TRANS-TEXAS WATER PROGRAM

West Central Study Area Phase I Interim Report

Volume 3

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

November, 1994

HDR

HDR Engineering, Inc.
in association with
Paul Price Associates, Inc.
LBG-Guyton Associates
H. B. Zachry Company

TRANS-TEXAS WATER PROGRAM
WEST CENTRAL STUDY AREA

PHASE I
INTERIM REPORT

VOLUME 3

Prepared for

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Guadalupe-Blanco River Authority
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by

HDR Engineering, Inc.
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November, 1994

TRANS-TEXAS WATER PROGRAM
WEST CENTRAL STUDY AREA
PHASE I INTERIM REPORT

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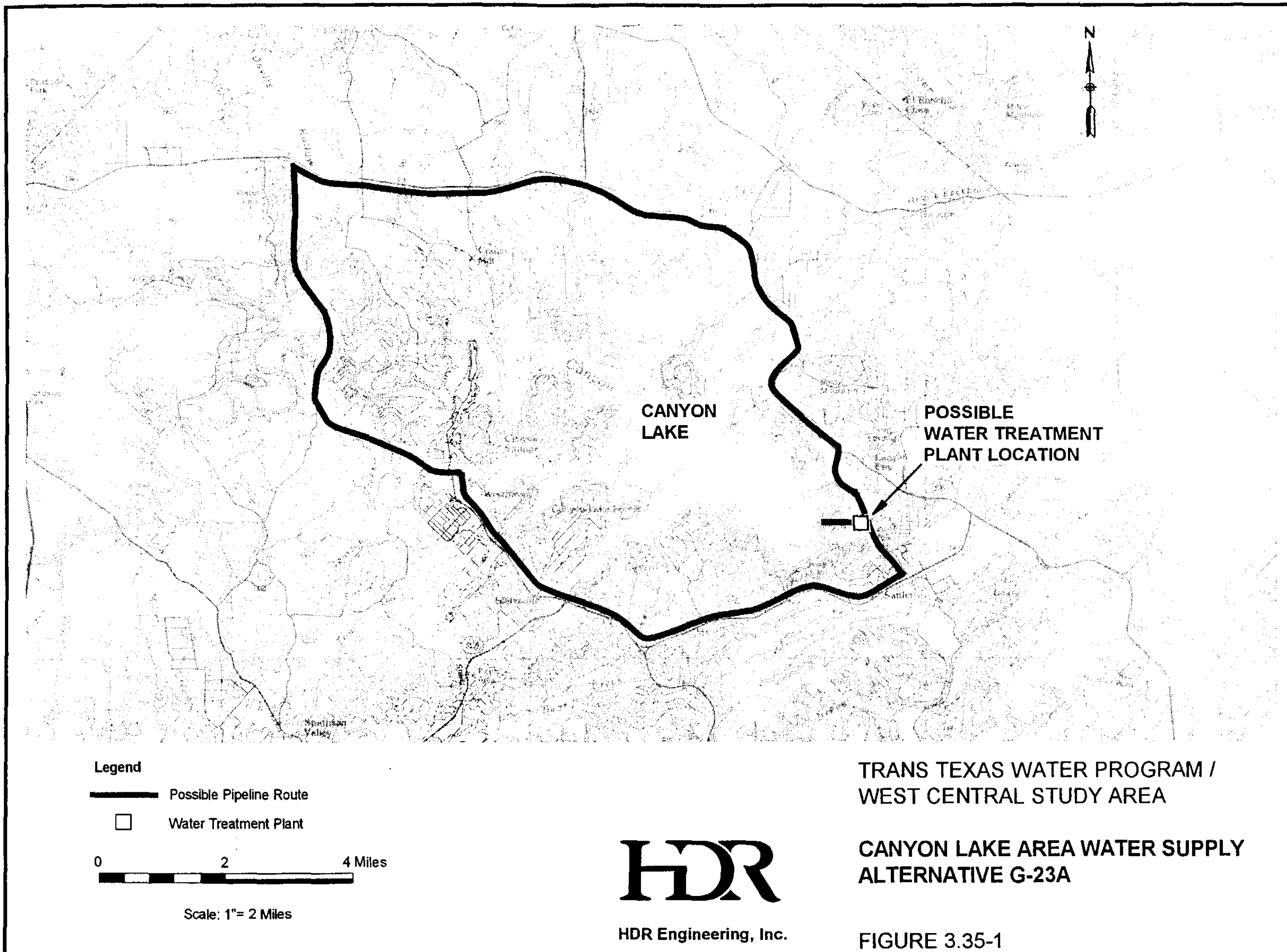

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TRANS TEXAS WATER PROGRAM /
WEST CENTRAL STUDY AREA

CANYON LAKE AREA WATER SUPPLY ALTERNATIVE G-23A

FIGURE 3.35-1

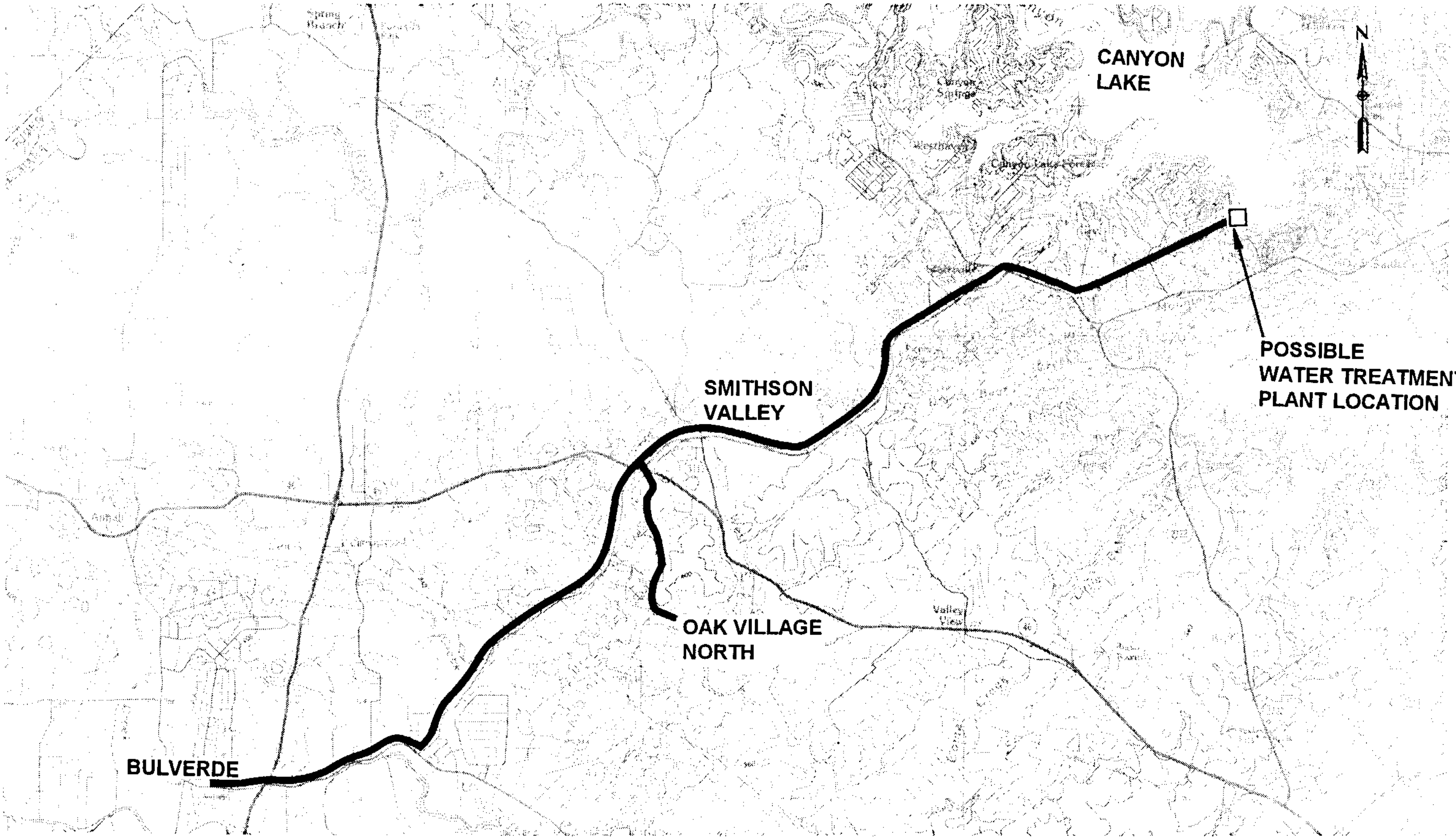
3.35 Canyon Lake Regional Plan (G-23)

3.35.1 Description of Area with Projections of Population and Water Demand

Construction of Canyon Lake was completed in 1964 and since that time, residential subdivisions have been platted around the lake and are being developed for both permanent homes and as dwellings for weekend and holiday visitors. To the southwest of Canyon Lake, in the scenic hill country of Comal County, the residential subdivisions of Smithson Valley, Oak Village North, and Bulverde have also been developing. These areas are shown on Figures 3.35-1 and 3.35-2. In both the lakeside and hill country subdivisions, water has been supplied to individual residences (homes and condominiums) by private water supply systems that are classified and regulated by the Texas Natural Resource Conservation Commission (TNRCC) as public water systems. The source of water for these systems is the underlying Trinity Group Aquifer, which is not adequate over the long term to meet the demands upon it, according to studies sponsored by the TWDB. Thus, a surface water system is needed in order to meet both the present needs and for growth.

The Canyon Lake Regional Plan, as conceptualized in this study, consists of two separate water supply systems. One system would consist of a water treatment plant and treated water storage facilities located at Canyon Lake, with pipelines from the treatment plant to convey treated Canyon Lake water on a wholesale basis to the existing water supply systems around Canyon Lake (see Figure 3.35-1). The other system would contain similar facilities sized to supply Smithson Valley, Oak Village North, and Bulverde (see Figure 3.35-2) for wholesale delivery to existing subdivision distribution systems. In the following discussion, the Texas Water Development Board (TWDB) high case, with conservation projections are given of population and the quantities of water needed for the Canyon Lake Regional System for the years 2000, 2010, 2020, 2030, 2040, and 2050. In addition, cost estimates are given for a treatment plant, storage facilities, and pipelines to convey treated water from the treatment plant to the subdivision wholesale delivery points.

The population of the Canyon Lake regional water demand area, including estimates of temporary (weekend and holiday visitors) residents was 12,540 in 1990 and is projected to increase to 19,159 by 2000, to 33,837 by 2020, and to 53,028 by 2050 (Table 3.35-1). Of these totals, 78 percent was in subdivisions located around Canyon Lake in 1990, and 83 percent would be in Canyon Lake Subdivisions in 2050 (Table 3.35-1).



Legend

Possible Pipeline Route

Water Treatment Plant

0 2 4 Miles

Scale: 1"= 2 Miles

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TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

CANYON LAKE AREA WATER SUPPLY ALTERNATIVE G-23B

FIGURE 3.35-2

Table 3.35-1
Population and Water Demand Projections
Canyon Lake Area

Area/Projection	1990 Actual	Projection Date 2000	2010	2020	2030	2040	2050
Population [1]							
Canyon Lake Area							
Permanent Residents [2]	7,340	10,353	13,914	17,811	21,711	25,198	27,834
Temporary Residents [3]	2,500	5,000	7,500	10,000	12,500	15,000	16,000
Subtotal	9,840	15,353	21,414	27,811	34,211	40,198	43,834
Smithson Valley	600	846	1,086	1,339	1,582	1,813	2,044
Oak Village North	750	1,057	1,357	1,674	1,977	2,265	2,553
Bulverde	1,350	1,903	2,443	3,013	3,559	4,078	4,597
Total	12,540	19,159	26,300	33,837	41,329	48,354	53,028
Water Demand (ac-ft) [4]							
Canyon Lake Area							
Permanent Residents [5]	1,233	1,739	2,337	2,992	3,647	4,233	4,676
Temporary Residents [5]	119	239	358	478	597	717	765
Subtotal	1,352	1,978	2,695	3,470	4,244	4,950	5,441
Smithson Valley	99	147	162	183	215	254	300
Oak Village North	124	183	245	277	325	384	454
Bulverde	224	330	725	820	961	1,134	1,341
Total	1,799	2,638	3,827	4,750	5,745	6,722	7,536
Supply from Trinity Aquifer [6]	1,799	1,799	1,799	1,799	1,799	1,799	1,799
Shortage [7]	0	839	2,028	2,951	3,646	4,923	5,737

[1] Texas Water Development Board high case projection.
[2] Estimated from number of water meter connections, assuming 3.2 persons per connection, "Water Supply Study for Western Comal County", Guadalupe-Blanco River Authority, November, 1993.
[3] Second residences for weekend and holiday use. Estimated from number of water meter connections, but this population is not included in Comal County total population.
[4] Texas Water Development Board high case projection, with conservation.
[5] Calculated at 150 gallons per person per day; for temporary residents calculated at two days per week or 104 days per year.
[6] Assuming continued use of existing wells.
[7] Assumed to be supplied from Canyon Lake.

Estimated water use by the population of the Canyon Lake and neighboring hill country subdivisions in 1990 was 1,799 acft (one acft is 325,851 gallons), of which 1,352 acft or 75 percent was used in Canyon Lake subdivisions (Table 3.35-1). All of this water was obtained from wells drilled into the underlying Trinity Group aquifer. As was noted earlier, this aquifer is not capable of continuing to meet the present plus the added demands of a growing population.

Future municipal water demands of the entire Canyon Lake regional area, as outlined above, are projected at 2,638 acft/yr in 2000, 4,750 acft/yr in 2020, and 7,536 acft/yr in 2050 (Table 3.35-1). In year 2000, 75 percent of this demand would be in subdivisions located around Canyon Lake, with 72 percent of the total being needed in these lakeside subdivisions in 2050 (Table 3.35-1). If it is assumed that the present systems can continue to maintain and use their existing wells, then the demand upon Canyon Lake would be about 839 acft/yr in 2000, 2,028 acft/yr in 2010, 2,951 acft/yr in 2020, and 5,737 acft/yr in 2050 (Table 3.35-1) (Note: calculations are the difference between projected demands at each future decade and the quantity of water pumped from the aquifer (1,799 acft) in 1990.) However, if the present wells are abandoned, then the demands upon surface water from Canyon Lake would begin as soon as the surface water system is in place and would grow to 2,638 acft/yr in 2000, 4,750 acft/yr in 2020, and 7,536 acft/yr in 2050 (Table 3.35-1).

3.35.2 Available Yield

The firm yield of Canyon Lake is defined to be the maximum amount of water the lake could have supplied through the drought of record after allowing for passage of inflows when required for senior (senior in time) downstream water rights. The drought of record for Canyon Lake covers a 116 month period of time which begins in July, 1947, and ends in February, 1957. Below Canyon Lake, there are senior water rights totaling more than 225,000 acft/yr that periodically require passage of lake inflows. When river flows originating below Canyon Lake exceed senior water rights requirements, inflows to the lake can be stored for later release. Springflow from the Edwards Aquifer contributes substantially to the base flow of the Guadalupe River and, consequently, provides water to meet a significant portion of downstream water rights, including GBRA and City of Seguin hydroelectric rights which are senior to Canyon Lake. If springflow is decreased, due to dry weather and/or aquifer pumpage, a greater proportion of downstream senior water rights must be met by passage of Canyon Lake inflows making less water available for storage. Because springflow and downstream hydroelectric rights have direct effect on the firm yield of Canyon Lake, firm yield has been estimated for several alternative scenarios of hydroelectric rights subordination and aquifer pumpage. Subordination of hydroelectric rights means that inflows to Canyon Lake are not subject to being called upon to meet a specified hydroelectric target flowrate downstream of Canyon.

The Guadalupe - San Antonio River Basin Model[1] (GSA Model) has been modified and applied to compute the firm yield of Canyon Lake subject to two hydroelectric rights subordination scenarios and three aquifer pumpage scenarios for a total of six combined alternatives. The uncommitted firm yield is the portion of the total firm yield which is not presently committed to satisfy existing GBRA contracts. Refer to Appendix G for a detailed presentation of GSA model modifications and a complete summary of Canyon Lake firm yield analyses. Table 3.35-2 contains a summary of total firm yield and uncommitted firm yield available for diversion directly from Canyon Lake.

Table 3.35-2 shows that with pumpage from the Edwards Aquifer set at 200,000 acft/yr through the period of record, the uncommitted firm yield of Canyon Lake (at the lake) is 20,100 acft/yr with a hydropower flow requirement of 365 cfs. If the hydropower requirement is reduced to 0 cfs, the uncommitted firm yield is 42,300 acft/yr. This is an increase of 22,200 acft/yr which represents a 38 percent increase in the total firm yield of Canyon Lake due to the subordination of the hydropower flow requirement.

Table 3.35-2 also shows that with pumpage of the Edwards Aquifer set at 368,000 acft/yr and 400,000 acft/yr, the uncommitted firm yield of Canyon Lake (at the lake) is 8,400 acft/yr and 6,500 acft/yr respectively, with a hydropower flow requirement of 365 cfs. If the hydropower requirement is reduced to 0 cfs, the uncommitted firm yield is about 37,000 acft/yr for either aquifer pumpage scenario. For the 368,000 acft/yr aquifer demand scenario, the total firm yield of Canyon Lake increases from 46,800 acft/yr to 75,900 acft/yr (62 percent increase) when hydropower is subordinated to 0 cfs. For the 400,000 acft/yr aquifer demand scenario, the total firm yield of Canyon Lake increases from 44,900 acft/yr to 75,300 acft/yr (68 percent increase) when hydropower is subordinated to 0 cfs.

Year 2050 projected water demand in the Canyon Lake area is 5,441 acft/yr (Table 3.35-1, with no groundwater supply) and availability of uncommitted Canyon Lake yield for all scenarios exceeds projected demands for the area. Therefore, the projected water demand for the area could be met with Canyon Lake yield provided a purchase contract is

[1]HDR Engineering, Inc., "Guadalupe - San Antonio River Basin Recharge Enhancement Study," Volumes I, II, and III, Edwards Underground Water District, September, 1993.

Table 3.35-2 Canyon Lake Yield Available for Direct Diversion from Canyon Lake			
Aquifer Demand Scenario [3]	Hydropower Scenario [2]	Total Firm Yield at Canyon Lake (acft/yr)	Uncommitted Firm Yield [1] at Canyon Lake (acft/yr)
200,000 acft/yr	365 cfs	58,500	20,100
	0 cfs	80,700	42,300
368,000 acft/yr	365 cfs	46,800	8,400
	0 cfs	75,900	37,500
400,000 acft/yr	365 cfs	44,900	6,500
	0 cfs	75,300	36,900

Notes:
[1] Uncommitted firm yield is the portion of the total firm yield of Canyon Lake which has not been contractually committed. Existing contracts total 38,438 acft/yr assuming an average of 6,000 acft/yr delivered to CP&L at Coleto Creek Reservoir. This includes 7,000 acft/yr to Canyon Regional Water Authority and Bexar Metropolitan Water Authority.
[2] Hydropower scenario represents the target flowrate for power generation at Lake Dunlap.
[3] The results of the simulated springflows from the TWDB Edwards Aquifer Model for all pumpage scenarios were adjusted to account for the difference in the model's simulated historical springflows and observed springflows.

signed with GBRA. For conceptual design, costing, and environmental analysis, the treatment and distribution system for both the Canyon Lake area and the Smithson Valley/Oak Village North/Bulverde corridor is sized to meet the year 2020 demands (Canyon Lake region: 3,470 acft/yr; Smithson Valley/Oak Village North/Bulverde corridor: 2,095, Table 3.35-1).

3.35.3 Environmental Issues

Environmental Issues Overview

This section is a comparative discussion of the potential environmental consequences and mitigation liabilities that would accompany implementation of centralized water supply alternatives for smaller municipalities and unincorporated areas north of the City of San Antonio. The Texas Water Development Board has adopted guidelines, developed cooperatively with Texas Parks and Wildlife Department, that outline major environmental concerns that must be addressed in evaluating the various water supply alternatives. These guidelines are for study purposes only and are not to be considered as permitting guidelines. The analyses in this report are not exhaustive environmental assessments, rather they have been developed by reference to existing information in published reports, maps, aerial photography, unpublished documents and communications from government agencies, individuals, and private organizations. This information has been abstracted and summarized in order to provide a general review level of the environmental disturbance that would be associated with the construction of new water supplies systems. This general review and screening level discussion does not address secondary impacts, such as that portion of projected population and water use growth some consider to be created by the availability of new water supplies. A site specific level of investigation, focus on environmental concerns raised in public review of this document, and more detailed assessments of system operations or multiple combinations of sources will be the subject of future phases of the Trans Texas Water Program. Site specific studies of water supply alternatives selected for later phases will establish the actual requirements for the amount and timing of streamflows following impoundment or diversion and reductions in freshwater input to the brackish wetlands and shallow estuarine bays.

