by the Texas Natural Resources Conservation Commission (TNRCC) authorizing direct diversions from the Guadalupe River for the City of Victoria, it would seem likely that the statistically derived 7Q2 should be replaced with a lower monthly water quality standard based on necessary assimilative capacity and maintenance of dissolved oxygen levels.

Table C-1 Natural Daily Streamflow Statistics[1,2]						
	Guadalupe R. @ Lake Dunlap			Guadalupe R. @ Gonzales		
Month	Median (cfs)	Quartile (cfs)	7Q2 (cfs)	Median (cfs)	Quartile (cfs)	7Q2 (cfs)
January	569	390	363	806	559	514
February	597	418	363	861	593	514
March	600	397	363	853	560	514
April	607	399	363	911	556	514
May	718	406	363	1,040	610	514
June	644	370	363	912	552	514
July	508	301	363	731	435	514
August	436	282	363	622	394	514
September	473	335	363	682	466	514
October	518	339	363	728	474	514
November	515	350	363	740	491	514
December	569	370	363	786	537	514
Annual Sum (acft)	407,300	262,530	262,800	583,160	375,260	372,120

(1) Natural daily streamflow statistics based on the 1934-89 historical period.
(2) Natural streamflows reflect adjustments for reported diversions and return flows as well as upstream impoundments, but are based on historical Edwards Aquifer pumpage and springflow.

Water Sources and Assumptions

Two general scenarios based on the source composition of water potentially available for diversion were considered in this study. Scenario #1 includes the periodic combined diversion of enhanced springflow and unappropriated streamflow made firm by water delivered from Canyon Lake. Scenario #2 includes the periodic combined diversion of enhanced springflow, water rights projected to be underutilized in 2020, and unappropriated streamflow made firm by water delivered from Canyon Lake. In addition, both uniform and summer peak monthly diversion patterns (see Table C-2) were considered for each location. Because of the relatively short transmission pipeline and steady flows from Comal Springs, the summer peak monthly diversion pattern for Lake Dunlap (Alternative G-37) does not reflect any balancing storage. On the other hand, the summer peak monthly diversion pattern for Gonzales (Alternatives G-38 and G-39) does reflect balancing storage in order to facilitate down-sizing of the longer transmission pipeline.

All estimates of water potentially available for diversion reported herein are based on full subordination of Guadalupe River hydropower rights to Canyon Lake, GBRA contractual commitments from Canyon Lake totaling 38,438 acft/yr, fixed Edwards Aquifer pumpage of

Table C-2 Monthly Diversion Patterns[1]			
Month	Uniform	Summer Peak Without Storage	Summer Peak With Storage
January	8.50%	3.40%	5.70%
February	7.70%	3.10%	5.40%
March	8.50%	3.40%	5.70%
April	8.20%	7.00%	7.00%
May	8.50%	11.30%	11.30%
June	8.20%	11.00%	11.00%
July	8.50%	17.00%	11.30%
August	8.50%	17.00%	11.30%
September	8.20%	11.00%	11.00%
October	8.50%	9.00%	9.00%
November	8.20%	3.40%	5.60%
December	8.50%	3.40%	5.70%
(1) Values presented are the monthly percentages of total annual demand.			

400,000 acft/yr, inclusion of recent water rights applications by the Cities of Victoria and San Marcos, simulation of consumptive reuse of SAWS treated effluent (SAWS/SARA Tunnel Reuse Project), and return flows throughout the basin at rates reported for 1989. The procedures and specific assumptions pertinent to the computation of water potentially available from each of the primary water sources are described in the following subsections.

Enhanced Springflow

The term "enhanced springflow" as used throughout this study is defined to be the estimated increase in discharge primarily from Comal and San Marcos Springs into the Guadalupe and San Marcos Rivers which, theoretically, would occur if Edwards Aquifer pumpage were reduced from an annual volume of 543,677 acft to an annual volume of 400,000 acft.

Approximations of increases in springflow resulting from potential reductions in Edwards Aquifer pumpage from the amount observed in calendar year 1989 (543,677 acft) to a fixed 400,000 acft/yr were obtained using the Edwards Aquifer Model developed and maintained by the TWDB. Simulated springflows from the TWDB Edwards Model were adjusted to account for monthly differences in simulated and actual springflows based on historical pumpage. Springflows based on pumpage of 543,677 acft/yr were compared to those for 400,000 acft/yr to estimate monthly quantities of enhanced springflow at Comal, San Marcos, and other springs originating in the Edwards Aquifer.

It was assumed that this enhanced springflow would first be dedicated to existing water rights, including increasing the firm yield of Canyon Lake, while the remainder would be available for diversion from the Guadalupe River at Gonzales and/or Lake Dunlap. Hence, the GSA Model was used to compute the uncommitted firm yield of Canyon Lake subject to Edwards Aquifer pumpage rates of 543,677 acft/yr and 400,000 acft/yr. The increase in the uncommitted firm yield associated with pumpage reduction ranged from 2,650 acft/yr to 3,070 acft/yr depending on the point of diversion. Draft Environmental Water Needs Criteria from the Consensus Planning Process were not applied to the incremental yield of Canyon Lake resulting from the subordination of hydropower because the environmental flow requirements below Canyon Dam established by the Federal Energy Regulatory Commission (FERC) were assumed to supersede any planning criteria. However, water rights on the Guadalupe River downstream of Lake Dunlap which are presently junior to Canyon Lake were simulated as senior water rights to ensure that they would be satisfied by the passage of Canyon Lake inflows to the same extent they would have been without subordination of hydropower.

Fixing Canyon Lake inflow pass-throughs, releases, spills, and firm yield diversions from each of these simulations, the GSA Model was used to compute water availability at Lake Dunlap and Gonzales for Edwards Aquifer pumpages rates of 543,677 acft/yr and 400,000 acft/yr subject to existing water rights. Month by month comparison of water availability estimates under the two aquifer pumpage scenarios reveals the balance of enhanced springflow available for diversion assuming existing surface water rights are honored first. Should implementation of a drought management plan cause pumpage to be reduced to less than 400,000 acft/yr during drought, estimates of enhanced springflow available for diversion presented herein would be increased. Quantities available for diversion were subsequently limited based on maximum daily diversion rate and monthly diversion pattern for specified annual diversion volumes.

At this time, it is not clear whether application of the Draft Environmental Water Needs Criteria to the diversion of enhanced springflow is appropriate since the additional flow is a direct result of Edwards Aquifer pumpage reductions deemed necessary to protect endangered species. For the purposes of this study, the sponsors chose not to apply the Draft Environmental

Water Needs Criteria to this increment of water since application of such "additional" environmental criteria could be overly restrictive when balanced against the human needs for water in the study area. Despite the choice not to apply additional environmental criteria to this increment of water, median streamflows below the point of diversion with each alternative project in place would exceed those without the project (and without Edwards Aquifer pumpage reduction) in all months subject to the uniform monthly diversion pattern and in ten or more months subject to the summer peak monthly diversion pattern. Median and annual decile average freshwater inflows to the Guadalupe Estuary with each alternative project in place would exceed those without the project (and without Edwards Aquifer pumpage reduction) in all months and all deciles subject to either monthly diversion pattern.