In general, the following environmental discussions evaluate potential effects on the abundant important species in terms of habitat changes, while protected species are treated more individually, with a focus on determining the potential for an occurrence of those species or specific habitat features they may require at a proposed project feature. Protected species (and other important environmental features) are listed as possibly occurring in the vicinity of an alternative water supply facility when they have been credibly reported from a nearby (within a few miles) location, and the area occupied by the water supply facility is likely to include the appropriate environmental conditions (habitat) for an occurrence there.

Important species include the local dominant (most abundant) species, species having some economic or recreational importance, those exerting disproportionate habitat impacts (habitat formers) and species listed, or proposed for listing as protected, by either the State of Texas or the federal government (protected species). The numerous unlisted species that are nevertheless of concern because of rarity, restricted distribution, direct exploitation or habitat vulnerability have not been included in the following discussions because the level of effort required to obtain the detailed distributional and life history information necessary to any meaningful evaluation is beyond that appropriate to a screening level survey. These species will be addressed in subsequent phases of the Trans Texas Water Program, following review and comment by the biologists on the Technical Advisory Committees, and as site specific environmental evaluations are developed.

Alternative G-23A: Delivery of Surface Water to Areas Adjacent to Canyon Lake

Environmental Setting

Located on the Edwards Plateau in northwest Comal County, Canyon Lake was constructed for water conservation and flood control on the Guadalupe River. Construction on the earth-fill dam was begun in 1958, deliberate impoundment of water was begun in June, 1964, and conservation pool elevation (909 ft MSL) was reached in 1968. Canyon Lake covers about 8,231 surface acres at conservation pool elevation (capacity 382,000 acre feet) and has an approximately 80 mile shoreline.

The topography of the Edwards Plateau is generally flat to rolling over most of its surface, but the eastern margin, which includes Canyon Lake, is a highly dissected area of canyons and steep, well drained hillsides. Canyon Lake is on the Glen Rose formation, the oldest and most extensive Cretaceous rock unit in the vicinity. The thin interbedded hard and soft limestone, dolomite, and marl create the distinctive stair-step topography due to the varying resistance to erosion. Soils are mostly thin, brownish, calcareous gravely clay loams.

In addition to the Guadalupe River, there are approximately five named creek drainages into Canyon Lake. These are Rebecca Creek, Schultz Creek, Potters Creek, Jentsch Creek and Tom Creek. Like most creek drainages in the area, they are intermittent, tending to cease flowing in the summer months, but maintaining isolated pools within their streambeds during some years. Where they intersect the shoreline, these and other unnamed drainages form variously sized, shallow coves that tend to support more wetland and mesic shoreline habitats than other areas. Emergent vegetation and broadleafed shrub in shoreline wetlands is more common along the upper shoreline away from the dam[2]. The vegetated shoreline is either grassed and gravely in the floodplain or gravel to juniper woods above flood level in the parks.

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[2]U.S. Fish and Wildlife. 1990. National Wetland Inventory Map Series; Devils Backbone; Fischer; Sattler; and Smithson Valley, U.S. Geological Service Quadrangles, U.S. Department of the Interior.

The lake is primarily surrounded by residential and recreational developments, and 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 predominantly rangeland with a spreading ring of suburban residential developments centered around the lake shore. Public access to scenic views and the lake shore is provided by the U.S. Corps of Engineers operated parks. 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.

Important species known in the project vicinity are listed in Table 3.35-3. However, the species listed in the table do not necessarily have habitat nor are specifically known to occur at the specific local of the alternative water supply facilities. This is a list of species and their preferred habitats that would be investigated or considered in a field survey program. In the case of migratory or transient species, the field survey would attempt to identify and evaluate habitat that may be attractive to these wandering species.

Several of the birds listed above are migratory, transient, or historic in the county. Migratory and wandering birds included in the list are the Bald Eagle, Arctic Peregrine Falcon, the American Peregrine Falcon, Fulvous Whistling - duck, White-faced Ibis, White-tailed hawk, and Wood Stork. The Bald Eagle is a rare winter resident in northern and north-central Texas along large lakes and rivers. A southern population breeds along the Texas Coast. Although historically common, the Bald Eagle has not been reported using or wintering on Canyon Lake. Bald Eagles are found in the more isolated lake and river habitats of the upper highland lakes, Lake Texoma and broad riparian corridors of the Gulf Coast[3,4]. The project area possesses no habitats likely to be of significance to Arctic Peregrine Falcon or the American Peregrine Falcon. It is improbable that habitats as regionally widespread as those in the study would be limiting for these migratory species with such low population levels. The Arctic Peregrine Falcon, American Peregrine and Fulvous Whistling - duck all are found along the Gulf Coast where more and better food

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[3]Oberholser, H.C. 1974. The Bird Life of Texas. 2 vol. University of Texas Press, Austin, TX.

[4]Rappole, J.H. and G.W. Blacklock. 1994. A Field Guide Birds of Texas. Texas A&M Press, College Station, Texas.

Table 3.35-3
Protected Endangered and Threatened Species, Comal County, Texas

Common Name	Scientific Name	Habitat Preference	Listing Agency [1]		Potential Occurrence in County
			USFWS	TPWD	
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
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies	NL	T	rare 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 chrysoparia*	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	C1	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	possible

Table 3.35-3 Protected Endangered and Threatened Species, Comal County, Texas					
Common Name	Scientific Name	Habitat Preference	Listing Agency [1]		Potential Occurrence in County
			USFWS	TPWD	
Texas Salamander	*Eurycea neotenes*	Edwards Aquifer creeks gravel bottom, emergent vegetation; underground & rocks, ledges	C2	T	resident
Texas Mock-Orange	*Philadelphus texensis*	On limestone bluffs and among boulders on the Edwards Plateau	C2	NL	resident

[1] E Endangered
T Threatened
3C No Longer a Candidate for Protection
C2 Candidate Category
C1 Candidate Category, Substantial Information
NL Not Listed

Source: Listed by the U.S. Department of the Interior (50 CFR 17.11 & 17.12, 16 April 1990) Candidate Species (50 CFR 17, 6 January 1989; 21 February 1990; 21 November 1991) and Texas Parks and Wildlife Department (31 T.A.C. Sec. 65.171-174 & 65.181-184)

sources and habitats may attract them for the winter or longer periods during migration. The White-tailed Hawk is found on the thorn brush and grassland savannas of South Texas along the coastal plain. It is a rare to casual resident of the Trans Pecos and Western Edwards Plateau[5]. The White Ibis and the Woodstork are transients in Texas. The White Ibis, uncommon in Comal County, is found mainly in marshes on the upper coastal plain in the summer. There are no breeding populations of the rare Woodstork in Texas. The lake and heavily wooded intermittent creeks possess little habitat that would appear useful to these transient marsh birds.

The Interior Least Tern nests on sandbars of large rivers, primarily the Red River in Texas, and no resident populations have been recorded in Comal County. The Swallow-tailed Kite was formerly reported in the coastal prairies to the Balcones Escarpment along riparian corridors. However, early in this century only widely separated nesting pairs were reported. Clearing activities in riparian woodlands and reduction of very tall (up to two hundred feet high) nesting trees may have limited this species nesting range to Louisiana

[5] Ibid.

to Florida in the United States[6]. It is now a rare transient, mainly along the Texas coastal prairies and has no recorded breeding populations in Texas.

Two birds, the Golden-cheeked Warbler and Black-capped Vireo, both listed as endangered by the U.S. Fish and Wildlife Service (USFWS), nest on the Edwards Plateau. Both species are known to nest in the vicinity of Canyon Lake in areas with suitable habitat[7]. The Golden-cheeked Warbler and the Black-capped Vireo are upland woodland/brushland species. Their breeding range includes Comal County. Although culturally induced changes in some apparently important features of habitat (e.g. dense brush patches amid an otherwise open woodland of oaks and junipers) have been suggested by ornithologists as reasons for decline of the species, nest parasitism by the Brown-headed Cowbird may be one of the most important causal factors.

Endemic species such as the Texas salamander (*Eurycea neotenes*) are known to occur in springs and streams surrounding the lake. Cagle's map turtle (*Graptemys caglei*) and the Guadalupe bass are found in the Guadalupe River, Blanco River and throughout the upper Guadalupe Basin[8,9]. These two river species use aquatic insects as their primary food[10]. Few Guadalupe bass have been found downstream of New Braunfels in Comal County[11]. Cagle's map turtle which has been found in the lower Guadalupe River at Victoria at time of the year when flows are very high and areas that are riffles during the summer would be runs during high flows[12].

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[6]Oberholser, H.C. 1974. The Bird Life of Texas. 2 vol. University of Texas Press, Austin, TX.

[7]Texas Parks and Wildlife Department, Unpublished 1994. September, 1994, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.

[8]Gary P. Garrett. 1991. Guidelines for the Management of Guadalupe Bass. Texas Parks and Wildlife, Austin, Texas.

[9]Haynes, David and Ronald R. McKown. 1974. A new species of map turtle (Genus *Graptemys)* from the Guadalupe River System in Texas. Tulane Studies in Zoology and Botany, Vol.18, Num. 4. pp. 143-152.

[10]Haynes, David and Ronald R. McKown. 1974. A new species of map turtle (Genus *Graptemys)* from the Guadalupe River System in Texas. Tulane Studies in Zoology and Botany, Vol.18, Num. 4. pp. 143-152.

[11]Gary P. Garrett. 1991. Guidelines for the Management of Guadalupe Bass. Texas Parks and Wildlife, Austin, Texas.

[12]Killebrew, Flavius C. and Dan A. Porter. 1991. Testudines, *Graptemys caglei*. Herp Review: 22(1), p. 24.

Texas Horned Lizard (*Phrynosoma cornutum*) is a denizen of open, well-drained habitats with sparse cover. Ants, spiders, and isopods are included in their diets. The habitat requirements of this lizard species could be met in the open areas. The decline of Texas horned lizard populations is associated with in invasion of fireants (*Solenopsis invicta*), agricultural practices and urbanization. Conservation measures to restore this lizard include controlling the invading fireant without broadcast chemicals and maintenance of native vegetation communities and corridors[13].

Effects Assessment

The proposed waterline loop around Canyon Lake is estimated to be about 30 miles long, and to require a construction corridor width of 30 feet, within which vegetation and soils may be disturbed. The proposed water treatment plant would occupy less than ten acres, for a total area potentially disturbed during construction of 119 acres. A ten foot right of way (ROW), totaling 36.4 acres free of woody vegetation, would be maintained for the life of the project.

The location of the proposed water treatment plant and the alignment of the water line around Canyon Lake is now only generally specified. The treatment plant would be located near Canyon Dam, while the water line would mostly parallel existing roadways (Figure 3.35-1). The land surrounding Canyon Lake in the vicinity of the water line shown in Figure 3.35-1 consists of about 60 percent live oak - ashe juniper savanna; 20 percent live oak - juniper woodland with areas of dense juniper thickets; 17 percent developed; and 3% wetland. Wetlands are primarily unvegetated, rocky, intermittent stream channels. Substantial numbers of relatively isolated rural residences are present within the savanna and woodlands.

Resource conflicts can generally be avoided or minimized by careful site and alignment selection, avoiding, for example, springs and vegetated wetlands where the pipeline crosses a stream channel, and mesic, wooded slopes. Two candidate species, the Texas salamander (*Eurycea neotenes*) and the Texas mock-orange (*Philadelphus texensis*), and two endangered species, the Golden-cheeked Warbler and Black-capped Vireo, are

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[13]Price, A., W. Donaldson, and J. Morse. 1993. Final Report As Required by the Endangered Species Act, Section 6, Texas Project No. E-1-4. Texas Parks and Wildlife Department, Austin, Texas.

species most likely to be in conflict with portions of this alternative, but those conflicts should be easily avoidable with appropriate habitat and species surveys. However, no mapped occurrences of important species showed direct conflict with the general facilities layout. Where any ROW clearing and construction activity may affect a federally protected species, consultation with the U.S. Fish and Wildlife Service (FWS) concerning the need for a permit for the incidental take of that species should be conducted. This level of study would occur during facility siting studies in later phases.

A cultural resources survey of all public property, including easements held by public entities, to be disturbed during construction is required by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resources Code of 1977). Any sites located would be tested for significance and eligibility for the National Register. Disturbance of significant sites should be avoided to the extent possible.

Alternative G-23B: Delivery of Surface Water to Smithson Valley, Oak Village North, and Bulverde

Environmental Setting

The area potentially affected by this alternative extends about ten miles south of Canyon Lake and encompasses a landscape very similar to the uplands surrounding the lake. The corridor that would be traversed by the water pipeline assessed as Alternative G-23B consists primarily of live oak - ashe juniper savanna (56 percent), and mesquite invaded rangeland (40 percent). Developed areas total 3 percent and wetlands occupy about 1 percent of the study corridor. There are relatively few streams, and perched ponds supply water for livestock. The streams are typically intermittent and similar to other streams around Canyon Lake. Important species listed in Table 3.35-3 apply to this potential water supply system.

Effects Assessment

The Smithson to Bulverde waterline, would mostly parallel existing roadways, and would be 8.2 miles long, with a branch water line from State Highway 311 to Oak Village North that would be 2.4 miles long (Figure 3.35-2). The 10.6 miles of proposed water line would require a construction corridor of about 30 feet and a maintenance corridor of about 10 feet. Construction would involve the disturbance of soils and vegetation on up to 38.6

acres, and the long-term impacts of maintaining the ROW free of woody vegetation would affect about 15.8 acres, including the water plant site.

Protected species that appear most likely to be encountered during construction of this alternative include the Texas Horned Lizard (*Phrynosoma cornutum*), the Texas salamander (*Eurycea neotenes*) and the Texas mock-orange (*Philadelphus texensis*). Alignments chosen along existing roadways are less likely to include the Texas mock-orange. Potential conflicts should be easily avoidable with appropriate habitat and important species surveys.

A cultural resources survey of all public property, including easements held by public entities, to be disturbed during construction is required by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resources Code of 1977). Any sites located would be tested for significance and eligibility for the National Register. Disturbance of significant sites should be avoided to the extent possible.

3.35.4 Water Quality and Treatability

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

3.35.5 Engineering and Costing

For this alternative, surface water would be supplied from a treatment plant at Canyon Lake with water delivered on a wholesale basis to existing water utilities in the service area. For engineering and costing purposes, the delivery system around Canyon Lake is shown as a separate system from the delivery system for Oak Village North, Smithson Valley and Bulverde. Figures 3.35-1 and 3.35-2 show possible locations of water treatment plant sites and pipeline routes for each system, however, route studies and on-the-ground surveys have not been performed. The possible facility locations are for reconnaissance - level studies for comparison of alternative projects. If the two systems were combined into a single system, the cost per acre-foot of water could be reduced.

<u>Alternative G-23A: Delivery of Surface Water to Areas Adjacent to Canyon Lake</u>

This alternative would provide a surface water supply to the developing areas adjacent to Canyon Lake to augment the existing groundwater sources. A surface water intake would be located as shown on Figure 3.35-1 in the general vicinity of the south end of Canyon Dam. From the intake, raw water would be pumped to a treatment plant located within two miles of the intake and from the treatment plant a pipeline would be constructed that loops around the lake and supplies water on a wholesale basis to existing distribution systems in each lakeside development. Treatment would consist of conventional surface water treatment (Treatment Level 3, Table 3.0-4). The treatment costs estimated for this alternative are for typical conventional treatment of surface water of average quality and are used for relative evaluation of alternatives. Treatability studies of Canyon Lake water may find that less expensive treatment methods are appropriate.

The major facilities required to implement this alternative are:

Reservoir Intake and Pump Station
Raw Water Pipeline to Treatment Plant
Water Treatment Plant (Level 3, Table 3.0-4, in Volume 2)
Finished Water Pump Station
Transmission Pipeline
Interconnects to Retail Water Utilities
Elevated Storage Tank or Standpipe

The system has been sized for delivery of year 2020 demands of 3,470 acft/yr (3.1 mgd, average day) with a maximum day to average day peaking factor of 2.2. Therefore, the intake, treatment plant, and finished water pump station are sized for 6.8 mgd with an 18-inch diameter pipeline looping around the lake (about half of the flow branches each direction in the looped pipeline). The cost estimate for this alternative is summarized in Table 3.35-4. Operating costs were determined for a total static lift of 300 feet and an annual delivery of 3,470 acft. Financing the project over 25 years at an 8.0 percent annual interest rate results in an annual expense of $2,200,000 (Table 3.35-4). The annual cost of water purchased from GBRA is $53/acft, for a payment of about $184,000 per year. Operation and maintenance costs, including power and purchase of stored water total $1,254,000. The annual costs, including debt repayment, interest, and operation and maintenance, total $3,454,000. For an annual delivery of 3,470 acft, the resulting annual cost of water is $995 per acft[14] (Table 3.35-4). This is the cost of treated water for a relatively

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[14]Costs for supply systems in the GBRA planning areas, which have capacity to meet peak demands, are typically higher when compared to alternatives in Volume 2, which are mostly larger projects with uniform annual delivery rates.

Table 3.35-4
Cost Estimate Summaries for Canyon Lake Regional Plan (G-23)
(Third Quarter - 1994 Prices)

Item	Alt. G-23A Delivery to Areas Adjacent to Canyon Lake	Alt. G-23 B Delivery to Smithson Valley, Bulverde, and Oak Village North
Capital Costs		
Intake and Treatment Plant	$7,300,000	$4,310,000
Transmission Pipelines	8,700,000	5,090,000
Interconnects to Existing Systems	1,360,000	380,000
Total Capital Cost	$17,360,000	$9,780,000
Engineering, Contingencies, and Legal Costs	4,860,000	3,050,000
Land Acquisition	260,000	210,000
Environmental Studies and Mitigation	310,000	260,000
Interest During Construction	680,000	530,000
Total Project Cost	$23,470,000	$13,850,000
Annual Costs		
Annual Debt Service	$2,200,000	$1,300,000
Annual Operation and Maintenance	870,000	430,000
Purchase of Stored Water	184,000	68,000
Annual Power Cost	200,000	80,000
Total Annual Cost	$3,454,000	$1,878,000
Annual Water Delivery (acft/yr)	3,470	1,280
Annual Cost of Water [1]	$995/acft	$1,467/acft

[1] Cost of treated water delivered on a wholesale basis and does not include the operating cost of the distribution system. Costs for supply systems in the GBRA planning areas, which have capacity to meet peak demands, are typically higher when compared to alternatives in Volume 2, which are mostly larger projects with uniform annual delivery rates.

Note: The cost to mitigate for hydro generation lost to subordination, if any, is not included and will depend on the amount and owner of the subordinated right.

small scale stand alone water treatment and conveyance facility delivered on a wholesale basis with capacity to meet peak demands, but does not include the operating cost of the distribution system. The cost to mitigate for hydro generation lost to subordination, if any, is not included and will depend on the amount and owner of the subordinated right.

Alternative G-23B: Delivery of Surface Water to Smithson Valley, Oak Village North, and Bulverde

This alternative would provide a surface water supply and augment the existing groundwater sources in the developing areas of Comal County southwest of Canyon Lake, including the communities of Smithson Valley, Oak Village North, and Bulverde. A surface water intake site would be constructed as shown on Figure 3.35-2 on the south side of Canyon Lake. From the intake, raw water would be pumped to a treatment plant located within a two miles of the intake and from the treatment plant a pipeline would be constructed along FM 3159 and FM 1863 to supply water on a wholesale basis to existing distribution systems at each community. Treatment would consist of conventional surface water treatment (Treatment Level 3, Table 3.0-4). The treatment costs estimated for this alternative are for typical conventional treatment of surface water of average quality and are used for relative evaluation of alternatives. Treatability studies of Canyon Lake water may find that less expensive treatment methods are appropriate.

The major facilities required to implement this alternative are:

Reservoir Intake and Pump Station
Raw Water Pipeline to Treatment Plant
Water Treatment Plant (Level 3, Table 3.0-4, in Volume 2)
Finished Water Pump Station
Transmission Pipeline
Interconnects to Retail Water Utilities
Elevated Storage Tank or Standpipe

The system has been sized for delivery of year 2020 demands of 1,280 acft/yr (1.1 mgd, average day) with a maximum day to average day peaking factor of 2.2. Therefore, the intake, treatment plant, and finished water pump station are sized for 2.5 mgd with an 18-inch diameter pipeline delivering the water along the first part of the route reducing to an 8-inch pipeline near the end of the route. The operating cost was determined for a total static lift of 600 feet and an annual delivery of 1,280 acft. Financing the project over 25 years at an 8.0 percent annual interest rate results in an annual expense of $1,300,000 (Table 3.35-4). The annual cost of water purchased from GBRA is $53/acft, for a payment of about $68,000 per year. Operation and maintenance costs, including power and purchase of stored water total $578,000. The annual costs, including debt repayment, interest, and operation and maintenance, total $1,878,000. For an annual delivery of 1,280 acft, the resulting annual cost of water is $1,467 per acft[15] (Table 3.35-4). This is the cost of treated water for a stand alone system delivered on a wholesale basis and does not include the operating cost of the distribution system[16]. The cost to mitigate for hydro generation lost to subordination, if any, is not included and will depend on the amount and owner of the subordinated right.

3.35.6 Implementation Issues

Requirements Specific to Amending the Canyon Lake Permit

1. If this alternative requires exceeding the current permitted average annual diversion from Canyon Lake of 50,000 acft, then a permit amendment will require:
    a. Application to the TNRCC
    b. Hydrologic studies substantiating requested firm yield.
    c. 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.

Requirements Specific to Treatment and Distribution

1. Necessary permits:
    a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings and raw water intake.
    b. TNRCC Discharge Permit for settling basin supernatant.
    c. GLO Sand and Gravel Removal permits.
    d. TPWD Sand, Gravel, and Marl permit for river crossings.
    e. Coastal Coordinating Council review may be required.
2. Right-of-way and easement acquisition.

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[15]The costs presented here are for relatively small stand alone systems and do not provide economics to size of larger volumes. Previous studies by GBRA to serve this area have included capacity for supplying treated water to other customers, including San Antonio, and thus, the cost per acre-foot, as estimated in those studies, ranges from $384 to $866 per acre-foot of water.

[16]Costs for supply systems in the GBRA planning areas, which have capacity to meet peak demands, are typically higher when compared to alternatives in Volume 2, which are mostly larger projects with uniform annual delivery rates.

3. Crossings:
    a. Highways and railroads
    b. Creeks and rivers
    c. Other utilities
4. Financing:
    a. Sponsoring entity must be identified and be able to incur debt to finance project.
    b. Participating entities must negotiate water purchase contracts with GBRA and establish appropriate rate structures.

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3.36 Wimberley and Woodcreek Supply from Canyon Lake (G-24)

3.36.1 Description of Area with Projections of Population and Water Demand

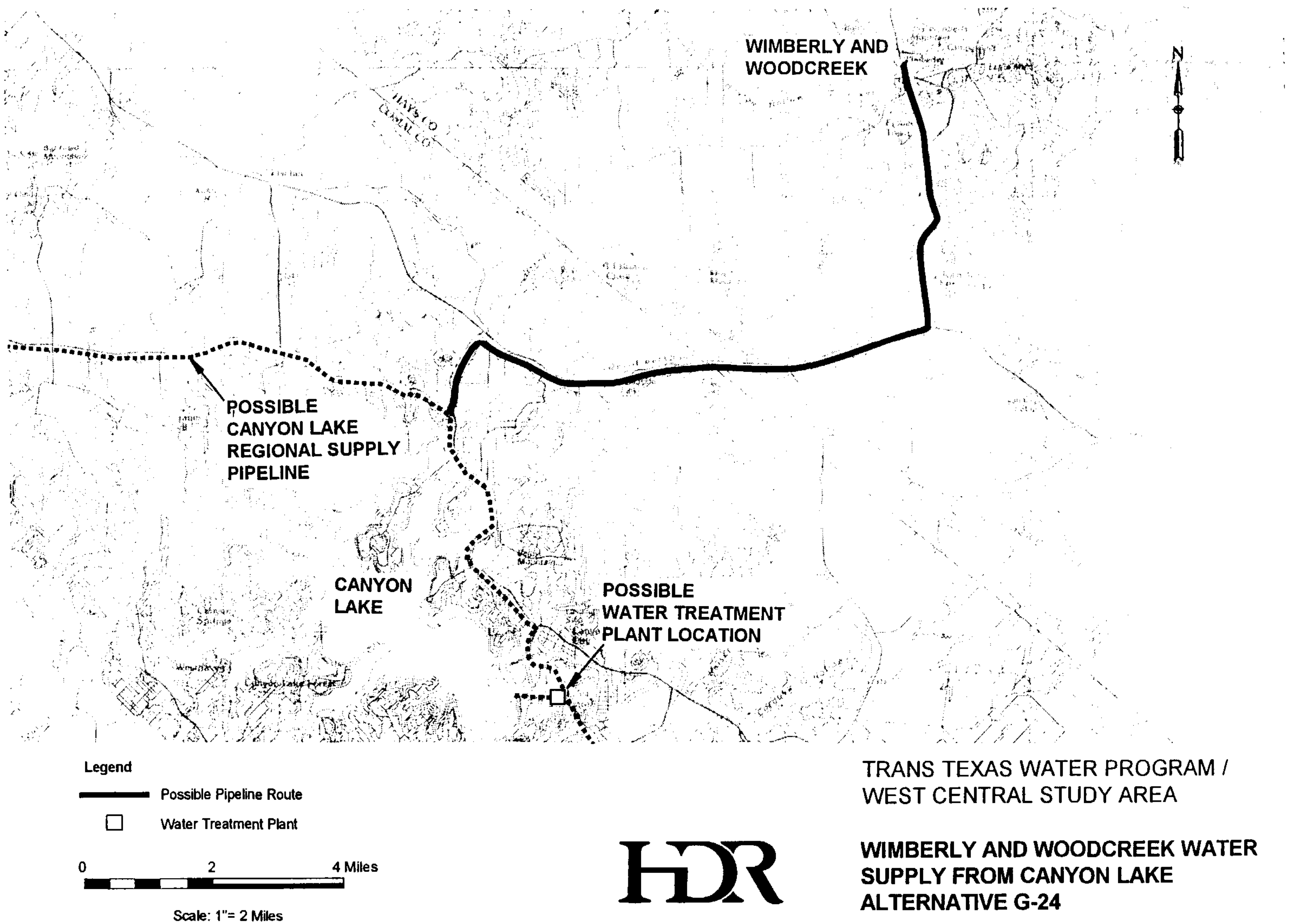
The unincorporated communities of Wimberley and Woodcreek are located next to each other near the Blanco River, within the Guadalupe River Basin, in Hays County, about 12 air miles to the northeast of Canyon Lake (Figure 3.36-1). As in the case of subdivisions around Canyon Lake, water has been supplied by water supply corporations, with water obtained from wells drilled into the Trinity Group aquifer, which is inadequate to meet all of the projected needs in the future. One potential source of additional water is Canyon Lake. This supply could be utilized by the construction of a pipeline that would bring treated water from a water treatment plant at Canyon Lake to the present water supply corporation systems (wholesale storage locations) for retail distribution through existing distribution systems. The TWDB high case, with conservation, population and municipal water demand projections for the Wimberley and Woodcreek communities are presented in Table 3.36-1.

In 1990, the population of Wimberley was 3,276 and is projected to increase to 8,525 by 2050 (Table 3.36-1). The population of Woodcreek was 1,004 in 1990, with projections to 2050, of 5,526 people (Table 3.36-1). The total population for these two neighboring communities was 4,280 in 1990, with projections of 14,051 by 2050 (Table 3.36-1).

In 1990, total water use in the Wimberley and Woodcreek communities was 673 acft (Table 3.36-1). For these two communities, projected water demands in 2020 are 1,424 acft, and in 2050 are 2,424 acft annually. If present levels of supply (673 acft/yr) from existing wells can be continued, then in 2050 an additional quantity of 1,751 acft/yr will need to be obtained from some other source, such as Canyon Lake (Table 3.36-1). Since the Trinity Group Aquifer is not expected to be able to continue to yield the quantities needed to meet present and projected needs of the local area, the quantity of water needed from other sources in year 2050 ranges from a low of 1,751 acft, as stated above, to the projected total demand of 2,424 acft (Table 3.36-1).

3.36.2 Available Yield

The firm yield of Canyon Lake is defined to be the maximum amount of water the lake could have supplied through the drought of record after allowing for passage of inflows



HDR

HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM /
WEST CENTRAL STUDY AREA

WIMBERLY AND WOODCREEK WATER SUPPLY FROM CANYON LAKE ALTERNATIVE G-24

FIGURE 3.36-1

Table 3.36-1
Population and Water Demand Projections
Wimberley and Woodcreek Areas of Hays County

Area/Projection	1990 Actual	Projection Date 2000	2010	2020	2030	2040	2050
Population [1]							
Wimberley [2]	3,276	4,151	5,329	6,389	7,241	8,078	8,525
Woodcreek [2]	1,004	1,349	1,813	2,436	3,274	4,400	5,526
Total	4,280	5,500	7,142	8,825	10,515	12,478	14,051
Water Demand (ac-ft) [3]							
Wimberley [2]	515	656	848	1,031	1,176	1,357	1,471
Woodcreek [2]	158	213	288	393	532	740	953
Total	673	869	1,136	1,424	1,708	2,097	2,424
Supply from Trinity Aquifer [4]	673	673	673	673	673	673	673
Shortage	0	196	463	751	1,035	1,424	1,751

[1] Texas Water Development Board high case projection.
[2] Source calculated from information in "Hays County Water and Wastewater Study", Hays County Water Development Board, San Marcos, Texas, 1989.
[3] Texas Water Development Board high case projection, with conservation.
[4] Assuming continued use of existing wells.

when required for senior (i.e., senior in time) downstream water rights. The drought of record for Canyon Lake covers a 116 month period of time which begins in July, 1947, and ends in February, 1957. Below Canyon Lake, there are senior water rights totaling more than 225,000 acft/yr that periodically require passage of lake inflows. When river flows originating below Canyon Lake exceed senior water rights requirements, inflows to the lake can be stored for later release. Springflow from the Edwards Aquifer contributes substantially to the base flow of the Guadalupe River and, consequently, provides water to meet a significant portion of downstream water rights, including GBRA and City of Seguin hydroelectric rights which are senior to Canyon Lake. If springflow is decreased, due to dry weather and/or aquifer pumpage, a greater proportion of downstream senior water rights demands must be met by passage of Canyon Lake inflows making less water available for storage. Because springflow and downstream hydroelectric rights have direct effect on the firm yield of Canyon Lake, firm yield has been estimated for several alternative scenarios of hydroelectric rights subordination and aquifer pumpage. Subordination of hydroelectric rights means that inflows to Canyon Lake are not subject to being called upon to meet specified hydroelectric target flow rates downstream of Canyon.

The Guadalupe - San Antonio River Basin Model[18] (GSA Model) has been modified and applied to compute the uncommitted firm yield of Canyon Lake subject to two hydroelectric rights subordination scenarios and three aquifer pumpage scenarios for a total of six combined alternatives. The uncommitted firm yield is the portion of the total firm yield which is not presently committed to satisfy existing GBRA contracts. Refer to Appendix G for a detailed presentation of GSA model modifications and a complete summary of Canyon Lake firm yield analyses. Table 3.36-2 contains a summary of estimated total firm yield and uncommitted firm yield available for diversion directly from Canyon Lake.

Table 3.36-2 shows that with pumpage from the Edwards Aquifer set at 200,000 acft/yr through the period of record, the uncommitted firm yield of Canyon Lake (at the lake) is 20,100 acft/yr with a hydropower flow requirement of 365 cfs. If the hydropower requirement is reduced to 0 cfs, the uncommitted firm yield is 42,300 acft/yr. This is an increase of 22,200 acft/yr which represents a 38 percent increase in the total firm yield of Canyon Lake due to the subordination of the hydropower flow requirement.

Table 3.36-2 also shows that with pumpage of the Edwards Aquifer set at 368,000 acft/yr and 400,000 acft/yr, the uncommitted firm yield of Canyon Lake (at the lake) is 8,400 acft/yr and 6,500 acft/yr respectively, with a hydropower flow requirement of 365 cfs. If the hydropower requirement is reduced to 0 cfs, the uncommitted firm yield is about 37,000 acft/yr for either aquifer pumpage scenario. This represents between a 62 and 63 percent increase in the total firm yield of Canyon Lake due to the elimination of the hydropower flow requirement.

Year 2050 projected water demand in the Wimberley/Woodcreek area is 2,424 acft/yr (Table 3.36-1, with no groundwater supply) and availability of uncommitted Canyon Lake yield for all scenarios exceeds projected demands for the area. Therefore, the projected water demand for the area could be met with Canyon Lake yield provided a purchase contract is signed with GBRA. For conceptual design, costing, and environmental

[18]HDR Engineering, Inc., "Guadalupe - San Antonio River Basin Recharge Enhancement Study," Volumes I, II, and III, Edwards Underground Water District, September, 1993.

Table 3.36-2
Canyon Lake Yield Available for Direct Diversion from Canyon Lake

Aquifer Demand Scenario [3]	Hydropower Scenario [2]	Total Firm Yield at Canyon Lake (acft/yr)	Uncommitted Firm Yield [1] at Canyon Lake (acft/yr)
200,000 acft/yr	365 cfs	58,500	20,100
	0 cfs	80,700	42,300
368,000 acft/yr	365 cfs	46,800	8,400
	0 cfs	75,900	37,500
400,000 acft/yr	365 cfs	44,900	6,500
	0 cfs	75,300	36,900

Notes:
[1] Uncommitted firm yield is the portion of the total firm yield of Canyon Lake which has not been contractually committed. Existing contracts total 38,438 acft/yr assuming an average of 6,000 acft/yr delivered to CP&L at Coleto Creek Reservoir. This includes 7,000 acft/yr to Canyon Regional Water Authority and Bexar Metropolitan Water Authority.
[2] Hydropower scenario represents the target flowrate for power generation at Lake Dunlap.
[3] The results of the simulated springflows from the TWDB Edwards Aquifer Model for all pumpage scenarios were adjusted to account for the difference in the model's simulated historical springflows and observed springflows.

analysis, the treatment and distribution system is sized to meet the year 2020 demands (1,424 acft/yr, Table 3.36-1).

3.36.3 Environmental Issues

The analyses in this report are not exhaustive environmental assessments, rather they have been developed by reference to existing information in published reports, maps, aerial photography, unpublished documents and communications from government agencies, individuals, and private organizations. These have been digested to provide a general review level of the environmental disturbance that would be associated with the production of new water supplies. This general review and screening level discussion does not address secondary impacts. A site specific level of investigation, focus on environmental concerns raised in public review of this document, and more detailed assessments of system operations or multiple combinations of sources will be the subject of future phases of the Trans Texas Water Program.

Important species include the local dominant (most abundant) species, species having some economic or recreational importance, those exerting disproportionate habitat impacts (habitat formers) and species listed, or proposed for listing, by either the State of Texas or the federal government (protected species). The numerous unlisted species that are nevertheless of concern because of rarity, restricted distribution, direct exploitation or habitat vulnerability have not been included in the following discussions because the level of effort required to obtain the detailed distributional and life history information necessary to any meaningful evaluation is beyond that appropriate to a screening level survey. These species will be addressed in subsequent phases of the Trans Texas Water Program, following review and comment by the biologists on the Technical Advisory Committees, and as site specific environmental evaluations are developed.

Environmental Setting

Wimberley and Woodcreek communities are located about 12 miles northeast of Canyon Lake in Hays County on the Edwards Plateau. Wimberley and Woodcreek are located in a valley of the Blanco River at about 800 to 900 feet MSL (Figure 3.36-1). Spring fed Cypress Creek flows through the center of town. Large cypress trees line Cypress Creek and portion of the Blanco River. The scenic Wimberley area is a popular tourist destination. Both the Blanco River and Cypress Creek are heavily used recreational resources.

Land use in Wimberley and Woodcreek is rural residential, suburban residential and recreational. Most of the surrounding land use is rangeland. Although an alignment study has not been performed, this report assumes that the waterline ROW's will cross the Blanco River west of the FM 12 crossing avoiding the mature cypress banks and springs at Wimberley.

Alternative G-24 study corridor consists primarily of live oak - ashe juniper savanna (46%), and mesquite invaded plateau live oak with midgrass series rangeland (48%). Developed areas total 5% and wetlands occupy less than 1% of the study corridor. There are relatively few streams, and perched ponds supply water for livestock. These mostly unnamed creeks are typically intermittent and similar to small creeks around Canyon Lake.

Important water resources in the study corridor are the Blanco River, Cypress Creek and a multitude of associated Edwards Aquifer springs[19,20,21,22].

Important species known to occur in Hays County and likely to have habitat within the study area are listed in Table 3.36-3. Although, the species listed in the table do not necessarily occur at the specific local of the alternative water supply facilities, this is a list of species and their preferred habitats that would be investigated, along with others known to Comal and Hays counties (see Table 3.35-3 and Appendix C of volume 2) or considered in a field survey program. In the case of migratory or transient species, the field survey would attempt to identify and evaluate habitat that may be attractive to these wandering species.

The Golden-cheeked Warbler and Black-capped Vireo, both listed as endangered by the U.S. Fish and Wildlife Service (USFWS), are known to nest in Comal and Hays counties in areas with appropriate habitat[23]. The Golden-cheeked Warbler and the Black-capped Vireo are upland woodland/brushland species. Endemic species such as the Texas salamander are known to occur in springs along the Blanco River drainage basin. Cagle's map turtle and the Guadalupe bass are found in the Blanco River and through out the upper Guadalupe Basin[24,25]. Texas Horned Lizard is a denizen of open, well-drained habitats with sparse cover. The decline of Texas horned lizard populations is associated

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[19]USFWS. 1991. National Wetland Inventory Map Series. Devils Backbone and Wimberley, Texas Quadrangles. USGS.

[20]Texas Parks and Wildlife Department. Unpublished 1994. September, 1994, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.

[21]Gould, F.W. 1975. Texas plants; a checklist and ecological summary. Texas A&M University. Texas Agricultural Experiment Station. MP-585/Rev. College Station, Texas.

[22]McMahan, C.A., R.G. Frye, K.L. Brown. 1982. The Vegetation Types of Texas Including Cropland. Texas Parks and Wildlife Department, Austin, Texas.

[23]Texas Parks and Wildlife Department. Unpublished 1994. September, 1994, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.

[24]Gary P. Garrett. 1991. Guidelines for the Management of Guadalupe Bass. TPWD Austin, Texas.

[25]Haynes, David and Ronald R. McKown. 1974. A new species of map turtle (Genus *Graptemys)* from the Guadalupe River System in Texas. Tulane Studies in Zoology and Botany, Vol.18, Num. 4. pp. 143-152.

Table 3.36-3 Important Species Known to Occur in the Study Area [1]					
Common Name	Scientific Name	Summary of Habitat Preference	Listing Agency [2]		Potential Occurrence in County
			USFWS	TPWD	
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	nesting/ migrant
Golden-cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	nesting/ migrant
Blanco blind salamander	*Typhlomolge robusta*	Troglobitic; Stream bed of the Blanco River	E	NL	resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands	C2	T	resident
Texas Salamander	*Eurycea neotenes*	Edwards Aquifer creek gravel bottoms, emergent vegetation; underground & rocks, ledges	C2	T	resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C1	NL	resident
Guadalupe Bass	*Micropterus terculi*	Streams of eastern Edwards Plateau	C2	NL	resident
Canyon Mock-Orange	*Philadelphus ernestii*	Edwards Plateau	C2	NL	resident

[1] Texas Parks and Wildlife Department. Unpublished 1994. September, 1994, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.

[2] E Endangered
T Threatened
3C No Longer a Candidate for Protection
C2 Candidate Category
C1 Candidate Category, Substantial Information
NL Not Listed

with the invasion of fireants (*Solenopsis invicta*), agricultural practices and urbanization all of which are present in the Wimberley and Woodcreek areas[26].

Two species not discussed in Section 3.35.3 are the Blanco blind salamander and the hill country wild-mercury (*Argythamnia aphoroides*). The Blanco blind salamander is a troglobitic salamander found once in the Blanco River stream bed. Other populations of this little known troglobitic may be present in the Blanco River Basin. The hill country wild-

[26] Price, A., W. Donaldson, and J. Morse. 1993. Final Report As Required by the Endangered Species Act, Section 6, Texas Project No. E-1-4. Texas Parks and Wildlife Department, Austin, Texas.

mercury, a plant, is listed in Hays County based on historic occurrence reports from before 1900.