Water Rights Transfer

Water potentially available from existing water rights projected to be underutilized in 2020 was considered when the combination of enhanced springflow, unappropriated streamflow, and available Canyon Lake firm yield would be inadequate to satisfy the selected annual diversion volume. Hence, water potentially available under 2020 underutilized rights was only considered for general source Scenario #2. For the purposes of this study, it was assumed that the portion of several large water rights (in excess of 8,000 acft/yr) not expected to be fully utilized prior to 2020 could be transferred by purchase or lease to supplement water potentially available for diversion from the Guadalupe River at Gonzales or Lake Dunlap. Table C-3 summarizes the large water rights considered and projected utilization of these rights in 2020. After adjusting these large water rights to projected 2020 utilization, accounting for diversions under enhanced springflow, and preserving unappropriated streamflow at the Saltwater Barrier (from the Canyon Lake firm yield simulation for Edwards Aquifer pumpage of 400,000 acft/yr), water potentially available for diversion under the transfer of existing, underutilized rights was computed using the GSA Model. Combined quantities diverted under enhanced springflow and transferred water rights were limited based on maximum daily diversion rate and monthly diversion pattern for specified annual diversion volumes. Draft Environmental Water Needs

Table C-3 Portions of Large Water Rights Potentially Available Through 2020				
Owner(s) of Water Rights	**Location**	**Total Water Rights Considered[1] (acft/yr)**	**Projected 2020 Utilization[2] (acft/yr)**	**Balance Potentially Available (acft/yr)**
GBRA, et.al., & Dupont deNemours	Guadalupe River above Tivoli	195,501	81,106	114,395
City of Victoria	Guadalupe River at Victoria	20,000	13,382	6,618
City of San Marcos	San Marcos River below San Marcos	26,379	18,712	7,667
	TOTAL	241,880	113,200	128,680

(1) Included only water rights in excess of 8,000 acft/yr after combination of rights for various types of use under one owner.
(2) Based on current TWDB demand projections or recent studies.

Criteria from the Consensus Planning Process were not applied as these diversions would be made under existing water rights. Instream flows below the point of diversion as well as freshwater inflows to the Guadalupe Estuary would generally remain unchanged or increase due to enhanced springflow (relative to that which would have occurred under the assumed baseline Edwards Aquifer pumpage of 543,677 acft/yr) and/or reduced water rights diversions.

<u>Unappropriated Streamflow</u>

The GSA Model was used to calculate unappropriated streamflow potentially available for diversion from the Guadalupe River at Gonzales or Lake Dunlap after accounting for applicable diversions under enhanced springflow and water rights transfers. Combined quantities diverted under enhanced springflow, transferred water rights, and unappropriated streamflow were limited based on maximum daily diversion rate and monthly diversion pattern for specified annual diversion volumes. Draft Environmental Water Needs Criteria from the Consensus Planning Process were applied in the computation of unappropriated streamflow potentially available for diversion and significantly limited water availability from this source.

Total Firm Availability with Canyon Lake

As combined water potentially available from each of the run-of-the-river diversion sources discussed above is highly variable from month to month, it was assumed that portions of the presently uncommitted firm yield of Canyon Lake would be made available to firm up these run-of-the-river diversions and develop a dependable supply defined herein as firm availability. Firm availability was calculated using spreadsheet analyses considering run-of-the-river water and "banked storage" in Canyon Lake during the July, 1947 through February, 1957 critical drought period. The procedure employed in the firm availability calculation is described in Appendix H bound in Volume 3 of the Phase 1 Interim Report[2]. Potential allocations of Canyon Lake firm yield necessary to ensure firm availability for annual diversion volumes considered in this study include adjustments for the additional evaporation associated with banked storage in Canyon Lake during the critical drought. It is important to note that the allocation of Canyon Lake firm yield to ensure firm availability presented herein is an annual average for the entire critical drought period. In any single year during the drought, deliveries from Canyon Lake to ensure firm availability may exceed the average allocation by more than 100 percent.

[2] HDR Engineering, Inc., "Trans-Texas Water Program, West Central Study Area, Phase I Interim Report," Volume 3, San Antonio River Authority, et.al., November, 1994.

Firm Availability at Lake Dunlap (Alternative G-37)

Sources of water for the firm annual diversion of 50,000 acft/yr from the Guadalupe River at Lake Dunlap under Scenarios #1 and #2 are summarized in Table C-4 and C-5, respectively. No balancing storage was included in Alternative G-37 because of the relatively short transmission pipeline and steady flows from Comal Springs. Key observations upon review of Tables C-4 and C-5 include the following:

1) Enhanced springflow and purchase from the firm yield of Canyon Lake are the primary sources of water potentially available for diversion at Lake Dunlap. Availability of unappropriated streamflow is severely limited by the draft Environmental Water Needs Criteria of the Consensus Planning Process and the diversion of water available from other sources.
2) Allocation of between 18,830 acft/yr and 33,630 acft/yr of the firm yield of Canyon Lake (assuming full subordination of hydropower rights to Canyon Lake) would be necessary to ensure firm availability of 50,000 acft/yr at Lake Dunlap. Including diversions under water rights transfers could reduce necessary allocations from the firm yield of Canyon Lake by up to 11,930 acft/yr.
3) Utilization of water purchased from the yield of Canyon Lake over the long-term, would average between 3,390 acft/yr and 11,070 acft/yr.
4) Diversions of enhanced springflow would average between 38,200 acft/yr and 42,000 acft/yr over the long-term and between 18,670 acft/yr and 22,580 acft/yr during drought.
5) An average of less than 730 acft/yr of unappropriated water would be diverted under any scenario because of limitations imposed by the draft environmental criteria and/or availability from other sources.