Effects Assessment

The waterline to Wimberley and Woodcreek from Canyon Lake, assumed to mostly parallel existing roadways, would be about 15 miles long (Figure 3.36-1). The proposed waterline would require a construction corridor of about 40 feet and a maintenance corridor of about 20 feet. Construction would involve the disturbance of soils and vegetation on up to 76 acres, and the long-term impacts of maintaining the ROW free of woody vegetation would affect about 40 acres, including the water plant site. One major stream crossing at the Blanco River would affect an estimated half acre of this lower perennial stream during construction and require about one-tenth acre permanent easement.

Resource conflicts can generally be avoided or minimized by careful site and alignment selection, avoiding, for example, springs and vegetated wetlands where the pipeline crosses a stream channel, and mesic, wooded slopes. The Texas salamander, Blanco blind salamander, Texas mock-orange, Golden-cheeked Warbler and Black-capped Vireo are species most likely to be in conflict with portions of this alternative, but those conflicts should be easily avoidable with appropriate habitat and species surveys. Any future detailed assessment would include a complete review for Edwards Aquifer springs and karst associated species and important species with appropriate habitat. No mapped occurrences of important species showed direct conflict with the general facilities layout. Where any ROW clearing and construction activity may affect a federally protected species, consultation with the U.S. Fish and Wildlife Service (FWS) concerning the need for a permit for the incidental take of that species should be conducted. This level of study would occur during facility siting studies in later phases.

A cultural resources survey of all public property, including easements held by public entities, to be disturbed during construction is required by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resources Code of 1977). Any sites located would be tested for significance and eligibility for the National Register. Disturbance of significant sites should be avoided to the extent possible.

3.36.4 Water Quality and Treatability

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

3.36.5 Engineering and Costing

For this alternative, surface water supply for the Wimberley/Woodcreek area would be supplied from a treatment plant at Canyon Lake on a wholesale basis to existing water utilities in the service area. To create a cost effective project, this alternative would share a portion of the facilities for Alternative G-23A (Canyon Lake Regional Project), resulting in a project that is feasible only if G-23A is completed. (However, Alternative G-23A, Canyon Lake Regional Project is a stand-alone project, not requiring G-24 to be built.) The facilities common to both alternatives are the raw water intake, the water treatment plant, and the transmission pipeline from the treatment plant to the junction at FM 3424. Figure 3.36-1 is a vicinity map showing possible locations of a water treatment plant site and pipeline routes.

For purposes of costing and general environmental assessment of this alternative, a surface water intake site is shown on Figure 3.36-1 in the general vicinity of the south end of Canyon Dam. From the intake, raw water would be pumped to a treatment plant located within two miles of the intake and from the treatment plant a 24 inch pipeline is required for the section common to the Canyon Lake loop, however the remainder of the Canyon Lake loop would be 18 inch diameter. At the junction with FM 3424, an 18-inch diameter pipeline will branch to Wimberley and Woodcreek to supply water on a wholesale basis to existing distribution systems. The waterline around the lake would also provide wholesale treated water to communities adjacent to Canyon Lake. Treatment would consist of conventional surface water treatment. The treatment costs estimated for this alternative are for typical conventional treatment of surface water of average quality and are used for relative evaluation of alternatives. Treatability studies of Canyon Lake water may find that less expensive treatment methods are appropriate.

The major facilities required to implement this alternative are:

Reservoir Intake and Pump Station
Raw Water Pipeline to Treatment Plant
Water Treatment Plant (Level 3, Table 3.0-4, Volume 2)
Finished Water Pump Station
Transmission Pipeline

Interconnects to Retail Water Utilities
Elevated Storage Tank or Standpipe

The portion of the facilities serving both Wimberley/Woodcreek and the Canyon Lake region (i.e., water intake, raw water pumps, treatment plant, finished water pump station, and part of the transmission pipeline) have been sized for delivery of year 2020 demands of 4,894 acft/yr (3,470 acft to the Canyon Lake region plus 1,424 acft to Wimberley/Woodcreek for a total of 4.4 mgd, average day). With a maximum day to average day peaking factor of 2.2, the intake, treatment plant, and finished water pump station are sized for 9.6 mgd with a 24-inch pipeline from the plant to the Wimberley/Woodcreek lateral intersection, reducing to an 18-inch diameter pipeline to Wimberley/Woodcreek. Table 3.36-4 contains the cost summary for the combined Canyon Lake Regional Plan and Wimberley/Woodcreek supply system in the first cost column. Cost Column 2 contains the costs for the Canyon Lake Regional Plan alone and Column 3 contains the difference in Column 1 and Column 2 which is the incremental cost of the Wimberley/Woodcreek Supply Plan. The operating cost for the combined system was determined for a total static lift of 300 feet and an annual delivery of 1,424 acft to Wimberley/Woodcreek and 3,470 acft to the Canyon Lake region. Financing the combined system over 25 years at an 8.0 percent annual interest rate results in an annual expense of $3,020,000 (Table 3.36-4). The annual cost of water purchased from GBRA is $53/acft, for a payment of $259,000 per year. Operation and maintenance costs, including power and purchase of stored water total $1,629,000. Total annual costs, including debt repayment, interest, and operation and maintenance, total $4,649,000. For an annual delivery of 4,894 acft, the resulting annual cost of water is $950 per acft[27] (Table 3.36-4), and the incremental cost of the Wimberley/Woodcreek portion of the system is about $839 acft/yr. This is the cost of treated water delivered on a wholesale basis and does not include the operating cost of the distribution system. The cost to mitigate for hydro generation lost to subordination, if any, is not included and will depend on the amount and owner of the subordinated right.

[27]Costs for supply systems in the GBRA planning areas, which have capacity to meet peak demands, are typically higher when compared to alternatives in Volume 2, which are mostly larger projects with uniform annual delivery rates.

Table 3.36-4
Cost Estimate Summaries for Wimberley and Woodcreek Supply from Canyon Lake (G-24)
(Third Quarter - 1994 Prices)

Item	Alt G-23A with G-24 Canyon Lake Regional Plan Combined with Wimberley/Woodcreek	Alt G-23A Stand Alone Canyon Lake Regional Plan [2]	Alt G-24 Incremental Cost Wimberley/ Woodcreek Supply
Capital Costs			
Intake and Treatment Plant	$8,950,000	($7,300,000)	$1,650,000
Transmission Pipelines	12,400,000	(8,700,000)	3,700,000
Interconnects to Existing Systems	1,580,000	(1,360,000)	220,000
Total Capital Cost	$22,930,000	($17,360,000)	$5,570,000
Engineering, Contingencies, and Legal Costs	7,330,000	(4,860,000)	2,050,000
Land Acquisition	360,000	(260,000)	100,000
Environmental Studies and Mitigation	440,000	(310,000)	130,000
Interest During Construction	1,240,000	(680,000)	540,000
Total Project Cost	$32,300,000	($23,470,000)	$8,390,000
Annual Costs			
Annual Debt Service	$3,020,000	($2,200,000)	$820,000
Annual Operation and Maintenance	1,120,000	(870,000)	250,000
Purchase of Stored Water	259,000	(184,000)	75,000
Annual Power Cost	250,000	(200,000)	50,000
Total Annual Cost	$4,649,000	($3,454,000)	$1,195,000
Annual Water Delivery (acft/yr)	4,894 [1]	3,470	1,424
Annual Cost of Water [3]	$950/acft	$995/acft	$839/acft

[1] Sum of projected annual delivery to Canyon Lake Region plus Wimberley/Woodcreek in year 2020 (i.e., 3,470 acft/yr plus 1,424 acft/yr).
[2] From Table 3.35-3.
[3] Cost of treated water delivered on a wholesale basis and does not include the operating cost of the distribution system. Costs for supply systems in the GBRA planning areas, which have capacity to meet peak demands, are typically higher when compared to alternatives in Volume 2, which are mostly larger projects with uniform annual delivery rates.

Note: The cost to mitigate for hydro generation lost to subordination, if any, is not included and will depend on the amount and owner of the subordinated right.

3.36.6 Implementation Issues

Requirements Specific to Amending the Canyon Lake Permit (if required):

1. If this alternative requires exceeding the current permitted average annual diversion from Canyon Lake of 50,000 acft, then a permit amendment will require:
   a. Application to the TNRCC
   b. Hydrologic studies substantiating requested firm yield.
   c. 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.

Requirements Specific to Treatment and Distribution

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. TNRCC discharge of water treatment plant settling basin blowdown and filter backwash.
   c. GLO Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel, and Marl permit for river crossings.
   e. 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
4. Financing:
   a. Sponsoring entity must be identified and be able to incur debt to finance project.
   b. Participating entities must negotiate water purchase contract with GBRA and establish rate structures.

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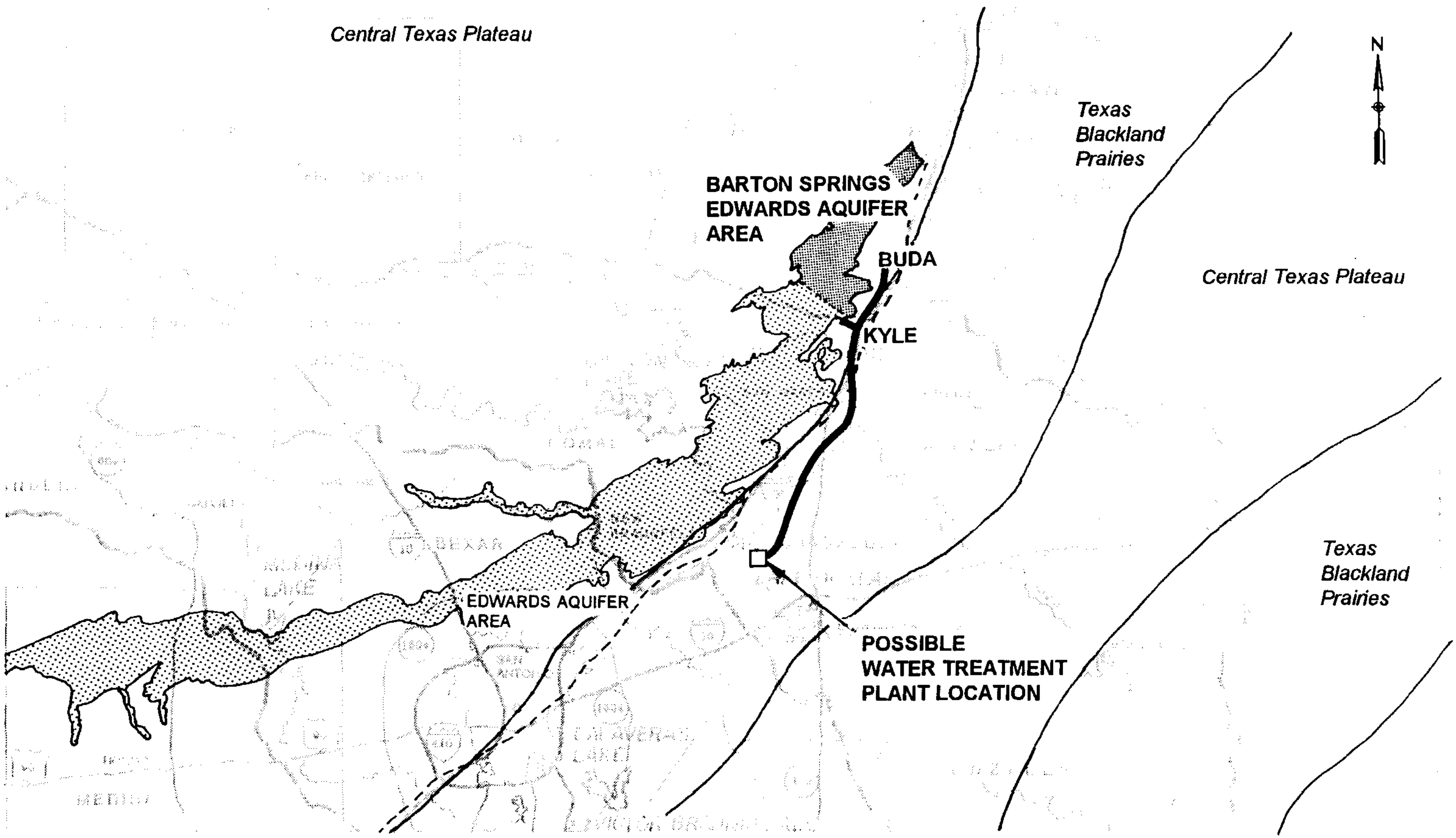
3.37 Northeast Hays and Northwest Caldwell Counties Water Supply from Near Lake Dunlap (G-25)

3.37.1 Description of Area with Projections of Population and Water Demand

The Northeast Hays/Northwest Caldwell counties area is located within the Guadalupe River Basin service area and contains the cities of Kyle and Buda along Interstate Highway 35 and areas within Hays and Caldwell counties to the east of these two cities in which residential subdivisions are located (Figure 3.37-1). The water supply for Buda, and Goforth and Plum Creek Water Supply Corporation service areas is obtained from wells drilled into the Barton Springs Edwards Aquifer along its eastern boundary, which in this area is near Interstate Highway 35. In the case of Kyle and areas to the east of Kyle, water is obtained from wells drilled into the Edwards Aquifer. The Uhland, County Line, and Maxwell Water Supply Corporations (WSCs) have extended pipelines eastward from their Edwards wells and established retail distribution systems to supply their respective service areas of northeastern Hays and northwestern Caldwell Counties. However, in view of: (1) the fact that the Barton Springs Edwards Aquifer has limited capacity and may not be capable of meeting the growing demands that are being placed upon it, and (2) limitations are being placed upon pumpage from the Edwards Aquifer in order to maintain spring flows at San Marcos and Comal Springs, and to protect endangered species of the aquifer, a supplemental water supply is needed for the Northeast Hays/Northwest Caldwell Counties area. One alternative is the development of a surface water treatment plant located alongside the Guadalupe River near Lake Dunlap, and construction of a treated water line from the plant to northeast Hays County, with wholesale delivery of treated surface water to the respective water supply corporation and city systems. This is the alternative selected for analysis in this study. Another approach would be to upsize a planned surface water treatment plant under consideration by the City of San Marcos. This plant would divert water from the San Marcos River downstream of the confluence with the Blanco River. A treated water line would need to be constructed to northeast Hays and northwest Caldwell counties, as described above. However, costs of this option have not been made in this study. (Note: San Marcos has purchased 5,000 acft/yr of Canyon Lake water and at the present time is in the process of planning a treatment plant to meet its needs. Thus, the timing is advantageous to consider the inclusion of both



Legend

Basin Divide
Possible Pipeline Route
Ecoregion
Water Treatment Plant

0 10 20 Miles
Scale

HDR
HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM /
WEST CENTRAL STUDY AREA

NORTHEAST HAYS AND NORTHWEST CALDWELL COUNTIES WATER SUPPLY ALTERNATIVE G-25

FIGURE 3.37-1

treatment plant and pipeline capacities needed to serve the Kyle/Buda/Northeast Hays/Northwest Caldwell Counties areas.) Projections of population and water demand are presented in Table 3.37-1.

The population of the Northeast Hays/Northwest Caldwell counties areas in 1990 was 14,992, and is projected to increase to 41,393 in 2050 (Table 3.37-1). Of the Northeast Hays/Northwest Caldwell counties total population in 1990, 8,765 resided in areas served from the Barton Springs Edwards Aquifer and 6,227 resided in areas served from the Edwards Aquifer. Projections of population in 2050 for the Buda, Goforth WSC and Plum Creek WSC areas now served from the Barton Springs Aquifer are 25,384 (Table 3.37-1). For the Kyle, Uhland WSC, County Line WSC, and Maxwell WSC service areas, population is projected to increase from 6,227 in 1990 to 16,009 in 2050 (Table 3.37-1). San Marcos' population in 1990 was 28,743, with projections to 2050 of 71,295 (Table 3.37-1[28]).

Water use from the Barton Springs Edwards Aquifer in the Northeast Hays County area in 1990 was 1,266 acft, with projected high case, with conservation water demands in 2050 of 3,788 acft annually for the Buda/Goforth/Plum Creek WSC service areas (Table 3.37-1). Water use from the Edwards Aquifer by Kyle, Uhland WSC, County Line WSC, and Maxwell WSC in 1990 was 953 acft, with projected demands for these service areas in 2050 of 2,502 acft annually (Table 3.37-1). San Marcos' water use in 1990 from the Edwards Aquifer was 6,321 acft; San Marcos projected 2050 water demands are 16,699 acft/yr (Table 3.37-1).

Regulatory efforts to protect spring flows at Comal and San Marcos Springs are expected to reduce the quantities of water available from the Edwards Aquifer and would apply to all present users of Edwards Aquifer Water[29]. Under the conditions of Senate Bill 1477, the estimated quantity of water available to the Northeast Hays/Northwest Caldwell Counties area from the Edwards Aquifer could be only 86 percent of the quantity that was

[28]San Marcos projections are included for information purposes.

[29]Senate Bill 1477, Texas Legislature, Regular Session, 1993, specifies that maximum pumpage from the Aquifer through year 2007 can be no more than 450,000 acre-feet per year, and after 2007, must be reduced to 400,000 acre-feet per year, with the further condition that by 2012, there must be an Aquifer management plan which assures that flows from the springs will not be threatened. This latter condition plus the ever present possibility of droughts that result in less than normal runoff which recharges the Aquifer could result in even less pumpage during droughts than is specified by Senate Bill 1477.

Table 3.37-1
Population and Water Demand Projections
Northeast Hays/Northwest Caldwell Counties

Area/Projection	1990 Actual	Projection Date 2000	2010	2020	2030	2040	2050
Population [1]							
Barton Springs Edwards Aquifer Area							
Buda	1,795	2,475	3,559	4,547	5,342	5,738	6,134
Goforth WSC	3,746	4,873	6,000	7,000	8,000	9,000	10,000
Plum Creek WSC	3,224	3,861	4,624	5,537	6,630	7,940	9,250
Subtotal	8,765	11,209	14,183	17,084	19,972	22,678	25,384
Edwards Aquifer Area							
Kyle	2,225	2,612	2,970	3,282	3,526	3,654	3,780
Uhland WSC	213	320	446	584	766	1,004	1,242
County Line WSC	834	997	1,192	1,425	1,703	2,036	2,369
Maxwell WSC	2,955	3,532	4,222	5,046	6,032	7,210	8,618
Subtotal	6,227	7,461	8,830	10,337	12,027	13,904	16,009
Total NE Hays/NW Caldwell	14,992	18,670	23,013	27,421	31,999	36,582	41,393
San Marcos *	28,743	36,320	46,477	55,459	63,205	67,250	71,295
Water Demand (ac-ft) [2]							
Barton Springs Edwards Aquifer Area							
Buda	174	363	486	591	682	726	770
Goforth WSC [3]	587	764	941	1,098	1,254	1,411	1,568
Plum Creek WSC [3]	505	605	725	868	1,039	1,245	1,450
Subtotal	1,266	1,732	2,152	2,557	2,975	3,382	3,788
Supply from BS Edwards Aquifer [4]	1,266	1,266	1,266	1,266	1,266	1,266	1,266
Edwards Aquifer Area							
Kyle	326	474	509	537	569	577	585
Uhland WSC [3]	33	50	70	92	120	157	195
County Line WSC [3]	131	156	187	223	267	319	371
Maxwell WSC [3]	463	554	662	791	946	1,130	1,351
Subtotal	953	1,234	1,428	1,643	1,902	2,183	2,502
Total NE Hays/NW Caldwell	2,219	2,966	3,580	3,900	4,877	5,565	6,290
Supply from Edwards Aquifer [5]	953	819	714	714	714	714	714
San Marcos (SM) Demand *	6,321	9,357	11,453	13,232	14,939	15,819	16,699
Supply from Edwards Aquifer (SM) [5]	6,321	5,436	4,740	4,740	4,740	4,740	4,740
Projected NE Hays/NW Caldwell Shortage [5]							
BS Edwards Aquifer Area	0	466	886	991	1,709	2,116	2,522
Edwards Aquifer Area	0	415	714	929	1,188	1,469	1,788
Total	0	881	1,600	1,920	2,897	3,585	4,310

[1] Texas Water Development Board high case projection.
[2] Texas Water Development Board high case projection, with conservation.
[3] Data from "Hays County Water and Wastewater Study", Hays County Water Development Board, San Marcos, Texas, May, 1989; per capita water use at 140 gallons per person per day.
[4] Assuming Barton Springs (BS) Edwards Aquifer pumpage can be maintained at the 1990 level.
[5] Assuming Edwards Aquifer pumpage will be reduced 25 percent of the 1990 level beginning in 2008 to protect spring flows (14 percent reduction between 1995 and 2008). During severe droughts the pumpage could be less than shown here.
* San Marcos projections are included for information only.

used in 1990 for the period 1995 through 2007, and beginning in 2008 could be about 75 percent of the quantity that was used in 1990. These estimates are based upon the 1990 Edwards Aquifer total pumpage of 519,796 acft, as reported to the Texas Water Development Board in surveys of water users, and the assumption that pumpage would be scaled back proportionately for all users in order to achieve the levels allowed under Senate Bill 1477. Given the conditions and assumptions stated above, the quantity of Edwards Aquifer water available to the Northeast Hays/Northwest Caldwell counties area annually for the period 1996 through 2007 would be about 819 acft/yr (Table 3.37-1; 953 acft x 0.86). If it is assumed that the Barton Springs Edwards Aquifer is capable of continuing to supply 1,266 acft of water per year to the Northeast Hays County area, then the quantity of water needed from other sources in the year 2000 for the Northeast Hays/Northwest Caldwell Counties area would be 881 acft (Table 3.37-1; 2,966 minus 1,266 minus 819 = 881), with an additional 3,921 acft needed for San Marcos, bringing the total needed in 2000 to 4,802 acft (Table 3.37-1). The projected quantities of surface water needed in 2010 for the Northeast Hays County area are 1,600 acft, with 714 acft needed for areas served from the Edwards Aquifer, and an additional 6,713 acft needed for San Marcos (Table 3.37-1). Projected quantities of water needed in 2050 for Northeast Hays County (area served from the Barton Springs Edwards Aquifer) are 2,522 acft, with 1,788 acft needed in Northeast Hays/Northwest Caldwell Counties area served from the Edwards Aquifer and 11,959 acft needed by San Marcos for a total of 16,269 acft (Table 3.37-1). (Note: San Marcos has purchased a supply of 5,000 acft/yr of Canyon Lake Water and is in the process of developing a plan to obtain and use this supply.)