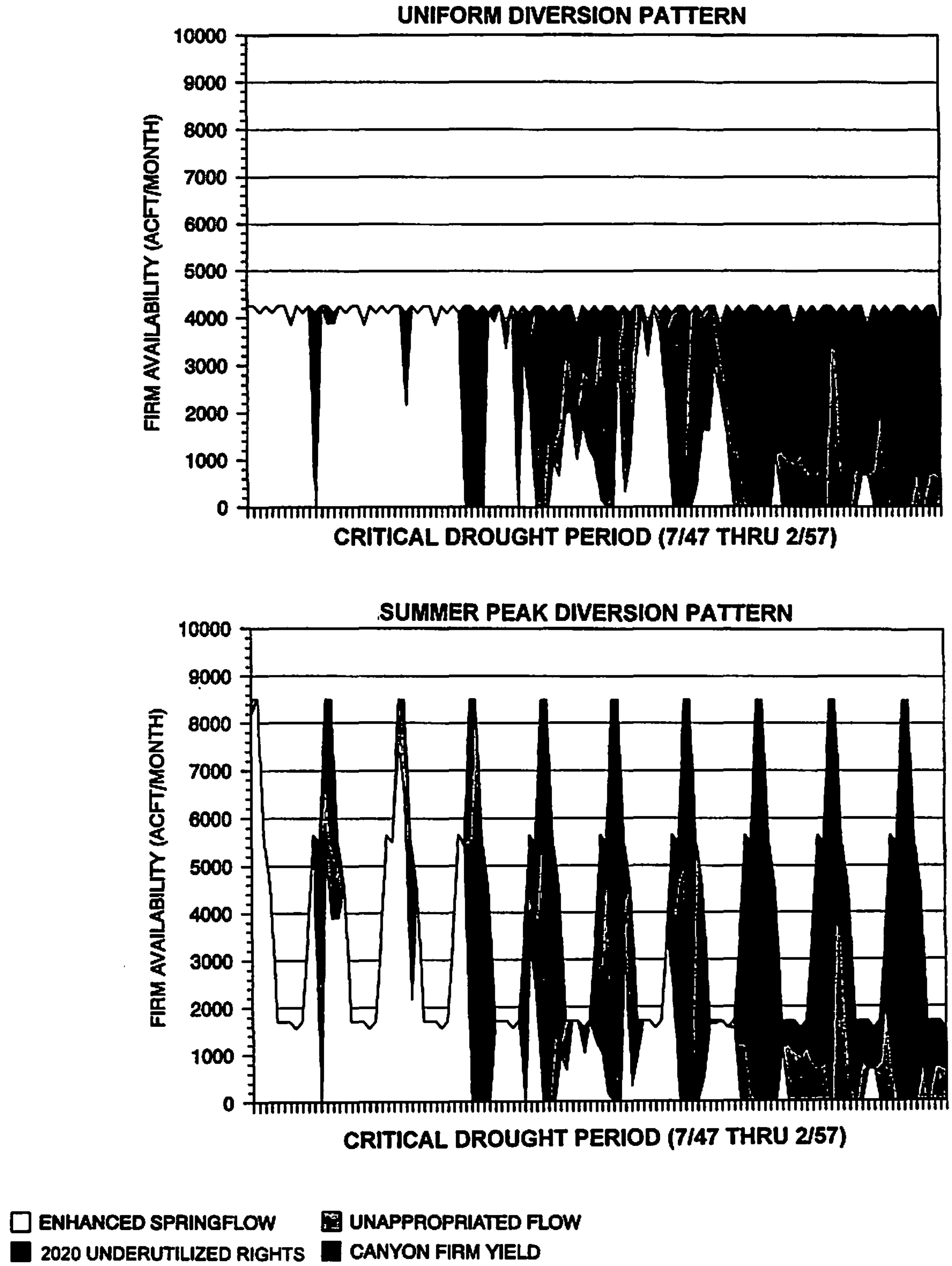
Figure C-1 illustrates monthly utilization of water from all sources considered in Scenario #2 for the diversion of 50,000 acft/yr from the Guadalupe River at Lake Dunlap subject to uniform and summer peak diversion patterns. Refer to Section 3.4 of this report for additional information regarding Alternative G-37.

Table C-4 Scenario #1 Diversion of 50,000 acft/yr at Lake Dunlap from Enhanced Springflows, Unappropriated Streamflow, and Canyon Firm Yield (Alternative G-37)				
Water Source Scenario #1	Uniform Diversion		Summer Peak Diversion (No Storage)	
	Average[1] (acft/yr)	Drought[2] (acft/yr)	Average[1] (acft/yr)	Drought[2] (acft/yr)
Enhanced Springflow	42,000	22,580	38,200	18,670
Unappropriated Streamflow	390	90	730	150
Year 2020 Underutilized Rights	0	0	0	0
Subtotal	42,390	22,670	38,930	18,820
Canyon Firm Yield[3] (Evaporation on Banked Storage[4])	7,610	30,220 (2,890)	11,070	33,630 (2,450)
Total	50,000	50,000	50,000	50,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage is calculated only during the drought and is included in Canyon Firm Yield.

Table C-5 Scenario #2 Diversion of 50,000 acft/yr at Lake Dunlap from Enhanced Springflows, Water Rights Transfer, Unappropriated Streamflow, and Canyon Firm Yield (Alternative G-37)				
Water Source Scenario #2	Uniform Diversion		Summer Peak Diversion (No Storage)	
	Average[1] (acft/yr)	Drought[2] (acft/yr)	Average[1] (acft/yr)	Drought[2] (acft/yr)
Enhanced Springflow	42,000	22,580	38,200	18,670
Unappropriated Streamflow	60	40	140	60
Year 2020 Underutilized Rights	4,550	11,130	7,040	11,980
Subtotal	46,610	33,750	45,380	30,710
Canyon Firm Yield[3] (Evaporation on Banked Storage[4])	3,390	18,830 (2,580)	4,620	21,700 (2,410)
Total	50,000	50,000	50,000	50,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage is calculated only during the drought and is included in Canyon Firm Yield.



TRANS TEXAS WATER PROGRAM /
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HDR Engineering, Inc.

GUADALUPE RIVER AT LAKE DUNLAP
50,000 ACFT/YR DIVERSION
ALT. G-37, SCENARIO #2

FIGURE C-1

Firm Availability at Gonzales (Alternative G-38)

Sources of water for the firm annual diversion of 40,000 acft/yr or 75,000 acft/yr from the Guadalupe River at Gonzales under general source Scenarios #1 and #2 are summarized in Tables C-6 through C-9. Balancing storage was included for Alternative G-38 to facilitate down-sizing of the transmission line from Gonzales to the water treatment plant. Key observations upon review of Tables C-6 through C-9 include the following:

1) Enhanced springflow and purchase from the firm yield of Canyon Lake are the primary sources of water potentially available for diversion at Gonzales. Availability of unappropriated streamflow is severely limited by the draft Environmental Water Needs Criteria of the Consensus Planning Process and the diversion of water available from other sources.
2) Firm availability of 40,000 acft/yr at Gonzales can be obtained both with (Scenario #2) and without (Scenario #1) water rights transfers. Firm availability of 75,000 acft/yr at Gonzales, however, cannot be obtained without water rights transfers (see Table C-8) because the necessary allocation of Canyon Lake firm yield would exceed the uncommitted firm yield.
3) Allocation of between 8,090 acft/yr and 20,310 acft/yr of the firm yield of Canyon Lake (assuming full subordination of hydropower rights to Canyon Lake) would be necessary to ensure firm availability of 40,000 acft/yr at Gonzales. Firm availability of 75,000 acft/yr at Gonzales could be obtained with the allocation of between 21,930 acft/yr and 45,770 acft/yr of the firm yield of Canyon Lake.
4) For firm availability of 40,000 acft/yr, diversions of enhanced springflow would average between 20,880 acft/yr and 22,760 acft/yr during the drought and between 34,850 acft/yr and 38,800 acft/yr over the long-term.
5) For firm availability of 75,000 acft/yr, diversions of enhanced springflow would average between 30,670 acft/yr and 32,900 acft/yr during the drought and between 57,370 acft/yr and 60,960 acft/yr over the long-term.
6) An average of less than 2,710 acft/yr of unappropriated water would be diverted under any scenario because of limitations imposed by the draft environmental criteria and/or availability from other sources.

Figure C-2 illustrates monthly utilization of water from all sources considered in Scenario #2 for the diversion of 75,000 acft/yr from the Guadalupe River at Gonzales subject to uniform and summer peak diversion patterns. Refer to Section 3.5 of this report for additional information regarding Alternative G-38.

Table C-6
Scenario #1 Diversion of 40,000 acft/yr at Gonzales from Enhanced Springflows, Unappropriated Streamflow, and Canyon Firm Yield (Alternative G-38)

Water Source Scenario #1	Uniform Diversion		Summer Peak Diversion (With Storage)	
	Average[1] (acft/yr)	Drought[2] (acft/yr)	Average[1] (acft/yr)	Drought[2] (acft/yr)
Enhanced Springflow	34,850	22,760	38,800	20,880
Unappropriated Streamflow	320	460	360	620
Year 2020 Underutilized Rights	0	0	0	0
Subtotal	35,170	23,220	34,160	21,500
Canyon Firm Yield[3]	4,830	18,710	5,840	20,310
(Evaporation on Banked Storage[4])		(1,930)		(1,180)
Total	40,000	40,000	40,000	40,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage is calculated only during the drought and is included in Canyon Firm Yield.

Table C-7
Scenario #2 Diversion of 40,000 acft/yr at Gonzales from Enhanced Springflows, Water Rights Transfer, Unappropriated Streamflow, and Canyon Firm Yield (Alternative G-38)

Water Source Scenario #2	Uniform Diversion		Summer Peak Diversion (With Storage)	
	Average[1] (acft/yr)	Drought[2] (acft/yr)	Average[1] (acft/yr)	Drought[2] (acft/yr)
Enhanced Springflow	34,850	22,760	38,800	20,880
Unappropriated Streamflow	130	230	100	420
Year 2020 Underutilized Rights	3,530	10,080	4,280	10,670
Subtotal	38,510	33,070	38,180	31,970
Canyon Firm Yield[3]	1,490	8,090	1,820	9,280
(Evaporation on Banked Storage[4])		(1,160)		(1,250)
Total	40,000	40,000	40,000	40,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage is calculated only during the drought and is included in Canyon Firm Yield.

Table C-8
Scenario #1 Diversion of 75,000 acft/yr at Gonzales from Enhanced Springflows, Unappropriated Streamflow, and Canyon Firm Yield (Alternative G-38)

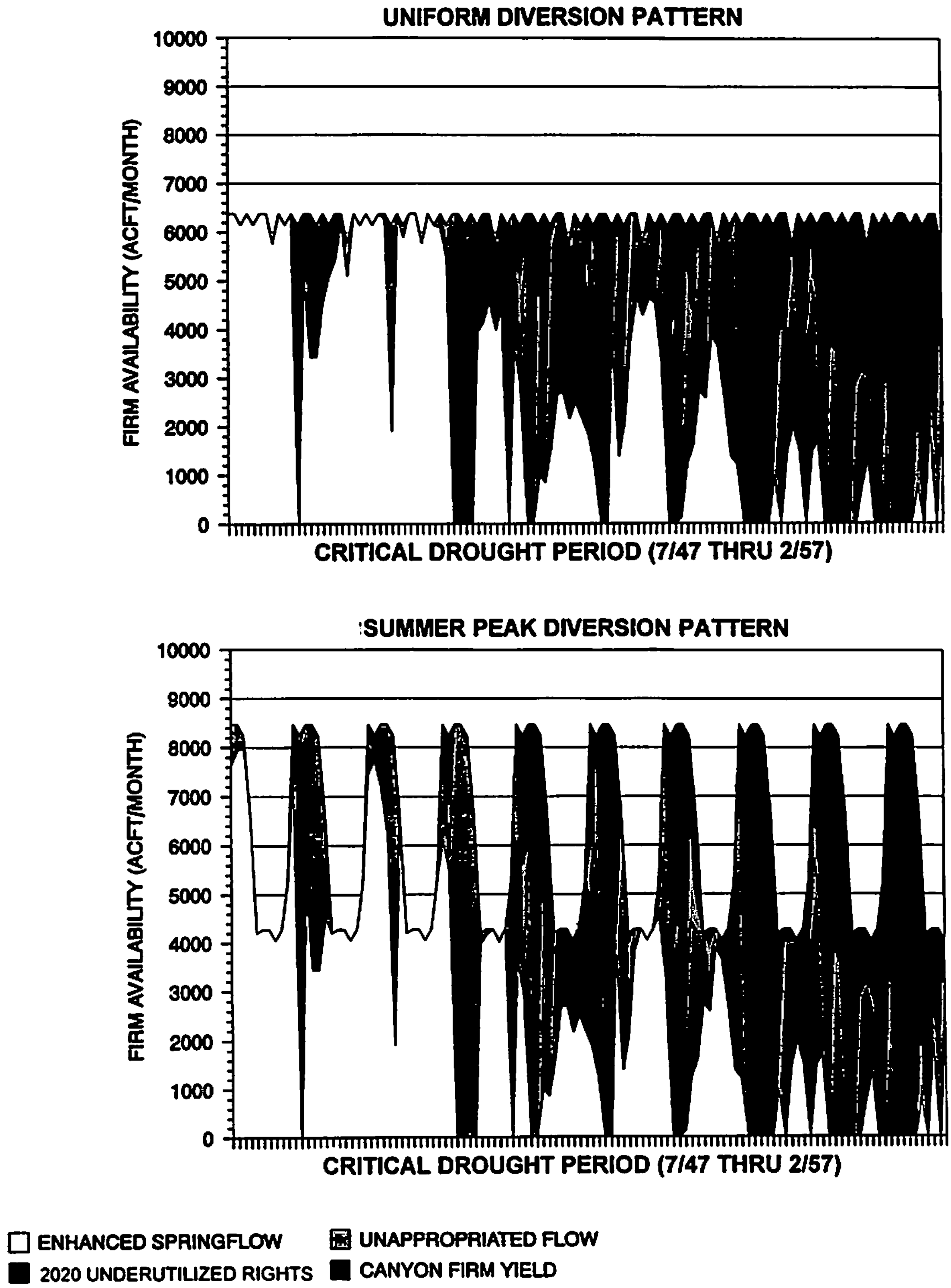
Water Source Scenario #1	Uniform Diversion		Summer Peak Diversion (With Storage)	
	Average(1) (acft/yr)	Drought(2) (acft/yr)	Average(1) (acft/yr)	Drought(2) (acft/yr)
Enhanced Springflow	60,960	32,900	57,370	30,670
Unappropriated Streamflow	1,970	1,480	2,710	1,820
Year 2020 Underutilized Rights	0	0	0	0
Subtotal	62,930	34,380	60,080	32,490
Canyon Firm Yield(3) (Evaporation on Banked Storage(4))	12,070	44,360 (3,740)	14,920	45,770 (3,260)
Total	75,000	75,000	75,000	75,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage is calculated only during the drought and is included in Canyon Firm Yield.

Table C-9
Scenario #2 Diversion of 75,000 acft/yr at Gonzales from Enhanced Springflows, Water Rights Transfer, Unappropriated Streamflow, and Canyon Firm Yield (Alternative G-38)

Water Source Scenario #2	Uniform Diversion		Summer Peak Diversion (With Storage)	
	Average(1) (acft/yr)	Drought(2) (acft/yr)	Average(1) (acft/yr)	Drought(2) (acft/yr)
Enhanced Springflow	60,960	32,900	57,370	30,670
Unappropriated Streamflow	780	1,170	1,130	1,300
Year 2020 Underutilized Rights	9,100	22,080	11,370	21,990
Subtotal	70,840	56,150	69,870	53,960
Canyon Firm Yield(3) (Evaporation on Banked Storage(4))	4,160	21,930 (3,080)	5,130	24,060 (3,020)
Total	75,000	75,000	75,000	75,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage is calculated only during the drought and is included in Canyon Firm Yield.



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HDR Engineering, Inc.