3.37.2 Available Yield

The firm yield of Canyon Lake is defined to be the maximum amount of water the lake could have supplied through the drought of record after allowing for passage of inflows when required for senior (senior in time) downstream water rights. The drought of record for Canyon Lake covers a 116 month period of time which begins in July, 1947, and ends in February, 1957. Below Canyon Lake, there are senior water rights totaling more than 225,000 acft/yr that periodically require passage of lake inflows. When river flows originating below Canyon Lake exceed senior water rights requirements, inflows to the lake can be stored for later release. Springflow from the Edwards Aquifer contributes substantially to the base flow of the Guadalupe River and, consequently, provides water to meet a significant portion of downstream water rights, including GBRA and City of Seguin hydroelectric rights which are senior to Canyon Lake. If springflow is decreased, due to dry weather and/or aquifer pumpage, a greater proportion of downstream senior water rights demands must be met by passage of Canyon Lake inflows making less water available for storage. Because springflow and downstream hydroelectric rights have direct effect on the firm yield of Canyon Lake, firm yield has been estimated for several alternative scenarios of hydroelectric rights subordination and aquifer pumpage. Subordination of hydroelectric rights means that inflows to Canyon Lake are not subject to being called upon to meet specified hydroelectric target flow rates downstream of Canyon.

The Guadalupe - San Antonio River Basin Model[30] (GSA Model) has been modified and applied to compute the uncommitted firm yield of Canyon Lake (diverted at Lake Dunlap) subject to two hydroelectric rights subordination scenarios and three aquifer pumpage scenarios for a total of six combined alternatives. The uncommitted firm yield is the portion of the total firm yield which is not presently committed to satisfy existing GBRA contracts. Refer to Appendix G for a detailed presentation of GSA model modifications and a complete summary of Canyon Lake firm yield analyses. Table 3.37-2 contains a summary of the Canyon Lake estimated total firm yield and uncommitted firm yield available for diversion at Lake Dunlap.

Table 3.37-2 shows that with pumpage from the Edwards Aquifer set at 200,000 acft/yr through the period of record, the uncommitted firm yield of Canyon Lake (at Lake Dunlap) is 21,200 acft/yr with a hydropower flow requirement of 365 cfs. If the hydropower requirement is reduced to 0 cfs, the uncommitted firm yield is 49,600 acft/yr. This is an increase of 28,400 acft/yr which represents a 48 percent increase in the total firm yield of Canyon Lake due to the subordination of the hydropower flow requirement.

Table 3.37-2 also shows that with pumpage of the Edwards Aquifer set at 368,000 acft/yr and 400,000 acft/yr, the uncommitted firm yield of Canyon Lake (at Lake Dunlap) is 8,500 acft/yr and 6,600 acft/yr respectively, with a hydropower flow requirement of 365

[30]HDR Engineering, Inc., "Guadalupe - San Antonio River Basin Recharge Enhancement Study," Volumes I, II, and III, Edwards Underground Water District, September, 1993.

cfs. If the hydropower requirement is reduced to 0 cfs, the uncommitted firm yield is about 43,000 acft/yr for either aquifer pumpage scenario. This represents about a 75 percent increase in the total firm yield of Canyon Lake due to the elimination of the hydropower flow requirement.

Table 3.37-2
Canyon Lake Yield Available for Diversion at Lake Dunlap

Aquifer Demand Scenario [3]	Hydropower Scenario [2]	Total Firm Yield at Lake Dunlap (acft/yr)	Uncommitted Firm Yield [1] at Lake Dunlap (acft/yr)
200,000 acft/yr	365 cfs	59,600	21,200
	0 cfs	88,000	49,600
368,000 acft/yr	365 cfs	46,900	8,500
	0 cfs	82,300	43,900
400,000 acft/yr	365 cfs	45,000	6,600
	0 cfs	81,600	43,200

Notes:
[1] Uncommitted firm yield is the portion of the total firm yield of Canyon Lake which has not been contractually committed. Existing contracts total 38,438 acft/yr assuming an average of 6,000 acft/yr delivered to CP&L at Coleto Creek Reservoir. This includes 7,000 acft/yr to Canyon Regional Water Authority and Bexar Metropolitan Water Authority.
[2] Hydropower scenario represents the target flowrate for power generation at Lake Dunlap.
[3] The results of the simulated springflows from the TWDB Edwards Aquifer Model for all pumpage scenarios were adjusted to account for the difference in the model's simulated historical springflows and observed springflows.

Year 2050 projected water shortage in the Northeast Hays/Northwest Caldwell counties area is 4,310 acft/yr, including the estimated longterm supply from the Edwards Aquifer (Table 3.37-1) and availability of uncommitted Canyon Lake yield at Lake Dunlap for all scenarios exceeds projected shortages for the area. Therefore, the projected water demand for the area could be met with Canyon Lake yield provided a purchase contract is signed with GBRA. For conceptual design, costing, and environmental analysis, the treatment and distribution system is sized to meet the year 2020 demands (1,920 acft/yr, Table 3.37-1).

3.37.3 Environmental Issues

Environmental Sétting

Alternative G-25 includes a water treatment plant located near Lake Dunlap. Lake Dunlap is on the Guadalupe River southeast of New Braunfels in Guadalupe County (Figure 3.37-1). The waterline would extend north along the western edge of the Blackland Prairie, just east of the Balcones Fault, through the northwest corner of Caldwell County into northeastern Hays County. The proposed alignment would require a river crossing of the San Marcos River east of IH 35.

The headwaters of the Guadalupe River are in Kerr County, Texas, and it flows over 430 miles to San Antonio Bay on the Gulf of Mexico. The river is impounded by Canyon Lake and a series of small hydroelectric dams including the Guadalupe - Blanco River Authority dam at Lake Dunlap. The source waters of the river are surface runoff and springs. Two high volume spring systems, Comal Springs and San Marcos Springs, are the sources of water for the Comal and San Marcos Rivers which are major tributaries of the Guadalupe River below Canyon dam.

Lake Dunlap is a long, moderately deep lake (average depth, 13 feet) with a surface area of about 420 acres filling the Guadalupe River channel just east of IH-35. Because the storage capacity of Lake Dunlap is small (5,900 acre-feet) relative to the normal discharge of the Guadalupe River, average residence time is short, thermal stratification is not persistent, and its effects on water quality are small.

The land use and habitat in the water supply alternative area reflect its location at the western edge of the Blackland Prairies. The soils of the water line corridor range from light-colored, acid sandy loams (upland), dark-gray acid sandy loams and clays (bottomland) to fairly uniform dark-colored calcareous clays. Climax grasses of the Blackland Prairies are little bluestem, Indian grass, switch grass, purpletop, silver bluestem and Texas wintergrass as well as sideoats grama, hairy grama and tall dropseed. Unimproved pastures and abandoned croplands are invaded by mesquite. Post oak and blackjack oak are present as overstory, although only small remnants of this upland woodland are generally present in this ecoregion.

Although the Texas Natural Heritage Program does not report endangered or threatened species directly along the proposed water line corridors or possible water treatment plant site, some have been reported in the vicinity (Appendix B, Tables 10, 22 and 33, Volume 2)[31]. The remnant areas of prairie grassland; brush and shrub invaded grassland; and rivers provide habitat for several endangered or threatened species. In upland habitats the Texas horned lizard and Texas garter snake may be present where habitat is appropriate.

Comal Springs and San Marcos Springs provide habitat for Edwards associated protected species. The upper Comal and San Marcos Rivers have relatively constant temperature regime and stable water quality. From its headwaters to about 0.5 miles downstream of its confluence with the Blanco River, the San Marcos is critical habitat for the Texas wildrice, the fountain darter, and the San Marcos gambusia. These Edwards spring related species ranges do not extend into the Blackland Prairie ecoregion where the transmission line crossing would be located.

The Cagle's map turtle, Guadalupe bass, and the blue sucker ranges extend from the Edwards Plateau through the Blackland Prairie to the Coastal Plains in the Guadalupe River. Cagle's map turtle has been located as far south as Victoria on the Coastal Plain. The Guadalupe bass may be found in Lake Dunlap. Streamflow is an important component of its habitat requirements. The Guadalupe bass, best adapted for flowing water, is often found in flowing water near riffles feeding on aquatic insects. Although the Guadalupe bass is found in reservoirs such as Canyon Lake, it may be at a competitive disadvantage with other bass species in more lentic environments[32]. The blue sucker, a large river fish, would not be present in Lake Dunlap.

Effects Assessment

The waterline construction corridor is assumed to be a uniform 30 feet (ft) wide. Maintenance procedures would keep a 10 ft ROW free of woody vegetation. The water treatment plant and water line corridor are in an area that is predominantly cropland (80%) and a mixture of woods, brush and urban areas. The waterline construction ROWs would

[31]TPWD. 1994. Unpublished data files and maps including species listed by the Texas Organization for Endangered Species, Natural Heritage Program, Resource Protection Division, Austin, Texas.

[32]Garrett, Gary P. 1991. Guidelines for the Management of Guadalupe Bass. Publication PWD-RP-N3200-367-11/91, Texas Parks and Wildlife Department, Austin, Texas.

result in disturbance to about 121 acres from Lake Dunlap. Permanently maintained ROW and the water treatment plant site will amount to an estimated 52 acres. The waterline from Lake Dunlap would cross the San Marcos River downstream of the critical habitat reach of the Texas wildrice, the fountain darter, and the San Marcos gambusia. Surveys for protected species or other biological resources of restricted distribution would be conducted within the proposed construction corridor where described habitat is present.

With the majority of the water supply corridor and possible water treatment plant sites located in either cropland or urbanized areas, terrestrial impacts can generally be avoided or minimized by careful site selection. Erosion control measures would be implemented at stream crossings and the intake construction area, and following construction, the construction right-of-way (ROW) would be revegetated. Where any ROW clearing and construction activity may affect a federally protected species, consultation with the U.S. Fish and Wildlife Service (FWS) concerning the need for a permit for the incidental take of that species should be conducted. This level of study would occur during facility siting studies in later phases.

A cultural resources survey of all public property, including easements held by public entities, to be disturbed during construction is required by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resources Code of 1977). Any sites located would be tested for significance and eligibility for the National Register. Disturbance of significant sites should be avoided to the extent possible.

3.37.4 Water Quality and Treatability

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

3.37.5 Engineering and Costing

For this alternative, surface water supply for the Northeast Hays/Northwest Caldwell counties area would be supplied from a treatment plant located near Lake Dunlap to existing water utilities in the service area. This alternative would augment the existing groundwater supplies in the area by providing surface water on a wholesale basis to existing water supply companies. Figure 3.37-1 is a vicinity map showing possible locations of a water treatment plant site and pipeline routes.

For purposes of costing and general environmental assessment of this alternative, a surface water intake site was selected in the general vicinity of the south side of Lake Dunlap. From the intake, raw water would be pumped to a treatment plant located within two miles of the intake and from the treatment plant a pipeline would be constructed to supply water on a wholesale basis to existing distribution systems. Treatment would consist of conventional surface water treatment (Treatment Level 3, Table 3.0-4). The treatment costs estimated for this alternative are for typical conventional treatment of surface water of average quality and are used for relative evaluation of alternatives. Treatability studies of Canyon Lake water may find that less expensive treatment methods are appropriate.

The major facilities required to implement this alternative are:

Surface Water Intake and Pump Station
Raw Water Pipeline to Treatment Plant
Water Treatment Plant (Level 3, Table 3.0-4, in Volume 2)
Finished Water Pump Station
Transmission Pipeline
Interconnects to Retail Water Utilities
Elevated Storage Tank or Standpipe

The system has been sized for delivery of year 2020 demands of 1,920 acft/yr (1.7 mgd, average day) assuming a maximum day to average day peaking factor of 2.2. Therefore, the intake, treatment plant, and finished water pump station are sized for 3.8 mgd with an 18-inch diameter pipeline beginning at the treatment plant and reducing to a 12-inch pipeline. The operating cost was determined for the total static lift of 160 feet and an annual delivery of 1,920 acft. Financing the project over 25 years at an 8.0 percent annual interest rate results in an annual expense of $1,560,000 (Table 3.37-3). The annual cost of water purchased from GBRA is $53/acft, for a payment of $102,000 per year. Operation and maintenance costs, including power and purchase of store water total $212,000. The annual costs, including debt repayment, interest, and operation and maintenance, total $2,312,000. For an annual delivery of 1,920 acft, the resulting annual cost of water is $1,204 per acft[33] (Table 3.37-3). This is the cost of treated water delivered on a wholesale basis and does not include the operating cost of the distribution system. The

[33]Costs for supply systems in the GBRA planning areas, which have capacity to meet peak demands, are typically higher when compared to alternatives in Volume 2, which are mostly larger projects with uniform annual delivery rates.

Table 3.37-3
Cost Estimate Summaries for Northeast Hays and Northwest Caldwell Counties Water Supply (G-25)
(Third Quarter - 1994 Prices)

Item	Alt G-25 Costs
Capital Costs	
Intake and Treatment Plant	$4,970,000
Transmission Pipelines	5,700,000
Interconnects to Existing Systems	840,000
Total Capital Cost	$11,510,000
Engineering, Contingencies, and Legal Costs	3,710,000
Land Acquisition	230,000
Environmental Studies and Mitigation	280,000
Interest During Construction	940,000
Total Project Cost	$16,670,000
Annual Costs	
Annual Debt Service	$1,560,000
Annual Operation and Maintenance	540,000
Purchase of Stored Water	102,000
Annual Power Cost	110,000
Total Annual Cost	$2,312,000
Annual Water Delivery (acft/yr)	1,920
Annual Cost of Water [1]	$1,204/acft

[1] Cost of treated water delivered on a wholesale basis and does not include the operating cost of the distribution system. Costs for supply systems in the GBRA planning areas, which have capacity to meet peak demands, are typically higher when compared to alternatives in Volume 2, which are mostly larger projects with uniform annual delivery rates.

Note: The cost to mitigate for hydro generation lost to subordination, if any, is not included and will depend on the amount and owner of the subordinated right.

cost to mitigate for hydro generation lost to subordination, if any, is not included and will depend on the amount and owner of the subordinated right.

3.37.6 Implementation Issues

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

1. If this alternative requires exceeding the current permitted average annual diversion from Canyon Lake of 50,000 acft, then a permit amendment will require:
    a. Application to the TNRCC
    b. Hydrologic studies substantiating requested firm yield.
    c. 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>Requirements Specific to Treatment and Distribution</u>

1. Necessary permits:
    a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
    b. TNRCC Discharge Permit for settling basin supernatant.
    c. GLO Sand and Gravel Removal permits.
    d. TPWD Sand, Gravel, and Marl permit for river crossings.
    e. Coastal Coordination 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
4. Financing:
    a. Sponsoring entity must be identified and be able to incur debt to finance project.
    b. Participating entities must negotiate a water purchase contract with GBRA and establish rate structure.

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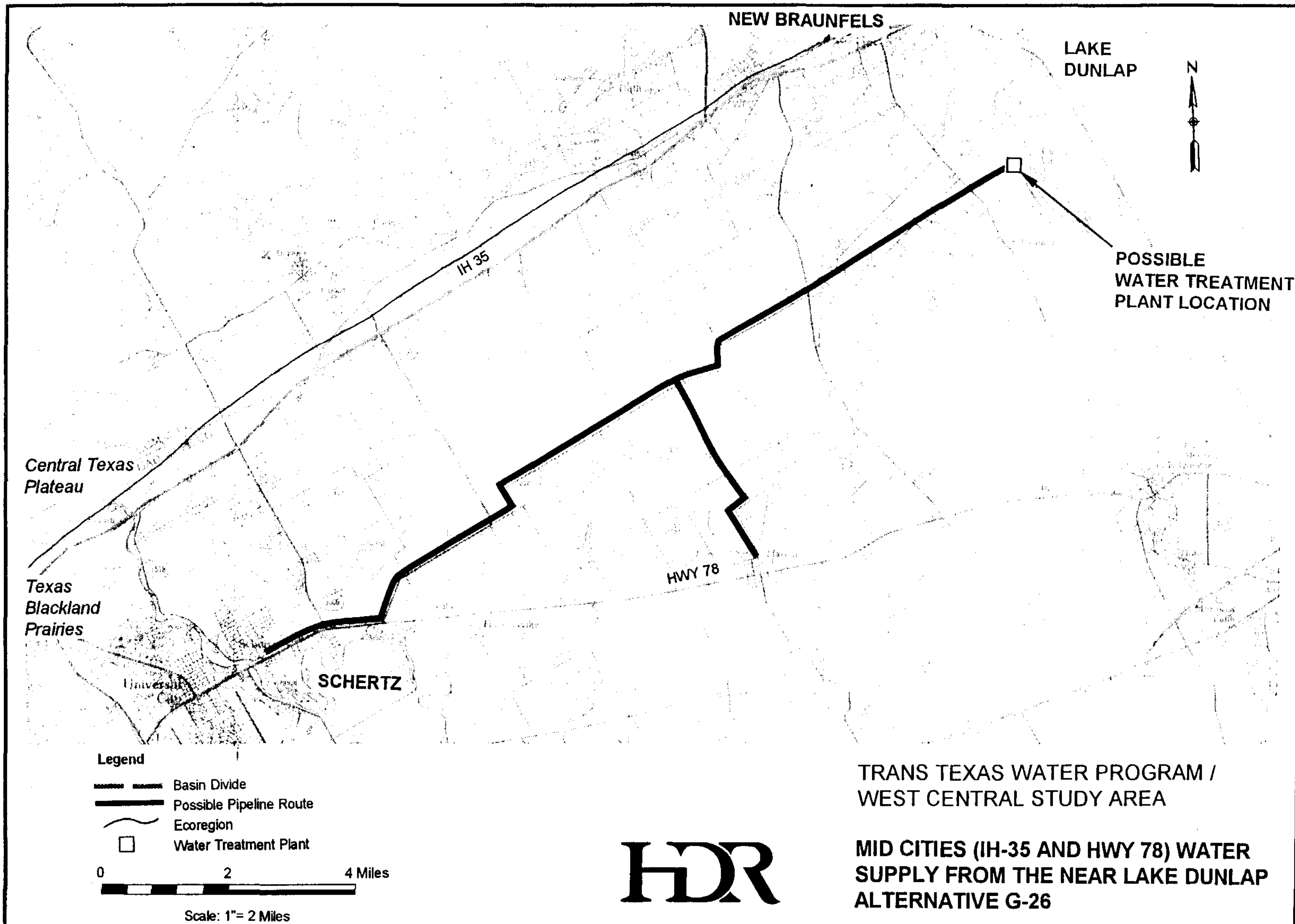
3.38 Mid-Cities (IH-35 and Highway 78) Water Supply from Near Lake Dunlap (G-26)

3.38.1 Description of Area with Projections of Population and Water Demand

The Mid-Cities area includes the southern corner of Comal County, the western corner of Guadalupe County and adjacent areas in Northeastern Bexar County (Figure 3.38-1). Interstate Highway 35 and State Highway 78 are major transportation corridors through the area. The communities of the area include Marion, Garden Ridge, Schertz, Cibolo, Selma, Universal City, Randolph Air Force Base, Live Oak, and Converse, plus unincorporated areas of western Guadalupe and southern Comal Counties. These communities obtain their water supplies from the Edwards Aquifer and are faced with the same problem as was described in Section 3.37; i.e., limits on Edwards Aquifer pumpage to protect spring flows.

The Mid-Cities area is quite similar to northeast Hays and northwest Caldwell counties, as described in Section 3.37 above, in that the cities and unincorporated areas have developed water systems which obtain their present water supply from the Edwards Aquifer. (Note: Within the past two or three years some surface water from the Guadalupe River has been added to the supplies of the area by the Canyon Regional Water Authority, and the City of New Braunfels to the east has developed a surface water supply which meets a part of its needs.) Since all Aquifer users are faced with potential reductions of present pumping levels in order to maintain flows at Comal and San Marcos Springs (see Section 3.37), it is necessary to develop water supplies from other sources. The most readily available supply is the Guadalupe River. Thus, a regional water supply system, which would convey treated surface water to the area from a water treatment plant at Lake Dunlap and make wholesale delivery via pipelines to the respective cities and water supply corporations' storage tanks for distribution through existing systems, could be developed to supply water to all or parts of the area. Projections of population and water demands of the Mid-Cities area are presented in Table 3.38-1. Cost estimates of water treatment plants and pipelines are given in later sections.

In 1990, the population of the Mid-Cities service area located in southern Comal, western Guadalupe and parts of northwestern Bexar County served by Green Valley WSC, East Central WSC, and Bexar Met. LC/East was about 64,634 and is projected to increase to 151,169 by 2020, and 199,054 by 2050 (Table 3.38-1). The population of New Braunfels



HDR

HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

MID CITIES (IH-35 AND HWY 78) WATER SUPPLY FROM THE NEAR LAKE DUNLAP ALTERNATIVE G-26

FIGURE 3.38-1

Table 3.38-1 Population Projections [1] Mid-Cities (IH-35 and Highway 78) Areas							
		Projection Date					
Area	1990 Actual	2000	2010	2020	2030	2040	2050
Comal/Guadalupe Counties Areas							
Garden Ridge	1,450	1,993	2,561	3,122	3,687	4,155	4,623
Selma	520	712	912	1,111	1,303	1,468	1,621
Schertz	10,141	13,630	15,423	17,156	19,401	21,074	22,747
Cibolo	1,757	2,715	3,802	4,569	5,141	5,690	6,239
Marion [2]	984	1,309	1,676	1,945	2,149	2,350	2,545
Green Valley WSC [2]	11,505	17,766	22,742	26,393	29,154	31,887	34,532
Crystal Clear WSC's [2]	6,639	10,365	13,268	15,399	17,010	18,604	20,148
Springs Hill WSC's [2]	3,839	15,343	19,641	22,794	25,179	27,539	29,823
East Central WSC [2]	7,206	12,092	15,479	17,964	19,844	21,704	23,504
Bexar Met. LC/East [2]	20,593	27,408	35,084	40,716	44,976	49,192	53,272
Subtotal	64,634	103,333	130,588	151,169	167,844	183,663	199,054
Northeast Bexar County Areas							
Universal City	13,057	15,429	18,665	22,435	27,194	31,905	36,616
Randolph AFB	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Live Oak	10,023	12,001	14,584	17,593	21,391	25,152	28,913
Converse	8,887	13,177	19,598	26,379	34,940	43,415	51,890
Subtotal	35,967	44,607	56,847	70,407	87,525	104,472	121,419
New Braunfels *	27,334	33,300	40,792	47,011	54,691	57,930	61,641
Seguin *	18,853	20,298	21,873	24,686	26,410	27,876	29,343
Total	146,788	201,538	250,100	293,273	336,470	373,941	411,457

[1] Texas Water Development Board, high case.
[2] Projected at Texas Water Development Board's growth rates for Guadalupe County. Note: Service areas of Green Valley and East Central WSC's include parts of Northeast Bexar County, and Bexar Met. LC East obtains water from the Guadalupe River via purchase from the Guadalupe-Blanco River Authority through the Canyon Regional Water Authority.
* New Braunfels and Seguin included for information only.

was 27,344 in 1990 and is projected at 61,641 in 2050 (Table 3.38-1[33]). The population of the Mid-Cities area of northeast Bexar County was 35,967 in 1990 and is projected to increase to 121,419 in 2050 (Table 3.38-1). The population of Seguin was 18,853 in 1990 and is projected to increase to 29,343 in 2050 (Table 3.38-1).

Water use by customers of entities located in southern Comal, western Guadalupe and those parts of Northeastern Bexar County served by Green Valley WSC, East Central

[33]Although New Braunfels and Seguin are not included in the Mid-Cities plan, the population and water demand projections are included in Table 3.38-1 for information purposes.

WSC and Bexar Met. LC/East was 10,832 acft in 1990 and is projected to increase to 32,418 acft in 2050 (Table 3.38-2).

Given the expected reductions in Edwards Aquifer pumpage under Senate Bill 1477 to maintain spring flows, the estimated supply of Edwards Aquifer water for the Southern Comal/Western Guadalupe Counties Mid-Cities area after 2007 would be about 8,124 acft/yr except during severe droughts when it could be less. Under the conditions of Senate Bill 1477, the area is projected to need about 13,394 acft of Guadalupe River water in 2010, and the quantity would increase to about 24,294 acft/yr in 2050 (projected demands minus estimated supply from the Edwards Aquifer) (Table 3.38-2). Under Senate Bill 1477, for New Braunfels, the estimated quantities of water available from the Edwards Aquifer after 2007 would be about 4,690 acft/yr. Given this estimate, New Braunfels would need 6,779 acft of Guadalupe River water in 2010, and by 2050 would need an estimated 11,553 acft of Guadalupe River water. It is noted that New Braunfels has developed a surface water treatment plant and has obtained 6,720 acft of Canyon Lake water which is now being used.

Water use in the Mid-Cities area of northeast Bexar County adjacent to southern Comal and western Guadalupe counties in 1990 was 6,251 acft and water demand is projected to increase to 21,445 acft/yr in 2050 (Table 3.38-2). Given the expected reductions in Edwards Aquifer pumpage to maintain spring flows, the estimated supply of Edwards Aquifer water for this part of the Mid-Cities area after 2007 would be 4,688 acft/yr. Under conditions of SB 1477, as described above, this part of the Mid-Cities area would need 4,396 acft of additional supply in year 2000, 8,584 acft in 2020, and 16,757 acft in 2050 (shortages shown at bottom of Table 3.38-2).

Water demands for Seguin increase from 3,604 acft in 1990 to 5,495 acft in 2050. Seguin has run-of-river municipal water rights to Guadalupe River flows of 7,000 acft, and a contract for 2,000 acft of Canyon Lake water, which would be expected to meet Seguin's needs except perhaps during severe droughts.

3.38.2 Available Yield

The firm yield of Canyon Lake is defined to be the maximum amount of water the lake could have supplied through the drought of record after allowing for passage of inflows

Table 3.38-2
Water Demand Projections (Acft/Yr) [1]
Mid-Cities (IH-35 and Highway 78) Areas

Area	1990 Actual	Projection Date 2000	2010	2020	2030	2040	2050
Comal/Guadalupe Counties Areas [2]							
Garden Ridge	397	650	800	941	1,103	1,233	1,363
Selma	134	156	182	244	286	322	356
Schertz	2,140	2,840	3,075	3,267	3,651	3,919	4,187
Cibolo	204	414	545	624	691	758	825
Marion [3]	150	205	262	304	337	368	399
Green Valley WSC [3]	1,804	2,785	3,566	4,138	4,571	5,000	5,415
Crystal Clear WSC's [3]	1,042	1,625	2,080	2,414	2,667	2,917	3,159
Springs Hill WSC's [3]	602	2,405	3,080	3,574	3,948	4,318	4,676
East Central WSC [3]	1,130	1,896	2,427	2,816	3,111	3,403	3,685
Bexar Met. LC/East [3]	3,229	4,297	5,501	6,384	7,052	7,713	8,353
Subtotal	10,832	17,273	21,518	24,706	27,417	29,951	32,418
Supply from Edwards Aquifer [4]	10,832	9,315	8,124	8,124	8,124	8,124	8,124
Shortage	0	7,958	13,394	16,582	19,293	21,867	24,294
Northeast Bexar County Areas							
Universal City	2,323	3,405	3,910	4,473	5,361	6,218	7,075
Randolph AFB	1,494	1,635	1,582	1,528	1,514	1,501	1,488
Live Oak	1,221	2,473	2,842	3,252	3,882	4,536	5,190
Converse	1,213	2,258	3,139	4,019	5,244	6,468	7,692
Subtotal	6,251	9,771	11,473	13,272	16,001	18,723	21,445
Supply from Edwards Aquifer [4]	6,251	5,375	4,688	4,688	4,688	4,688	4,688
Shortage	0	4,396	6,785	8,584	11,313	14,035	16,757
New Braunfels (NB) Demand [5]	6,254	9,773	11,469	12,796	14,636	15,509	16,243
NB Supply from Edwards Aquifer [4]	6,254	5,378	4,690	4,690	4,690	4,690	4,690
New Braunfels Shortage	0	4,395	6,779	8,106	9,946	10,819	11,553
Seguin Demand [5]	3,604	4,365	4,484	4,811	5,059	5,277	5,495
Seguin Run-of-River/Canyon	9,000	9,000	9,000	9,000	9,000	9,000	9,000
Shortages							
Comal/Guadalupe Areas	0	7,958	13,394	16,582	19,293	21,867	24,294
Northeast Bexar County	0	4,396	6,785	8,584	11,313	14,035	16,757
Total	0	12,354	17,179	25,166	30,606	35,902	41,051

[1] Texas Water Development Board, high case, with conservation.
[2] Service areas of Green Valley and East Central WSCs of Guadalupe County include parts of Northeast Bexar County, and Bexar Met. LC East obtains water from the Guadalupe River via purchase from the Guadalupe-Blanco River Authority through the Canyon Regional Water Authority.
[3] Projected at 140 gallons per person per day.
[4] Assuming pumpage will be reduced 25 percent of the 1990 level beginning in 2008 to protect spring flows (14 percent reduction between 1995 and 2008). During severe droughts pumpage could be less than shown here.
[5] New Braunfels and Seguin are included for information purposes. Both cities use surface water from the Guadalupe River; Seguin has no Edwards Aquifer supply.

when required for senior (senior in time) downstream water rights. The drought of record for Canyon Lake covers a 116 month period of time which begins in July, 1947, and ends in February, 1957. Below Canyon Lake, there are senior water rights totaling more than 225,000 acft/yr that periodically require passage of lake inflows. When river flows originating below Canyon Lake exceed senior water rights requirements, inflows to the lake can be stored for later release. Springflow from the Edwards Aquifer contributes substantially to the base flow of the Guadalupe River and, consequently, provides water to meet a significant portion of downstream water rights, including GBRA and City of Seguin hydroelectric rights which are senior to Canyon Lake. If springflow is decreased, due to dry weather and/or aquifer pumpage, a greater proportion of downstream senior water rights must be met by passage of Canyon Lake inflows making less water available for storage. Because springflow and downstream hydroelectric rights have direct effect on the firm yield of Canyon Lake, firm yield has been estimated for several alternative scenarios of hydroelectric rights subordination and aquifer pumpage. Subordination of hydroelectric rights means that inflows to Canyon Lake are not subject to being called upon to meet specified hydroelectric target flow rates downstream of Canyon.

The Guadalupe - San Antonio River Basin Model[35] (GSA Model) has been modified and applied to compute the uncommitted firm yield of Canyon Lake (diverted at Lake Dunlap) subject to two hydroelectric rights subordination scenarios and three aquifer pumpage scenarios for a total of six combined alternatives. The uncommitted firm yield is the portion of the total firm yield which is not presently committed to satisfy existing GBRA contracts. Refer to Appendix G for a detailed presentation of GSA model modifications and a complete summary of Canyon Lake firm yield analyses. Table 3.38-2 contains a summary of the Canyon Lake estimated total firm yield and uncommitted firm yield available for diversion at Lake Dunlap.

Table 3.38-3 shows that with pumpage from the Edwards Aquifer set at 200,000 acft/yr through the period of record, the uncommitted firm yield of Canyon Lake (at Lake Dunlap) is 21,200 acft/yr with a hydropower flow requirement of 365 cfs. If the hydropower requirement is reduced to 0 cfs, the uncommitted firm yield is 49,600 acft/yr. This is an

[35]HDR Engineering, Inc., "Guadalupe - San Antonio River Basin Recharge Enhancement Study," Volumes I, II, and III, Edwards Underground Water District, September, 1993.

Aquifer Demand Scenario [3]	Hydropower Scenario [2]	Total Firm Yield at Lake Dunlap (acft/yr)	Uncommitted Firm Yield [1] at Lake Dunlap (acft/yr)
200,000 acft/yr	365 cfs	59,600	21,200
	0 cfs	88,000	49,600
368,000 acft/yr	365 cfs	46,900	8,500
	0 cfs	82,300	43,900
400,000 acft/yr	365 cfs	45,000	6,600
	0 cfs	81,600	43,200

Table 3.38-3
Canyon Lake Yield Available for Diversion at Lake Dunlap

Notes:
[1] Uncommitted firm yield is the portion of the total firm yield of Canyon Lake which has not been contractually committed. Existing contracts total 38,438 acft/yr assuming an average of 6,000 acft/yr delivered to CP&L at Coleto Creek Reservoir. This includes 7,000 acft/yr to Canyon Regional Water Authority and Bexar Metropolitan Water Authority.
[2] Hydropower scenario represents the target flowrate for power generation at Lake Dunlap.
[3] The results of the sumulated springflows from the TWDB Edwards Aquifer Model for all pumpage scenarios were adjusted to account for the difference in the model's simulated historical springflows and observed springflows.

increase of 28,900 acft/yr which represents a 48 percent increase in the total firm yield of Canyon Lake due to the subordination of the hydropower flow requirement.

Table 3.38-3 also shows that with pumpage of the Edwards Aquifer set at 368,000 acft/yr and 400,000 acft/yr, the uncommitted firm yield of Canyon Lake (at Lake Dunlap) is 8,500 acft/yr and 6,600 acft/yr respectively, with a hydropower flow requirement of 365 cfs. If the hydropower requirement is reduced to 0 cfs, the uncommitted firm yield is about 43,000 acft/yr for either aquifer pumpage scenario. This represents about a 75 percent increase in the total firm yield of Canyon Lake due to the elimination of the hydropower flow requirement.

Year 2050 projected water shortage in the Mid-Cities area is 41,051 acft/yr, including the estimated longterm supply from the Edwards Aquifer (Table 3.38-2). This quantity of Canyon Lake yield would only be available from the remaining uncommitted firm yield of Canyon Lake with full subordination of hydropower rights. Interlocal agreements would be needed to secure the hydro subordination, manage aquifer demand to pre-determined limits, and commit the available yield to the Mid-Cities area. A conceptual water treatment and transmission facility design has been completed to meet the projected shortage assuming the

Canyon Lake yield would be available from and diverted at Lake Dunlap. For conceptual design, costing, and environmental analysis, the treatment and distribution system is sized to meet the year 2020 demands (25,166 acft/yr, Table 3.38-2, includes longterm supply from the Edwards Aquifer).

3.38.3 Environmental Issues

Environmental Setting

The land use and habitat in water supply alternative G-26 area reflects its location at the confluence of the Blackland Prairies with the Post Oak Savannah vegetation regions. The soils of the area range from light-colored, acid sandy loams (upland), dark-gray acid sandy loams and clays (bottomland) to fairly uniform dark-colored calcareous clays. Post Oak Savannah grasses are little bluestem, Indian grass, switch grass, purpletop, silver bluestem and Texas wintergrass. The overstory is primarily post oak and blackjack oak. Savannah and grasslands have been invaded by mesquite brushlands. There are relatively few streams, and perched ponds supply water for livestock. Santa Clara Creek and Long Creek are the major creek crossings. These streams are intermittent tending to cease flowing in the summer months, but maintaining isolated pools within their streambeds during some years.

The water lines are primarily in pasture and cropland (80%) and a mixture of woods, brush and urban areas. The southwestern quarter of the pipelines cross a region that is about 50% developed, 20% cropland and the remainder a mix of brush, shrub and grassland.

Effects Assessment

The water line construction corridor is assumed to be a uniform 30 feet (ft) wide which is required for the size waterline described in Section 3.38.5. Maintenance procedures would keep a 10 ft ROW free of woody vegetation. The water line construction ROW and water treatment plant would result in disturbance to about 58 acres, and the long-term impacts of maintaining the ROW free of woody vegetation would affect about 36 acres, including the water plant site of mainly vacant cropland and unimproved pastures. The water line would cross several intermittent stream and effect less than a half acre of wetlands during construction and less than a tenth acre long term. Less than 0.25 acres of riparian woodland along the Guadalupe River would be impacted during construction of the river intake structure.

Although the Natural Heritage Program does not report any endangered or threatened species directly along the water line corridor (Appendix B, Table 6), the remnant areas of brush, shrub and grassland in northeastern Bexar County may provide habitat for several endangered or threatened species, such as the Texas Tortoise, Reticulate Collared Lizard, and the Indigo Snake. In upland habitats of Guadalupe County (Appendix B, Table 22), the Texas horned lizard and Texas garter snake may be present in appropriate areas. Surveys for protected species or other biological resources of restricted distribution would be conducted within the proposed construction corridor where described habitat is present.

The Cagle's map turtle, Guadalupe bass, and the blue sucker ranges extend from the Edwards Plateau through the Blackland Prairie to the Coastal Plains in the Guadalupe River. Cagle's map turtle has been located as far south as Victoria on the Coastal Plain. Best adapted for flowing water, the Guadalupe bass is often found in flowing water near riffles feeding on aquatic insects and moving water associated fish such as the Texas shiner and channel catfish. Streamflow is an important component of its habitat requirements. Although the Guadalupe bass is found in reservoirs such as Canyon Lake, it may be at a competitive disadvantage with other bass species in more lentic environments[36]. Populations of Guadalupe bass tend to decline as the river enters the Coastal Plan. In the Guadalupe River, few are found downstream of Luling in Caldwell County. Although Lake Dunlap does not present a habitat that correlates with abundant population of Guadalupe bass, some may be found in Lake Dunlap. The blue sucker, a large river fish, is a candidate for federal protection with probable occurrence, although the presence of several dams in this reach of the Guadalupe, together with a lack of suitable substrate and flow conditions, suggests that it may no longer be present.

Water supply alternative G-26 is located in mostly upland pastures, cropland or urbanized areas. Terrestrial impacts can generally be avoided or minimized by careful selection of the pipeline ROW. Erosion control measures would be implemented at stream crossings and following construction, the construction right-of-way (ROW) would be

[36]Garrett, Gary P. 1991. Guidelines for the Management of Guadalupe Bass. Publication PWD-RP-N3200-367-11/91, Texas Parks and Wildlife Department, Austin, Texas.

revegetated. Where any ROW clearing and construction activity may affect a federally protected species, consultation with the U.S. Fish and Wildlife Service (FWS) concerning the need for a permit for the incidental take of that species should be conducted. This level of study would occur during facility siting studies in later phases.

A cultural resources survey of all public property, including easements held by public entities, to be disturbed during construction is required by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resources Code of 1977). Any sites located would be tested for significance and eligibility for the National Register. Disturbance of significant sites should be avoided to the extent possible.

3.38.4 Water Quality and Treatability

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

3.38.5 Engineering and Costing

For this alternative, surface water supply for the Mid-Cities area would be supplied from a treatment plant located near Lake Dunlap and delivered to existing water utilities in the service area. This alternative would augment the existing groundwater sources in the area by providing surface water on a wholesale basis to existing distribution companies. Figure 3.38-1 is a vicinity map showing possible locations of a water treatment plant site and pipeline routes.

For purposes of costing and general environmental assessment of this alternative, a surface water intake site was selected in the general vicinity of the south side of Lake Dunlap. From the intake, raw water would be pumped to a treatment plant located within two miles of the intake and from the treatment plant a pipeline would be constructed to supply water to existing distribution systems. Treatment would be conventional surface water treatment (Treatment Level 3, Table 3.0-4). The treatment costs estimated for this alternative are for typical conventional treatment of surface water of average quality and are used for relative evaluation of alternatives. Treatability studies of Canyon Lake water may find that less expensive treatment methods are appropriate.