GUADALUPE RIVER AT GONZALES
75,000 ACFT/YR DIVERSION
ALT. G-38, SCENARIO #2

FIGURE C-2

Firm Availability at Gonzales with Diversions at Lake Dunlap (Alternative G-39)

Sources of water for the firm annual diversion of 35,000 acft/yr or 60,000 acft/yr from the Guadalupe River at Gonzales under general source Scenarios #1 and #2 in combination with respective diversions from Lake Dunlap of 5,000 acft/yr and 15,000 acft/yr are summarized in Tables C-10 through C-13. Diversions of 5,000 acft/yr and 15,000 acft/yr from Lake Dunlap were assumed to be purchased from the firm yield of Canyon Lake, hence, all run-of-the-river diversions were assumed to be made at Gonzales. Balancing storage was included for Alternative G-39 to facilitate down-sizing of the transmission line from Gonzales to the water treatment plant. Key observations upon review of Tables C-10 through C-13 include the following:

1) Enhanced springflow and purchase from the firm yield of Canyon Lake are the primary sources of water potentially available for diversion under Alternative G-39. Availability of unappropriated streamflow is severely limited by the draft Environmental Water Needs Criteria of the Consensus Planning Process and the diversion of water available from other sources.
2) Combined firm availability of 40,000 acft/yr can be obtained both with (Scenario #2) and without (Scenario #1) water rights transfers (see Tables C-10 and C-11). Combined firm availability of 75,000 acft/yr, however, cannot be obtained without water rights transfers (see Table C-12) because the necessary allocation of Canyon Lake firm yield would significantly exceed the uncommitted firm yield.
3) Allocation of between 12,140 acft/yr and 22,390 acft/yr of the firm yield of Canyon Lake (assuming full subordination of hydropower rights to Canyon Lake) would be necessary to ensure combined firm availability of 40,000 acft/yr. Combined firm availability of 75,000 acft/yr could be obtained with the allocation of between 32,600 acft/yr and 49,740 acft/yr of the firm yield of Canyon Lake.
4) For combined firm availability of 40,000 acft/yr, diversions of enhanced springflow would average between 18,670 acft/yr and 20,430 acft/yr during the drought and between 29,700 acft/yr and 30,620 acft/yr over the long-term.
5) For combined firm availability of 75,000 acft/yr, diversions of enhanced springflow would average between 26,730 acft/yr and 28,840 acft/yr during the drought and between 48,000 acft/yr and 50,220 acft/yr over the long-term.
6) An average of less than 1,210 acft/yr of unappropriated water would be diverted under any scenario because of limitations imposed by the draft environmental criteria and/or availability from other sources.

Refer to Section 3.6 of this report for additional information regarding Alternative G-39.

Table C-10
Diversion of 35,000 acft/yr at Gonzales and 5,000 acft/yr at Lake Dunlap from Enhanced Springflows, Unappropriated Streamflow, and Canyon Firm Yield (Alternative G-39)

Water Source Scenario #1	Uniform Diversion Average[1] (acft/yr)	Uniform Diversion Drought[2] (acft/yr)	Summer Peak Diversion (With Storage) Average[1] (acft/yr)	Summer Peak Diversion (With Storage) Drought[2] (acft/yr)
Enhanced Springflow	30,620	20,430	29,700	18,670
Unappropriated Streamflow	250	360	260	490
Year 2020 Underutilized Rights	0	0	0	0
Subtotal	30,870	20,790	29,960	19,160
Canyon Firm Yield (Lake Dunlap)	5,000	5,000	5,000	5,000
Canyon Firm Yield (Gonzales)[3]	4,130	15,860	5,040	17,390
(Evaporation on Banked Storage[4])		(1,650)		(1,550)
Total	40,000	40,000	40,000	40,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage is calculated only during the drought and is included in Canyon Firm Yield.

Table C-11
Diversion of 35,000 acft/yr at Gonzales and 5,000 acft/yr at Lake Dunlap from Enhanced Springflows, Water Rights Transfer, Unappropriated Streamflow, and Canyon Firm Yield (Alternative G-39)

Water Source Scenario #2	Uniform Diversion Average[1] (acft/yr)	Uniform Diversion Drought[2] (acft/yr)	Summer Peak Diversion (With Storage) Average[1] (acft/yr)	Summer Peak Diversion (With Storage) Drought[2] (acft/yr)
Enhanced Springflow	30,620	20,430	29,700	18,670
Unappropriated Streamflow	100	160	60	220
Year 2020 Underutilized Rights	2,970	8,300	3,630	8,980
Subtotal	33,690	28,890	33,390	27,870
Canyon Firm Yield (Lake Dunlap)	5,000	5,000	5,000	5,000
Canyon Firm Yield (Gonzales)[3]	1,310	7,140	1,610	8,240
(Evaporation on Banked Storage[4])		(1,030)		(1,110)
Total	40,000	40,000	40,000	40,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage is calculated only during the drought and is included in Canyon Firm Yield.

Table C-12
Diversion of 60,000 acft/yr at Gonzales and 15,000 acft/yr at Lake Dunlap from Enhanced Springflows, Unappropriated Streamflow, and Canyon Firm Yield (Alternative G-39)

Water Source Scenario #1	Uniform Diversion Average[1] (acft/yr)	Uniform Diversion Drought[2] (acft/yr)	Summer Peak Diversion (With Storage) Average[1] (acft/yr)	Summer Peak Diversion (With Storage) Drought[2] (acft/yr)
Enhanced Springflow	50,220	28,840	48,000	26,730
Unappropriated Streamflow	890	1,000	1,210	1,170
Year 2020 Underutilized Rights	0	0	0	0
Subtotal	51,110	29,840	49,210	27,900
Canyon Firm Yield (Lake Dunlap)	15,000	15,000	15,000	15,000
Canyon Firm Yield (Gonzales)[3]	8,890	33,080	10,790	34,740
(Evaporation on Banked Storage[4])		(2,920)		(2,640)
Total	75,000	75,000	75,000	75,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage is calculated only during the drought and is included in Canyon Firm Yield.

Table C-13
Diversion of 60,000 acft/yr at Gonzales and 15,000 acft/yr at Lake Dunlap from Enhanced Springflows, Water Rights Transfer, Unappropriated Streamflow, and Canyon Firm Yield (Alternative G-39)

Water Source Scenario #2	Uniform Diversion Average[1] (acft/yr)	Uniform Diversion Drought[2] (acft/yr)	Summer Peak Diversion (With Storage) Average[1] (acft/yr)	Summer Peak Diversion (With Storage) Drought[2] (acft/yr)
Enhanced Springflow	50,220	28,840	48,000	26,730
Unappropriated Streamflow	390	790	580	950
Year 2020 Underutilized Rights	5,980	15,280	7,220	15,330
Subtotal	56,590	44,910	55,800	43,010
Canyon Firm Yield (Lake Dunlap)	15,000	15,000	15,000	15,000
Canyon Firm Yield (Gonzales)[3]	3,410	17,600	4,200	19,490
(Evaporation on Banked Storage[4])		(2,510)		(2,500)
Total	75,000	75,000	75,000	75,000

(1) Average based on 1/34 through 12/89 period.
(2) Drought based on 7/47 through 2/57 critical drawdown period for Canyon Lake.
(3) In any single year, water from Canyon Lake firm yield may vary from almost zero to more than twice the drought average shown.
(4) Evaporation on banked storage is calculated only during the drought and is included in Canyon Firm Yield.