The major facilities required to implement this alternative are:

Surface Water Intake and Pump Station
Raw Water Pipeline to Treatment Plant

Water Treatment Plant (Level 3, Table 3.0-4, in Volume II)
Finished Water Pump Station
Transmission Pipeline
Interconnects to Retail Water Utilities
Elevated Storage Tank or Standpipe

The system has been sized for delivery of year 2020 demands of 25,166 acft/yr (22.5 mgd, average day) with a maximum day to average day peaking factor of 2.2. Therefore, the intake, treatment plant, and finished water pump station are sized for 49.4 mgd through a 54-inch diameter transmission pipeline. The operating cost was determined for the total static lift of 180 feet and an annual delivery of 25,166 acft. Financing the project over 25 years at an 8.0 percent annual interest rate results in an annual expense of $5,870,000 (Table 3.38-4). The annual cost of water purchased from GBRA is $53/acft, for a payment of about $1,334,000 per year. Operation and maintenance costs, including power and purchase of stored water total $6,144,000. The annual costs, including debt repayment, interest, and operation and maintenance, total $12,014,000. For an annual delivery of 25,166 acft, the resulting annual cost of water is $477 per acft[37] (Table 3.38-4). This is the cost of treated water delivered on a wholesale basis and does not include the operating cost of the distribution system. The cost to mitigate for hydro generation lost to subordination, if any, is not included and will depend on the amount and owner of the subordinated right.

3.38.6 Implementation Issues

Requirements Specific to Amending the Canyon Lake Permit

1. If this alternative requires exceeding the current permitted average annual diversion from Canyon Lake of 50,000 acft, then a permit amendment will require:
    a. Application to the TNRCC
    b. Hydrologic studies substantiating requested firm yield.
    c. 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.

[37] Costs for supply systems in the GBRA planning areas, which have capacity to meet peak demands, are typically higher when compared to alternatives in Volume 2, which are mostly larger projects with uniform annual delivery rates.

Table 3.38-4
Cost Estimate Summaries for Mid-Cities (IH-35 and Highway 78)
Water Supply (G-26)
(Third Quarter - 1994 Prices)

Item	Alt G-26 Costs
Capital Costs	
Intake and Treatment Plant	$27,910,000
Transmission Pipelines	14,840,000
Interconnects to Existing Systems	2,200,000
Total Capital Cost	$44,950,000
Engineering, Contingencies, and Legal Costs	14,870,000
Land Acquisition	200,000
Environmental Studies and Mitigation	240,000
Interest During Construction	2,410,000
Total Project Cost	$62,670,000
Annual Costs	
Annual Debt Service	$5,870,000
Annual Operation and Maintenance	3,970,000
Purchase of Stored Water	1,334,000
Annual Power Cost	840,000
Total Annual Cost	$12,014,000
Annual Water Delivery (acft/yr)	25,166
Annual Cost of Water [1]	$477/acft

[1] Cost of treated water delivered on a wholesale basis and does not include the operating cost of the distribution system. Costs for supply systems in the GBRA planning areas, which have capacity to meet peak demands, are typically higher when compared to alternatives in Volume 2, which are mostly larger projects with uniform annual delivery rates.

Note: The cost to mitigate for hydro generation lost to subordination, if any, is not included and will depend on the amount and owner of the subordinated right.

Requirements Specific to Treatment and Distribution

1. Necessary permits:
   a. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for stream crossings.
   b. TNRCC Discharge Permit for settling basin supernatant.
   c. GLO Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel, and Marl permit for river crossings.
   e. 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
4. Financing:
   a. Sponsoring entity must be identified and be able to incur debt to finance project.
   b. Participating entities must negotiate water purchase contracts with GBRA and establish rate structures.

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3.39 Lower Guadalupe River Basin Water Requirements

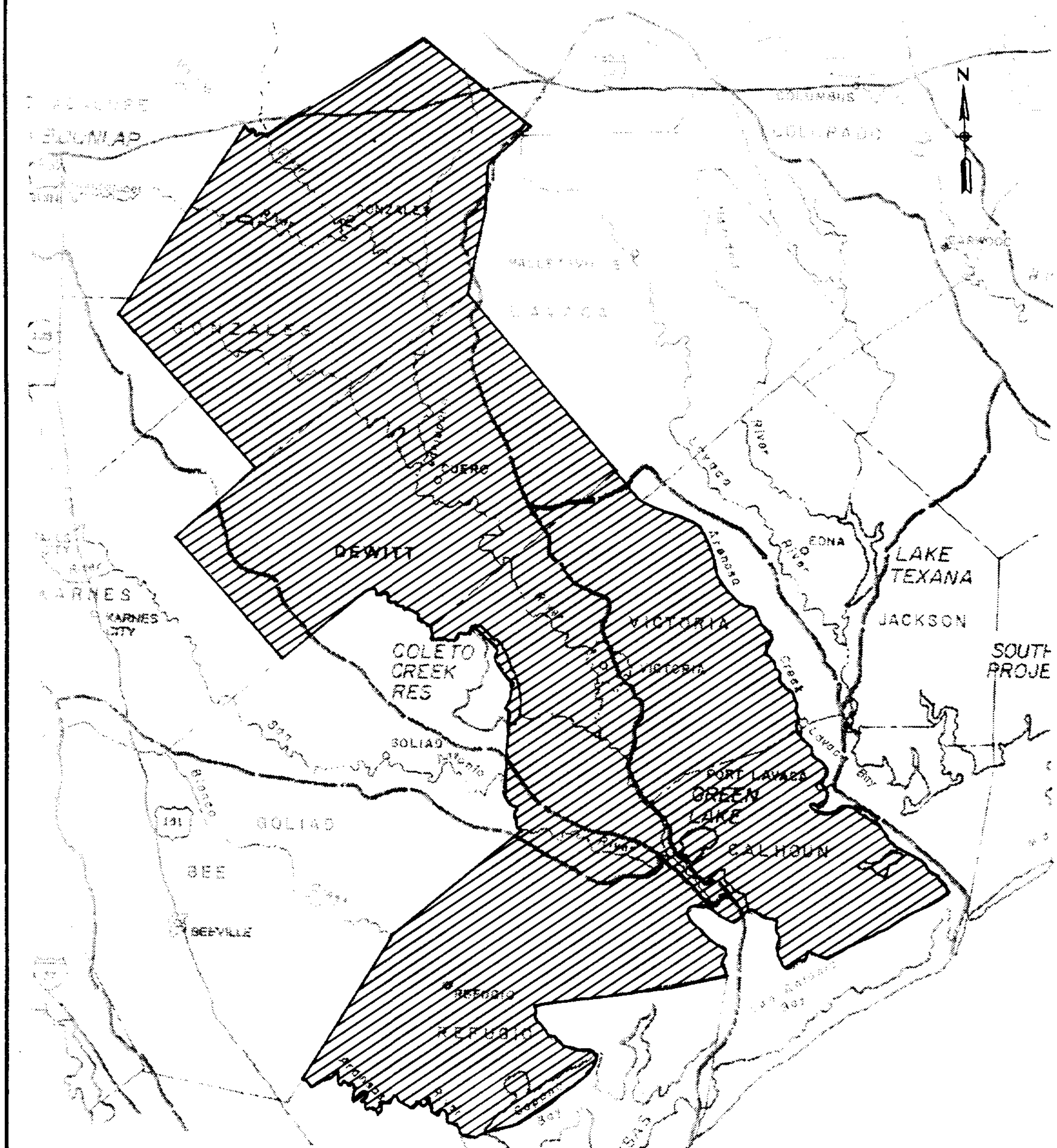
3.39.1 Description of Area with Projections of Population and Water Demand

The Lower Guadalupe River Basin Area as included here includes all of Gonzales, DeWitt, Victoria, Calhoun, and Refugio Counties (Figure 3.39-1). Gonzales county has been supplied from both groundwater and surface water sources (37 percent groundwater and 62 percent surface water in 1990). DeWitt County water use in 1990 was 69 percent groundwater and 31 percent surface water. The Victoria County area has relied upon groundwater from the Gulf Coast Aquifer, with industries of Victoria using surface water from the Guadalupe River. Due to declining water tables and the threat of salt water intrusion and subsidence in local areas of high pumpage, Victoria County water users are considering use of Guadalupe River water to meet a part of their future needs. In the case of Calhoun County, which is located along the Gulf Coast where aquifers tend to be quite saline, water supplies are now being obtained from the Guadalupe River and from Lake Texana of the Lavaca-Navidad River Basin. With the exception of livestock water from local surface sources (stock tanks and streams), water supplies for Refugio County are obtained from local aquifers.

The purposes of the following discussion are to present the Texas Water Development Board high case population and water demand, with conservation, projections for these Lower Guadalupe River Basin counties. The projections are for information purposes, and are without reference to any particular plan of development, as has been done for other subareas of the Basin.

The population of Gonzales County in 1990 was 17,205, with projections to 2050 of 19,897 (Table 3.39-1). Water use in Gonzales County in 1990 was 12,366 acft, of which 4,660 acft or 38 percent was groundwater. Projected water demand in the county in 2050 is 13,839 acft/yr (Table 3.39-1). According to Texas Water Development Board estimates, the dependable groundwater supply of Gonzales County is 45,560 acft/yr, which is significantly greater than projected water demands of the county. However, it is noted that there are potential problems with water quality which may affect the uses to which some of this water may be put.

DeWitt County's population in 1990 was 18,840 and is projected to increase to 22,608 in 2050 (Table 3.39-1). In 1990, water use in DeWitt County was 5,901 acft, of which 4,170



Legend

Lower Guadalupe River Basin Area

Basin Divide

0 10 20 Miles

Scale

HDR

HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

LOWER GUADALUPE RIVER BASIN AREA

FIGURE 3.39-1

Table 3.39-1
Population and Water Demand Projections [1]
Lower Guadalupe Basin Area

Area/Projection	1990 Actual	Projection Date 2000	2010	2020	2030	2040	2050
<u>Population</u>							
Gonzales County	17,205	18,023	18,603	18,883	19,179	19,538	19,897
Gonzales	6,527	7,120	7,414	7,556	7,707	7,889	8,071
Nixon	1,995	2,167	2,258	2,302	2,349	2,405	2,461
Rural	8,683	8,736	8,931	9,025	9,123	9,244	9,365
DeWitt County	18,840	19,485	20,040	20,553	21,276	21,942	22,608
Cuero	6,700	6,902	7,073	7,231	7,454	7,659	7,864
Yoakum	2,154	2,417	2,524	2,623	2,762	2,890	3,018
Yorktown	2,207	2,339	2,453	2,560	2,709	2,847	2,958
Rural	7,779	7,827	7,990	8,139	8,351	8,546	8,741
Victoria County	74,361	87,180	100,334	110,685	118,748	127,172	135,596
Victoria	55,076	65,250	75,679	83,885	90,278	96,956	103,634
Bloomington	1,888	2,640	3,121	3,623	4,171	4,590	5,009
Rural (Lavaca-Guadalupe Basin)	9,568	10,610	11,844	12,747	13,364	14,094	14,824
Rural (Guadalupe Basin)	7,829	8,680	9,690	10,430	10,935	11,532	12,129
Calhoun County	19,053	22,548	26,493	29,832	32,633	34,827	37,021
Point Comfort	956	1,120	1,239	1,340	1,425	1,491	1,557
Port Lavaca	10,886	12,387	14,235	15,799	17,111	18,138	19,165
Seadrift	1,277	1,695	2,105	2,535	2,858	3,110	3,362
Rural	5,934	7,346	8,914	10,158	11,239	12,088	12,937
Refugio County	7,976	7,939	8,415	8,780	9,096	9,278	9,460
Refugio	3,158	3,139	3,389	3,582	3,748	3,844	3,940
Woodsboro	1,731	1,723	1,820	1,893	1,957	1,993	2,029
Rural	3,087	3,077	3,206	3,305	3,391	3,441	3,491
<u>Water Demands (acft/yr)</u>							
Gonzales County Municipal	3,832	4,075	4,033	3,918	3,916	3,924	3,932
Gonzales Municipal	1,646	1,810	1,810	1,769	1,778	1,794	1,810
Nixon Municipal	373	398	395	384	384	385	386
Rural Municipal	1,813	1,867	1,828	1,765	1,754	1,745	1,736
Industrial	865	1,303	1,584	1,921	2,309	2,717	3,125
Steam-Electric Power	0	0	0	0	0	0	0
Irrigation	3,540	2,310	2,310	2,310	2,310	2,310	2,310
Mining	21	41	37	33	29	29	29
Livestock	4,108	4,443	4,443	4,443	4,443	4,443	4,443
Total Gonzales County	12,366	12,172	12,407	12,625	13,007	13,423	13,839

Table 3.39-1 (continued)
Population and Water Demand Projections [1]
Lower Guadalupe Basin Area

Area/Projection	1990 Actual	Projection Date 2000	2010	2020	2030	2040	2050
Water Demands (acft/yr)							
DeWitt County Municipal	3,556	3,699	3,646	3,562	3,614	3,654	3,697
Cuero Municipal	1,716	1,678	1,656	1,620	1,645	1,664	1,683
Yoakum Municipal	425	406	404	400	411	421	431
Yorktown Municipal	405	440	440	439	455	469	483
Rural Municipal	1,010	1,175	1,146	1,103	1,103	1,100	1,100
Industrial	91	139	181	228	282	326	370
Steam-Electric Power	0	0	0	0	0	0	0
Irrigation	285	3,250	3,250	3,250	3,250	3,250	3,250
Mining	129	148	120	95	67	53	39
Livestock	1,840	2,432	2,432	2,432	2,432	2,432	2,432
Total DeWitt County	5,901	9,668	9,629	9,567	9,645	9,715	9,788
Victoria County Municipal	11,545	14,851	16,400	17,327	18,326	19,316	20,306
Victoria Municipal	9,152	11,548	12,885	13,719	14,562	15,422	16,282
Bloomington Municipal	181	370	413	455	514	555	596
Rural (Lav.-Guad. Basin) Mun.	1,217	1,613	1,706	1,734	1,787	1,836	1,885
Rural (Guadalupe Basin) Mun.	995	1,320	1,396	1,419	1,463	1,503	1,543
Industrial	20,032	37,974	49,097	61,388	71,794	83,891	95,988
Steam-Electric Power [2]	887	26,000	26,000	31,000	31,000	31,000	31,000
Irrigation	13,699	12,172	10,800	10,350	9,900	9,450	9,000
Mining	2,409	2,314	2,088	1,090	2,207	2,424	2,641
Livestock	1,271	1,623	1,623	1,623	1,623	1,623	1,623
Total Victoria County	49,843	94,334	106,008	123,778	134,850	147,704	160,558
Calhoun County Municipal	3,916	4,022	4,497	4,849	5,221	5,500	5,779
Point Comfort Municipal	137	153	160	165	171	175	179
Port Lavaca Municipal	1,507	1,873	2,025	2,141	2,262	2,357	2,452
Seadrift Municipal	169	237	278	318	352	376	400
Rural Municipal	2,103	1,759	2,034	2,225	2,436	2,592	2,748
Industrial [3]	24,539	36,797	46,656	57,654	67,434	78,009	88,584
Steam-Electric Power	62	200	200	200	200	200	200
Irrigation	35,421	22,750	22,050	22,050	20,475	20,475	20,475
Mining	1	35	34	20	9	4	2
Livestock	291	649	649	649	649	649	649
Total Calhoun County [3]	64,230	64,453	74,086	85,422	93,988	104,837	115,689

Table 3.39-1 (continued)
Population and Water Demand Projections [1]
Lower Guadalupe Basin Area

Area/Projection	1990 Actual	Projection Date 2000	2010	2020	2030	2040	2050
Water Demands (acft/yr)							
Refugio County Municipal	1,227	1,359	1,372	1,363	1,382	1,380	1,378
Refugio Municipal	569	566	581	586	600	603	606
Woodsboro Municipal	309	334	338	337	342	342	342
Rural Municipal	349	459	453	440	440	435	430
Industrial	0	0	0	0	0	0	0
Steam-Electric Power	0	0	0	0	0	0	0
Irrigation	0	83	83	83	83	83	83
Mining	77	28	14	7	4	1	0
Livestock	563	673	673	673	673	673	673
Total Refugio County	1,867	2,143	2,142	2,126	2,142	2,137	2,134
Groundwater Supplies							
Gonzales County	45,560	45,560	45,560	45,560	45,560	45,560	45,560
DeWitt County	15,866	15,866	15,866	15,866	15,866	15,866	15,866
Victoria County	41,130	41,130	41,130	41,130	41,130	41,130	41,130
Calhoun County	2,940	2,940	2,940	2,940	2,940	2,940	2,940
Refugio County	7,768	7,768	7,768	7,768	7,768	7,768	7,768

[1] Texas Water Development Board, high case, with conservation.
[2] Note: Projections include rights to use run-of-the-river flows for existing steam-electric power generation plant located at Victoria, which may not be continued in its existing condition.
[3] A part of the projected water demands of Calhoun County will be met with water supplied from Lake Texana of the Lavaca Basin; i.e.; Formosa Plastics located in Calhoun County has purchased 30,000 acft of Lake Texana water and a pipeline has been constructed to deliver the water. Thus, the industrial water demand projections have been adjusted downward by this quantity, since Guadalupe Basin water will not be needed to meet these demands. It is further noted that new industrial water demand projections by TWDB for Calhoun County are expected to be somewhat lower than those shown here.

acft or 70 percent was groundwater. Projected water demands in DeWitt County in 2050 are 9,785 acft/yr (Table 3.39-1). Texas Water Development Board estimates of dependable groundwater supplies of DeWitt County are 15,866 acft annually, which is greater than projected water demands for the County.

In 1990, the population of Victoria County was 74,361, and is projected to increase to 135,596 in 2050 (Table 3.39-1). Water use in the county in 1990 was 49,843 acft, of which 29,222 acft was groundwater. Projected water demand in 2050 is 160,558 acft (Table 3.39-1). According to Texas Water Development Board estimates, the dependable groundwater supply of Victoria County is 41,130 acft/yr. Given these data, it is projected that with full development of groundwater, the 2050 demand for surface water would be 119,428 acft/yr.

The population of Calhoun County in 1990 was 19,053, with projections to 2050 of 37,021 (Table 3.39-1). Water use in Calhoun County in 1990 was 64,230 acft with 59,681 acft or 92 percent being surface water (Table 3.39-1). Projected 2050 water demands are 152,189 acft/yr, with 125,084 acft being for industrial purposes (Table 3.39-1). Since the county has only 2,940 acft of dependable groundwater supplies, according to data from the Texas Water Development Board, Calhoun County will be forced to continue to depend upon surface water to meet its projected future needs. In this regard, Formosa Plastics of Calhoun County has purchased 30,000 acft of Lake Texana Water. Lake Texana is located in the neighboring Lavaca River Basin.

The population of Refugio County in 1990 was 7,976, and is projected to increase to 9,460 in 2050 (Table 3.39-1). Water use in Refugio County in 1990 was 1,867 acft of which 1,360 acft or 73 percent was groundwater. Projected water demands in the county in 2050 are 2,134 acft annually (Table 3.39-1). Texas Water Development Board estimates of dependable groundwater supplies of Refugio County are 7,768 acft, which exceeds projected demands to the year 2050.

3.40 GUADALUPE RIVER DIVERSION NEAR LAKE DUNLAP WITH TRANSFER OF DOWNSTREAM RIGHTS (G-27)

3.40.1 Description of Alternative

This alternative includes a component of a comprehensive water management plan proposed by the San Antonio Water System[38] (SAWS plan) involving several interrelated water supply and demand management elements which affect the availability and movement of water in both the Edwards Aquifer (including both pumpage and springflows) and throughout the Guadalupe - San Antonio River Basin. This component of the plan involves the diversion of Guadalupe River water near Lake Dunlap. Water potentially available under this alternative would originate from several sources and be delivered to the proposed North Water Treatment Plant in the San Antonio metropolitan area. Water potentially available includes: stored water from Canyon Lake, possible run-of-river water rights and stored water currently used at the Central Power & Light (CP&L) Coleto Creek steam-electric power generating station, and possible run-of-river water rights currently used by GBRA and others at GBRA's Saltwater Barrier near Tivoli, Texas. Some of these water sources have been studied on a stand-alone basis in previous sections in Volume 2, however, this alternative considers combined quantities of water possibly available from several sources.