APPENDIX D

ENDANGERED AND THREATENED SPECIES TABLES

APPENDIX D -- TABLE 1
PROTECTED ENDANGERED AND THREATENED SPECIES, BEXAR COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184))

Common Name	Scientific Name	Habitat Preference	Listing USFWS	Agency TPWD	Potential Occurrence in County
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	E	E	[1]winter transient
Black-capped vireo	*Vireo atricapillus*	Semi-open Broad-leaved shrublands	E	E	nesting/migratory
Golden-cheeked Warbler	*Dendroica chrsoparia*	Woodlands with oaks and old juniper	E	E	nesting/migrant
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	[1]migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	[1]migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	[1]migratory
Swallow-Tailed Kite, American	*Elanoides forficatus*	Open wooded and forested areas; southern U.S. coastal plains	NL	T	[1]transient
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	[1]migratory
Wood Stork	*Mycteria americana*	Post-breeding; in wetlands of the coastal plain, major waterways, and lower Mississippi valley	E [2]	T	dispersal
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas Islands	E	E	[1]migratory
Zone-tailed Hawk	*Buteo albonotatus*	Canyons and wooded river bottoms in Southwest U.S.A.	NL	T	endemic
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1	NL	[3]endemic
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground are avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-November	NL	T	endemic
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Native grass prairies of South Texas Plains; usually thorn brush, mesquite-blackbrush	NL	T	[1]probable
Texas Horned Lizard	*Phrynosoma cornutum*	Open arid and semi-arid regions with sparse vegetation including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky, burrows in soil, enters rodent burrow, or hides under rocks when inactive	C2	T	endemic
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thorn brush woodland and mesquite savannah of coastal plain	NL	T	[1]endemic
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures	C2	NL	[3]endemic

APPENDIX D -- TABLE 1 (CONCLUDED)

Common Name	Scientific Name	Habitat Preference	Listing USFWS	Agency TPWD	Potential Occurrence in County
Timber Rattlesnake	*Crotalus horridus*	Bottomland hardwoods	NL	T	[1]possible
Blind Texas Salamander	*Typhlomolge rathbuni*	Edwards Aquifer springs and caves, thermally stable; troglobitic	E	E	[3]endemic
Toothless Blindcat	*Trogloglanis pattersoni*	Edwards Aquifer; subterranean; from artesian wells in Bexar Co., TX; troglobitic [4;6]	C2	T	endemic
Widemouth Blindcat	*Satan eurystomus*	Edwards Aquifer; subterranean; from artesian wells in Bexar Co., TX; troglobitic [4;5]	C2	T	endemic
Texas Cave Diving Beetle	*Haideoporus texanus*	Edwards Aquifer subterranean caverns[7;8;9;10]	C2	NL	endemic
Balcones Cave Amphipod	*Stygobromus balconis*	Limestone caves [10]	C2	NL	endemic
Bifurcated Cave Amphipod	*Stygobromus bifurcatus*	Spring openings [10]	C2	NL	endemic
Texas Cave Shrimp	*Palaemonetes antrorum*	Ezell's Cave and Edwards Aquifer subterranean caverns [7;8]	C2	NL	endemic
Mimic Cave Snail	*Phreatodrobia imitata*	Edwards Aquifer subterranean caverns; from artesian wells in Bexar Co., TX; troglobitic [11]	C2	NL	endemic
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer	3C	NL	endemic
Silvery Wild Mercury	*Argythamnia argyraea*	South Texas Plains, perennial herb, also in Kinney, LaSalle and Maverick Counties	3C	NL	endemic

APPENDIX D -- TABLE 2
PROTECTED ENDANGERED AND THREATENED SPECIES, COMAL COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184)

Common Name	SCIENTIFIC NAME	HABITAT PREFERENCE	LISTING USFWS	AGENCY TPWD	POTENTIAL OCCURRENCE IN COUNTY
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby roosting/resting sites	E	E	wintering / transient
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
	Falco peregrinus tundrius	Open coastal areas	T	T	migratory
COMMON NAME					
Swallow-tailed Kite, American	*Elanoides forficatus*	Varied, open land with tall trees for nesting	3C	T	resident
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	resident
Zone-tailed Hawk	*Buteo albonotatus*	Semi-aird canyon edges of Southwest U.S.	NL	T	historic nesting
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	nesting/migrant
Golden-cheeked Warbler	*Dendroica chrsoparia*	Woodlands with oaks and old juniper	E	E	nesting/migrant
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory
Whistling - duck, Fulvous	*Dendrocygna bicolor*	Ponds and freshwater marshes	C2	NL	resident
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	resident
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork	*Mycteria americana*	Post-breeding; in wetlands of the coastal plain, major waterways, and lower Mississippi valley	E[2]	T	dispersal
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	3C	NL	resident
Texas Horned Lizard	*Phrynosoma cornutum*	Open arid and semi-arid regions with sparse vegetation; grass, cactus, scattered brush; soil may vary from sandy to rocky, burrows in soil, rodent burrow, or hides under rocks	C2	T	resident
Texas Garter Snake	*Thamnophis sirtalis annectans*	Varied, especially moist habitats	C2	NL	resident
Timber Rattlesnake	*Crotalus horridus*	Bottomland hardwoods	NL	T	[1] possible
Texas Mock-Orange	*Philadelphus texensis*	On limestone bluffs and among boulders on the Edwards Plateau	C2	NL	resident

APPENDIX D -- TABLE 3
PROTECTED ENDANGERED AND THREATENED SPECIES, GONZALES COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC 65.171 - 174 & 65.181 - 184)

Common Name	Scientific Name	Habitat Preference	Listing USFWS	Agency TPWD	Potential Occurrence in County
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites; nesting in riparian forests near water	E	E	migratory
Golden-cheeked Warbler	*Dendroica chrsoparia*	Woodlands with oaks and old juniper	E	E	[1] possible
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Reddish Egret	*Egretta rufescens*	Coastal wetland islands	C2	T	endemic
Swallow-Tailed Kite, American	*Elanoides forficatus*	Open forested areas	3C	T	migratory
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	endemic
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	migratory
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating
Wood Stork	*Mycteria americana*	Post-breeding; in wetlands of the coastal plain, major waterways, and lower Mississippi valley	E[2]	T	dispersal
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1	NL	[2] endemic
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground are avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov.	NL	T	probable
Siren, Lesser, Rio Grande	*Siren intermedia texana*	Wet or temporally wet areas, arroyos,canals,ditches and shallow depressions; requires moisture to remain	C2	E	endemic

APPENDIX D -- TABLE 3 (CONCLUDED)

Texas Horned Lizard	*Phrynosoma cornutum*	Open arid and semi-arid regions with sparse vegetation including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky, burrows in soil, rodent burrow, or hides under rocks when inactive	C2	T	endemic
Timber Rattlesnake	*Crotalus horridus*	Bottomland woodlands, dense thickets	NL	T	[2] endemic
Blue Sucker	*Cycleptus elongatus*	Large rivers throught the Mississippi Basin; In Texas, major streams southward to the Rio Grande	C2	T	[1] possible
Guadalupe Bass	*Micropterus treculi*	Rivers of the Edwards Plateau including portions of the Brazos, Colorado, Guadalupe, and San Antonio River Basins; also the lower Colorado River and introduced in the Nueces River system	C2	NL	[1] possible

APPENDIX D -- TABLE 4
PROTECTED ENDANGERED AND THREATENED SPECIES, GUADALUPE COUNTY, TEXAS
LISTED BY THE U.S. DEPARTMENT OF THE INTERIOR (50 CFR 17.11 & 17.12, AUGUST 23, 1993) CANDIDATE SPECIES (50 CFR 17, NOVEMBER 15, 1994)
AND TEXAS PARKS AND WILDLIFE DEPARTMENT (31 T.A.C. SEC. 65.171 - 174 & 65.181 - 184)

Common Name	Scientific Name	Habitat Preference	Listing USFWS	Agency TPWD	Potential Occurrence in County
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby roosting/resting sites	E	E	wintering / transient
Peregrine Falcon, American	*Falco peregrinus anatum*	Open coastal areas	E	E	migratory
Peregrine Falcon, Arctic	*Falco peregrinus tundrius*	Open coastal areas	T	T	migratory
Swallow-tailed Kite, American	*Elanoides forficatus*	Varied, open land with tall trees for nesting	3C	T	resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	nesting/migrant [1]
Golden-cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	nesting/migrant
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E	migratory
White-faced Ibis	*Plegadis chihi*	Freshwater marshes	C2	T	resident
Whooping Crane	*Grus americana*	Coastal wetlands; Matagorda & Aransas islands	E	E	migrating transient
Wood Stork	*Mycteria americana*	Coastal wetlands	E**	T	dispersal
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands	C2	T	resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	3C	NL	resident
Texas Garter Snake	*Thamnophis sirtalis annectans*	Varied, especially moist habitats	C2	NL	resident
Timber Rattlesnake	*Crotalus horridus*	Bottomland hardwoods	NL	T	potential
Blue Sucker	*Cycleptus elongatus*	Rivers crossing eastern Edwards Plateau to coast	C2	T	resident
Guadalupe Bass	*Micropterus terculi*	Streams of eastern Edwards Plateau	C2	NL	resident

APPENDIX D -- TABLE 4 (CONCLUDED)

Common Name	Scientific Name	Habitat Preference	Listing USFWS	Agency TPWD	Potential Occurrence in County
Fountain Darter	*Etheostoma fonticola*	San Marcos River to confluence with Blanco River; associated with San Marcos Salamander in quite, clear water	E	E	resident
San Marcos Gambusia	*Gambusia georgei*	San Marcos River to confluence with Blanco River, large clear spring-fed river	E	E	resident, possibly extinct
Big Red Sage	*Salvia penstemonoides*	Moist rich ledges, rocky level creek floodplain; reintroduced through native plant nursey trade	C2	NL	historic endemic

Symbols under listing agency are as follows: C1-USFWS Candidate for protection with substantial information to support appropriateness of listing in USFWS files; C2-USFWS Candidate Category for protection; E-Endangered; T-Threatened; NL- not listed

[1] Source: TPWD, 05/09/88

[2] Endangered populations Alabama, Florida, Georgia, North Carolina, South Carolina

[3] Dixon, 1987

[4] Longley & Karnei 1979a,

[5] Longley & Karnei 1979b,

[6] Longley, 1979;

[7] W.R. Elliot, pers. com. January 1993;

[8] Sissom & Davis 1979;

[9] Young & Longley, 1976;

[10] J. R. Reddell, pers. com. January 1993;

[11] Hershler & Longley, 1986

Source for all other occurences in county: Texas Natural Heritage Program files, January, 1996

APPENDIX E

TEXAS WATER DEVELOPMENT BOARD'S MUNICIPAL WATER DEMAND PROJECTIONS METHODOLOGY

MUNICIPAL WATER DEMAND PROJECTIONS METHODOLOGY[1]

The quantity of water used for municipal purposes in Texas is heavily dependent on population growth, climatic conditions, and water conservation measures. For planning purposes, municipal water use comprises both residential and commercial water uses. Commercial water use includes business establishments, public offices, and institutions, but does not include industrial water use. Residential and commercial uses are categorized together because they are similar types of uses, i.e., they both use water primarily for drinking, cleaning, sanitation, air conditioning, and landscape watering.

The methodology for forecasting municipal water use relies on three primary components:

1) Population forecasts of the state, counties, cities, towns, and rural areas of counties;

2) Per capita (per person) municipal water use forecasts of cities, towns, and rural areas of counties; and

3) Improved water use efficiency due to the implementation of conservation measures.

<u>Population as a Component of Municipal Water Use Projections</u>

The population projections methodology and procedures used in the consensus planning process provides for the estimation of alternative future populations for each specific municipality and rural area of Texas. The latest population estimates published by the U.S. Bureau of the Census indicate that Texas currently ranks as the second most-populated state in the nation, with a population of more than 18.3 million. A large and increasing population will continue to place pressure on the state's water resources to provide sufficient quantities of water to meet local and regional municipal water needs. Because population is a causal factor associated with municipal water use, the TWDB develops population projections for use in assessing potential future municipal water needs. The methodology, assumptions, scenarios, and data sources used in the development of the consensus population projections are presented below.

Population Forecasting Methodology and Key Planning Assumptions: The technique for projecting population is a cohort-component procedure, which uses the separate cohorts (age/sex/race/ethnic groups) and components of cohort change (fertility rates, survival rates, and migration rates) to calculate future populations. Projections of each cohort are then summed to the total population. Cohorts used in the projection process are defined as single-year-of-age (0 to 75) cohorts by sex and race/ethnic groups, which include Anglo, Black, Hispanic, and Other. Anglos are defined as persons of white non-Spanish origin; Blacks are defined as persons of Black non-Spanish origin; Hispanics are defined as persons of Spanish origin of all racial and ethnic groups; and Other is defined as those persons of other race/ethnic groups of non-Spanish or non-Black origin.

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[1] Quoted from Texas Water Development Board's unpublished Water Planning information that is being used in development of the 1996 Texas Water Plan; Austin, Texas, 1996.

Many counties in Texas have special populations generally referred to as "institutional" populations. These are people who are assumed not to participate in the same demographic processes as the base population and generally tend to move in and out of these institutional arrangements in fixed intervals. More specifically, these groups are defined as college/university populations, military populations, prison populations, and populations in other institutional arrangements. Institutional populations are removed from the base population for computing future cohort populations, but are added back into the total projected base cohort population at the end of each projection interval.

The components of cohort change include fertility rates, survival rates, and migration rates. Fertility rates for each female cohort are incorporated into the projection procedure for calculating the number of births anticipated to occur between each projection interval. Survival rates for each cohort are used to compute the change in the number of cohorts relating to the number of deaths anticipated to occur between each projection interval. Migration rates for each cohort are used to compute the change in each cohort due to immigration or emigration in a specific locale.

Key assumptions used in developing the population projections are associated with the demographic components of change for each cohort and are described below:

1) Consistent with the planning information made available from the State Data Center, fertility rates for Anglo females are trended downward through the year 2010 and held constant at the 2010 rate through the year 2050; and fertility rates for Black, Hispanic, and Other females are trended downward through the year 2030 and held constant at the 2030 rate through the year 2050.

2) Survival rates are assumed to follow national trends over the projection period.

3) Migration rates are set to the 1980-1990 base period rates for each county and are varied from this base data set in accordance with the alternatively defined projection scenarios.

The projected county population is allocated to each city of 1,000 or more population based on each city's historic share of the county population. The rural or "country-other" population is calculated as the residual of the sum of the cities' projected population and the projected county population.

Forecasting Scenarios: Three population projection scenarios, based on varying the 1980-1990 migration rates, were selected to project a range of alternative future populations. The three population projection scenarios are presented below:

1) 0.0 Migration: Zero net migration over the projection period. Only the natural increase or decrease in population is assumed.

2) 0.5 Migration: One-half of the 1980-1990 migration rate is assumed to occur over the projection period.

3) 1.0 Migration: The 1980-1990 migration rate is assumed to occur over the projection period.

From this range of population projections, consensus planning staff and the Water Demand/Drought Management TAC approved a "most likely growth" scenario for each of the 254 counties, based on recent and prospective growth trends and their combined professional opinions.

Data Sources: The development of the population forecasts incorporated a number of data sources and information files based on the 1990 Census data obtained from Dr. Steve Murdock, Chief Demographer for the Texas State Data Center and Texas A&M University. These data sources included the following:

1) 1990 Population by Cohort (Age, Sex, and Race/Ethnic Groups) Modified for Age and Race/Ethnicity.

2) 1990 Institutional Populations (Prison Populations, College Populations, Military Populations, and Other Populations in Institutional Arrangements).

3) Projected Fertility Rates by Age and Race/Ethnic Groups.

4) Projected Survival Rates by Single Years of Age, Sex, and Race/Ethnic Groups.

5) 1980-1990 Migration Rates by Single-Year Estimates and Cohort.

Per Capita Water Use and Weather Influences

The quantity of water used for municipal purposes is reported to the Texas Water Development Board on an annual basis by cities and other water suppliers such as rural water supply corporations, municipal utility districts, fresh water supply districts, and other types of water suppliers. The types of information reported include ground water and/or surface water use, source of the water (aquifer, river, reservoir, or stream), water sales and water purchases to other municipalities and end-users, number of service connections, estimated population served, and other pertinent information. This information provides for the identification of the water use and water supply network for each geographical area of Texas.

In calculating the per capita water use for a specific entity, all water sales to other municipalities, industries, or other utilities are removed from the reported total water produced (pumpage or diversions) in order to arrive at the quantity of water used for municipal purposes by that specific entity. Annual per capita water use, typically stated in gallons per capita daily (gpcd), is then calculated by dividing the adjusted reported annual water use for a specific entity by its estimated annual population. Annual population estimates developed by the State Data Census Population Estimation Program are used for calculating city per capita water use.

The diversity of the state with respect to climatic conditions, population density, and the availability of water is indicative of the wide range of per capita water use estimates by geographical area across the state, as well as the varying quantities of water used on an annual basis. From a climatological perspective, rainfall conditions play a major role in the quantity of water used for municipal purposes, particularly for outdoor purposes. During below-normal rainfall conditions, people tend to use more water than during normal or average weather conditions. To portray this weather-related phenomenon, two types of per capita water use estimates were calculated for use in the consensus water planning efforts. One estimate assumes ~~a~~ below normal rainfall conditions; the other assumes normal weather conditions. These two estimates were incorporated into two separate scenarios of municipal water use forecasts.

To better represent current-day water use plumbing, appliances, and conservation technology, the assumed normal weather per capita water use is based on the average per capita water use over the last five years of record (1987-1991) for each entity. The assumed below-normal rainfall condition per capita water use is based on the highest per capita water use recorded by an entity over the last ten years of record (1982-1991). For planning purposes, the assumed below-normal rainfall per capita water use variable is constrained to an upper limit of 25 percent above the calculated (five year average) normal condition per capita water use variable. This constraint was used as an adjustment for water conservation practices put in place after 1985.

Municipal Water Conservation

Municipal water conservation is increasingly recognized by water utilities as a very cost-effective approach for extending water supplies. In addition, many conservation strategies are simply good management alternatives. Staffs of the three agencies have estimated a likely range of water conservation savings that could be attained over the 1990-2050 planning period. These are included in alternative municipal water use forecast scenarios. These potential savings are based on assumptions regarding the rate of implementation of indoor plumbing conservation measures as well as the rates of implementation of conservation measures in seasonal, dry-year irrigation, and other municipal water uses. These four municipal use sub-categories and associated potential savings assumptions are presented below:

Components of Municipal Water Conservation Savings

Areas of Potential Municipal Water Use Savings	**Expected Conservation Savings**	**Advanced Conservation Savings**
Indoor Plumbing Savings	20.5 gallons per capita daily	21.7 gallons per capita daily
Seasonal Water Savings	7.0% of total seasonal use	20% of total seasonal use
Dry-Year Irrigation Savings	10.5% of dry-year seasonal use	20% of dry-year seasonal use
Other Municipal Savings	5% of total average yearly use	7.5% of total average year use

A primary assumption associated with the definition of the "expected" municipal water conservation case is that these levels of savings are likely to occur from both market forces and regulatory requirements. The typical plumbing fixtures and appliances available for purchase are noticeably more water-efficient than those sold in earlier decades. The availability of water efficient landscaping in the marketplace and improved landscaping practices are changing outdoor water uses. Better public education on efficient indoor and outdoor water uses and pricing "signals" from the marketplace are also changing consumer behavior.

In addition to the market-type forces, a driving force underlying the expected municipal water conservation savings is the likely effect produced by the State Water-Efficient Plumbing Act passed in 1991. Not only are these potential water savings from the implementation of the Act substantial, but they are also economically sound from a cost-saving perspective, do not require day-to-day behavior changes by the consumer, affect the larger year-round base water use, and will occur with a relatively high degree of predictability.

The primary difference between the expected and advanced conservation savings scenarios is one of timing. The majority of the additional savings reflected in the advanced conservation case arises from accelerating the effect of the plumbing bill with municipal utilities engaging in active water-efficient plumbing retro-fit programs. Some additional savings are from slightly more aggressive assumptions on seasonal, dry-year urban irrigation, and other municipal uses. The advanced conservation scenario represents the maximum technical potential for water conservation savings. The expected scenario represents feasible strategies for water conservation savings that are economically sound.

Unique projected water conservation savings patterns were projected for each individual municipality and rural area considered in the forecasts, as well as for the state as a whole. These projected savings estimated by the consensus planning staff are provided as guidelines for regional and local water planners and managers. Although staffs of the three agencies feel the identified array of conservation measures embodied in the projections are reasonable and feasible, the particular selection of specific water conservation goals and implementation of strategies to achieve those goals are primary responsibilities of the utility manager and local government.

Each entity's projected municipal water conservation savings (measured in gallons) are subtracted from the appropriate estimated value of the two per capita water use scenarios, the assumed below-normal rainfall conditions and the assumed normal weather conditions. In most instances, this calculation results in declining per capita water use for each city and community. An example of how the expected and advanced conservation cases affect the two per capita water use scenarios is presented below.

Impact of Municipal Water Conservation Savings on State Average Per Capita Water Use

Below-Normal Rainfall Conditions*

	2000	2010	2020	2030	2040	2050
Planning Per Capita Use	189	189	189	189	189	189
Expected Case Conservation	181	172	164	160	157	156
Advanced Case Conservation	175	161	151	149	147	146
Plumbing Code Only	185	179	175	171	168	167

Normal Weather Conditions

	2000	2010	2020	2030	2040	2050
Planning Per Capita Use	165	165	165	165	165	165
Expected Case Conservation	157	149	141	137	134	133
Advanced Case Conservation	152	140	130	128	126	125
Plumbing Code Only	160	155	150	146	143	142

* Highest annual per capita water use over the last 10 years, constrained to an upper limit of 25 percent above the normal conditions per capita water use.

Calculation of Municipal Water Use

Estimates of future municipal water use are then computed by multiplying the projected population of an entity's projected per capita water use, adjusted for conservation savings. The projected municipal water use is then converted to an annual acre-foot measure.