Previous studies which are contained in Volume 2 considered water availability from stand alone sources and are briefly summarized herein. Section 3.17 describes the availability of unappropriated water at various points in the Guadalupe Basin, including at Lake Dunlap, and found that no firm yield exists from unappropriated flows without some kind of storage facility. Section 3.19 presents an alternative to divert unappropriated streamflow at Lake Dunlap and includes analysis of an off-channel storage facility which would create a small firm yield for the project. Section 3.20 contains studies of the purchase of 10,000 to 15,000 acft/yr of uncommitted stored water in Canyon Lake released to Lake Dunlap for diversion to the study area. Section 3.23 presents a study of McFaddin Reservoir, a proposed off-channel reservoir located near the Guadalupe - San Antonio river confluence, which might potentially be supplied by using senior water rights held by GBRA

[38]Proposed Water Resource Plan prepared by the San Antonio Water System and presented to the San Antonio Mayor's 2050 Water Resources Committee, April 27, 1994. The SAWS plan is summarized in Appendix F.

and others associated with GBRA's Calhoun Canal Division. Further work performed to estimate water availability with the SAWS plan is described in Appendices G and H. Appendix G contains a description of studies made of Canyon Lake firm yield for possible changes in degree of hydropower subordination and/or aquifer management. Appendix H contains a description of analyses using the Guadalupe - San Antonio River Basin Model[39] (GSA Model) to estimate firm water availability with the SAWS plan.

For this alternative (G-27), a program of combined water rights (i.e., stored water from Canyon Lake and transferred senior water rights) is studied for availability to meet peak summer demands of those served by SAWS. The major facilities needed for this alternative include a surface water intake structure and pump station at Lake Dunlap on the Guadalupe River, water transmission pipeline, and treatment plant. A possible location of the facilities is shown on Figure 3.40-1.

3.40.2 Available Yield

Water potentially available for diversion at Lake Dunlap for this alternative includes purchase of stored water from Canyon Lake (either uncommitted yield or by purchase (or transfer) of CP&L's existing contract for stored Canyon Lake water for make-up water for Coleto Creek Reservoir) and the use of senior downstream rights (i.e., rights senior in time to Canyon Lake) held by either CP&L for make-up water for Coleto Creek Reservoir or by GBRA and others associated with the Calhoun Canal Division.

Canyon Lake Yield

The firm yield of Canyon Lake is defined to be the maximum amount of water the lake could have supplied through the drought of record after allowing for passage of inflows when required for senior downstream water rights (i.e., water rights with priority dates senior to Canyon Lake). The drought of record for Canyon Lake covers a 116 month period of time which begins in July, 1947, and ends in February, 1957. Below Canyon Lake, there are senior water rights totaling more than 225,000 acft/yr (exclusive of hydropower rights)

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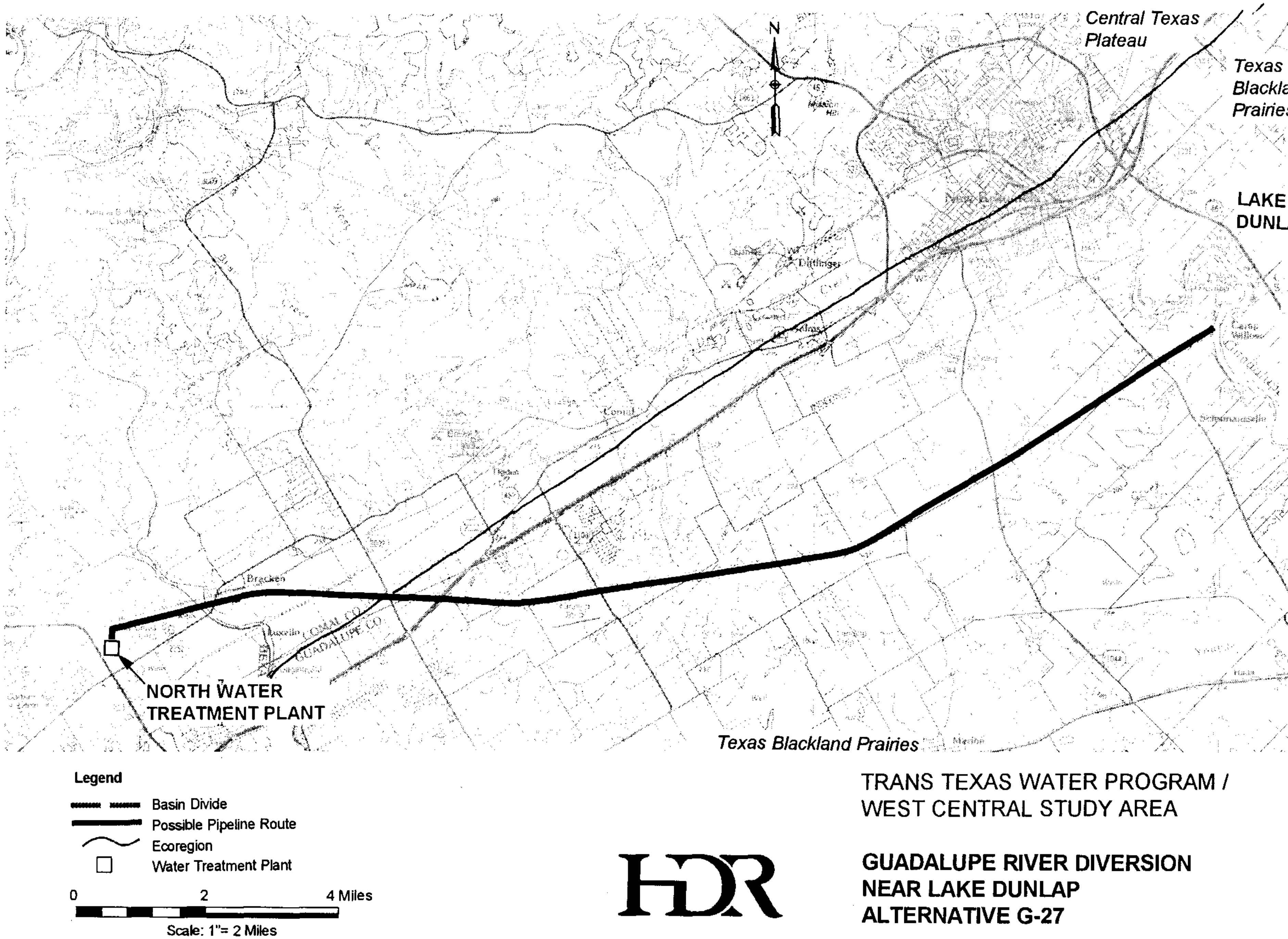
[39] HDR Engineering, Inc., "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Volumes I, II, and III, Edwards Underground Water District, September, 1993.



HDR

HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

GUADALUPE RIVER DIVERSION NEAR LAKE DUNLAP ALTERNATIVE G-27

FIGURE 3.40-1

that require passage of lake inflows to meet their rights. Additionally, GBRA holds non-consumptive hydropower rights for approximately 1,300 cfs below New Braunfels which are senior to Canyon Lake and the City of Seguin holds a senior non-consumptive hydroelectric right for 365 cfs. GBRA hydropower rights are currently subordinated to about 600 cfs. When river flows originating below Canyon Lake exceed senior water rights including hydropower needs, inflows to the lake can be stored for later release. Springflow from the Edwards Aquifer contributes substantially to the flow of the Guadalupe River and, consequently, provides water to meet a significant portion of downstream water rights, including GBRA and City of Seguin hydroelectric rights. If springflow is decreased, due to dry weather and/or aquifer pumpage, a greater proportion of downstream senior water rights must be met by passage of Canyon Lake inflows making less water available for storage. Because springflow and downstream hydroelectric rights have direct effect on the firm yield of Canyon Lake, firm yield has been estimated for several alternative scenarios of hydroelectric rights subordination and aquifer pumpage. Subordination of hydroelectric rights means that inflows to Canyon Lake are not subject to being released to meet a specified hydroelectric target flowrate downstream of Canyon. Canyon Lake inflows up to 90 cfs, 100 cfs, or 120 cfs depending on month of the year and drought conditions must be passed in accordance with the Federal Energy Regulatory Commission (FERC) requirements for hydroelectric facilities at Canyon Dam. FERC requirements at Canyon Dam were satisfied in all simulations using the GSA Model regardless of the degree of hydropower subordination downstream.

The GSA Model has been modified and applied to compute the uncommitted firm yield of Canyon Lake (diverted at Lake Dunlap) subject to two hydroelectric rights subordination scenarios and three aquifer pumpage scenarios for a total of six combined alternatives. The uncommitted firm yield is the portion of the total firm yield which is not presently allocated to satisfy existing contractual commitments. Table 3.40-1 contains a summary of the Canyon Lake estimated total firm yield and uncommitted firm yield available for diversion at Lake Dunlap. Refer to Appendix G for a detailed presentation of GSA Model modifications and a complete summary of Canyon Lake firm yield analyses.

Table 3.40-1 Canyon Lake Firm Yield Available for Diversion at Lake Dunlap			
Aquifer Demand Scenario [3]	**Hydropower Scenario [2]**	**Total Firm yield at Lake Dunlap (acft/yr)**	**Uncommitted Firm Yield [1] at Lake Dunlap (acft/yr)**
200,000 acft/yr	365 cfs	59,600	21,200
	0 cfs	88,000	49,600
368,000 acft/yr	365 cfs	46,900	8,500
	0 cfs	82,200	43,800
400,000 acft/yr	365 cfs	45,000	6,600
	0 cfs	81,500	43,100

Notes:
[1] Uncommitted firm yield is the portion of the total firm yield of Canyon Lake which has not been contractually committed. Existing contracts total 38,438 acft/yr assuming an average of 6,000 acft/yr delivered to CP&L at Coleto Creek Reservoir.
[2] Hydropower scenario represents the required flowrate for power generation at Lake Dunlap.
[3] The results of the simulated springflows from the TWDB Edwards Aquifer Model for all pumpage scenarios were adjusted to account for the difference in the model's simulated historical springflows and observed springflows.

Table 3.40-1 shows that with a demand on the Edwards Aquifer of 200,000 acft/yr the uncommitted firm yield of Canyon Lake (at Lake Dunlap) would be 21,200 acft/yr with a hydropower requirement of 365 cfs. If hydropower requirements were reduced to 0 cfs, the uncommitted firm yield could be increased to 49,600 acft/yr. This represents a potential 28,400 acft/yr increase in the total firm yield of Canyon Lake.

Table 3.40-1 also shows that with demands on the Edwards Aquifer of 368,000 acft/yr and 400,000 acft/yr, the uncommitted firm yield of Canyon Lake (at Lake Dunlap) would be 8,500 acft/yr and 6,600 acft/yr respectively, with a hydropower requirement of 365 cfs. If hydropower requirements were reduced to 0 cfs, the uncommitted firm yield could be increased to about 43,000 acft/yr for either aquifer pumpage scenario.

Transfer of Downstream Rights

At the point of diversion for the Calhoun Canal System which is located at the Saltwater Barrier just a few thousand feet downstream of the confluence of the San Antonio and Guadalupe Rivers, GBRA holds interests in six water rights permits (Certificate of Adjudication Nos: 18-5173, 18-5174, 18-5175, 18-5176, 18-5177, and 18-5178). These six permits have diversion rights totalling about 172,500 acft/yr, and are all senior to Canyon Lake. Of these senior rights, it was estimated for planning purposes that up to 40,000 acft/yr could be made available for long-term in basin and/or out-of-basin use and additional quantities could potentially be made available for short-term or temporary use[40].

At the Coleto Creek Project, CP&L presently has 20,000 acft/yr of run-of-the-river diversion rights from the Guadalupe River plus a contract with GBRA averaging 6,000 acft/yr for stored Canyon Lake water, both of which provide make-up water for cooling purposes at Coleto Creek Reservoir. To allow the possible transfer of CP&L's combined Coleto Creek rights from the Guadalupe River and Canyon Lake, potential shortfalls in cooling water needs could potentially be mitigated with SAWS reclaimed water diverted from the San Antonio River. Under this concept a new intake would be constructed at a diversion point near Goliad on the San Antonio River and a new 6.5 mile pipeline constructed to Coleto Creek Reservoir (see Section 3.42, for a more thorough discussion of reclaimed flows available to mitigate transferred water).

Two combinations of potential water transfers were studied:

(1) The GBRA/CP&L contract averaging 6,000 acft/yr of stored Canyon Lake water, together with the CP&L Coleto Creek run-of-the-river right from the Guadalupe River of 20,000 acft/yr;

(2) Both quantities in (1) plus 40,000 acft/yr from the GBRA Calhoun Canal Division rights.

The GSA Model was applied to compute firm water availability at Lake Dunlap from diversions under downstream senior water rights combined with a range of stored water allocations from Canyon Lake. Table 3.40-2 summarizes firm availability at Lake Dunlap with use of downstream water rights. Firm availability estimates were made both with and without application of the Trans-Texas Environmental Criteria for Instream Flows. As flows past the Saltwater Barrier were essentially unaffected by diversion under existing rights,

[40]Memo from GBRA to HDR, 4/18/94.

Table 3.40-2
Firm Availability at Lake Dunlap
with Selected Water Rights Transfers [1]

Trans-Texas Environmental Criteria Applied	Portion of Canyon Lake Yield Made Available by GBRA to Firm-Up Other Water (acft/yr)	Firm Availability at Lake Dunlap with Water Rights Transfers (acft/yr)	
		CP&L [2]	CP&L and 40,000 Acft/Yr GBRA CCD Rights
Yes	0	8,157	8,157
	10,000	18,157	18,405
	20,000	28,157	28,780
	40,599 Max [4]	48,756	49,785
No	0	8,157	14,703
	10,000	18,157	33,657
	20,000	28,157	49,680
	40,599 Max [4]	48,756	78,600

[1] Representative of 116 month drought period beginning July, 1947, and ending February, 1957.
[2] Includes both GBRA Canyon Lake contract and CP&L run-of-the-river rights.
[3] For other assumptions used in model runs refer to Appendix H.
[4] Maximum uncommitted firm yield made available by GBRA from Canyon Lake assuming SAWS return flows are fully utilized thereby reducing Canyon Lake firm yield from 43,800 acft/yr to 40,599 acft/yr.

consideration of Trans-Texas Environmental Criteria for freshwater inflows to bays and estuaries was unnecessary.

Water transferred under GBRA Calhoun Canal Division (CCD) rights was made firm to the extent possible by a range of allocations from the presently uncommitted firm yield of Canyon Lake both subject to and independent of Trans-Texas Environmental Criteria. All estimates of firm availability assume that the Canyon Lake firm yield created by the conversion of the CP&L run-of-the-river rights and GBRA contract for Coleto Creek Reservoir makeup water would be allocated to firm-up available run-of-the-river water.

Upon review of Table 3.40-2, it is clear that if Trans-Texas Environmental Criteria for Instream Flows were applied, firm availability would be limited to little more than the Canyon Lake firm yield made available by GBRA and the CP&L transfers. Without these environmental criteria, however, firm availability of up to 78,600 acft/yr could be achieved with diversion of 40,000 acft/yr of GBRA CCD rights. Hence, 75 percent of the CCD water could be made available on a firm basis at Lake Dunlap.

For environmental analysis and costing of this alternative, the firm availability analyzed includes the transfer or sale of 40,000 acft/yr of GBRA CCD water, all of CP&L's Coleto Creek rights, and a maximum of 40,599 acft/yr of stored water being made available by GBRA from Canyon Lake. The resulting combined firm availability is 78,600 acft/yr without the application of the Trans-Texas Environmental Criteria for Instream Flows. For information and comparative purposes, a cost estimate has also been prepared for facilities sized for delivery of the firm availability of 49,785 acft/yr based on application of the Trans-Texas Environmental Criteria to the transfer or sale of 40,000 acft/yr of GBRA CCD water.

Monthly median streamflows and annual streamflows averaged by decile below Canyon Lake, at Lake Dunlap, and at the Saltwater Barrier, are presented in Figures 3.40-2 and 3.40-3 for both existing conditions and with the diversion of the full 78,600 acft/yr of water made available under this alternative. Also shown in Figure 3.40-2 is the Trans-Texas desired monthly instream flow applicable below Lake Dunlap.

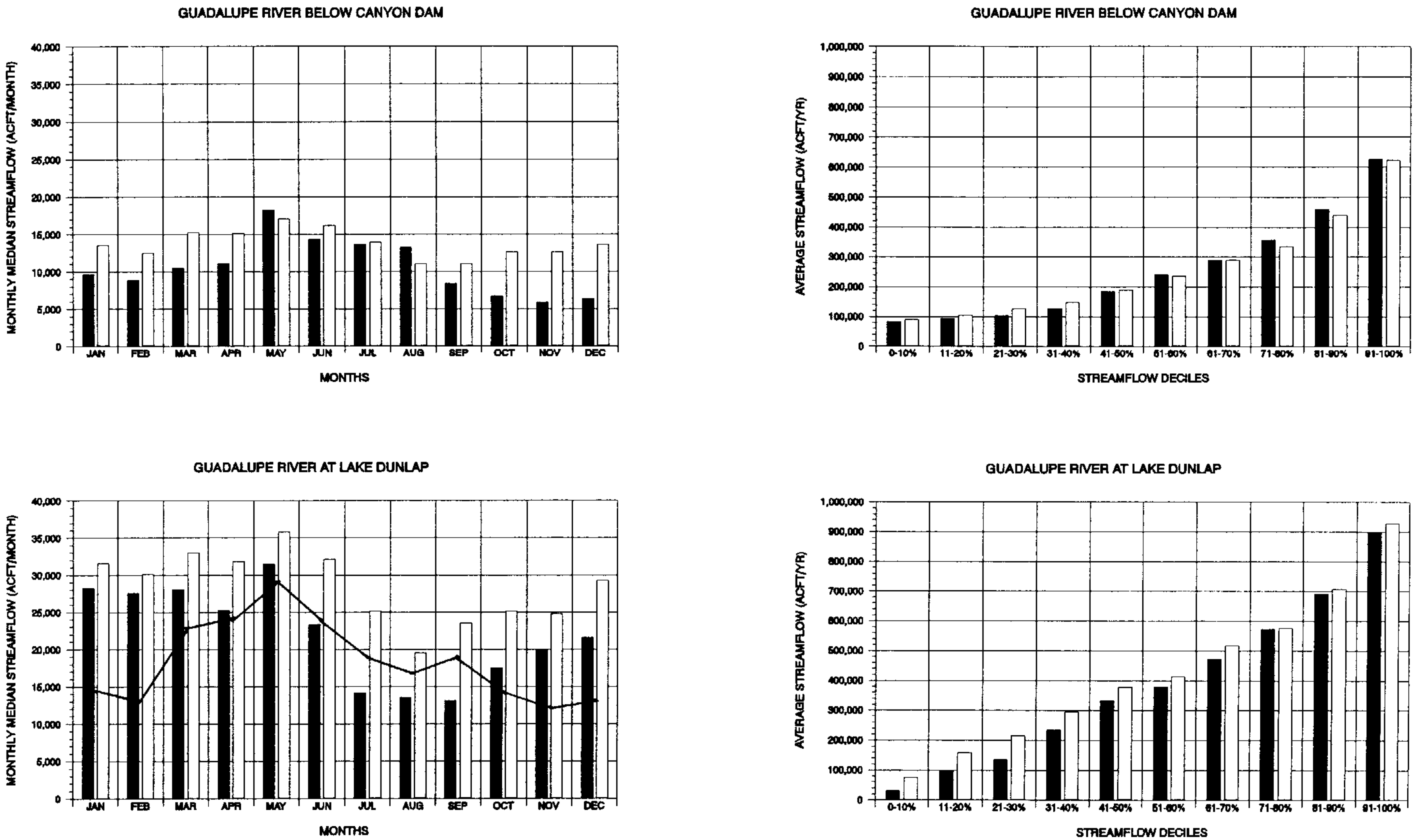
3.40.3 Environmental Issues

Alternative G-27, would divert water from the Guadalupe River at Lake Dunlap and be conveyed by pipeline to a treatment plant in the north San Antonio metro area (Figure 3.40-1). This alternative employs a portion of the same pipeline route as the Guadalupe River alternatives (G-13, G-14, and G-15) discussed in Volume 2.

Lake Dunlap is impounded by a small hydroelectric gated overflow dam on the Guadalupe River below New Braunfels and the confluence of the Comal River. Lake Dunlap is a long, moderately deep lake filling the Guadalupe River channel. The water exhibits alkaline to near neutral pH and high alkalinity[41].

The land use and habitat in the project area reflect its location at the confluence of the Blackland Prairies with the Central Texas Plateau ecoregions (Figures 3.40-1) and the

[41]Lockett, C.L. 1976. Classification of seventeen central Texas reservoirs. Master's Thesis. Southwest Texas State University.



LEGEND:

WITH PROJECT

WITHOUT PROJECT

TRANS-TEXAS ENVIRONMENTAL CRITERIA (PLOTTED FOR POINT OF DIVERSION ONLY)

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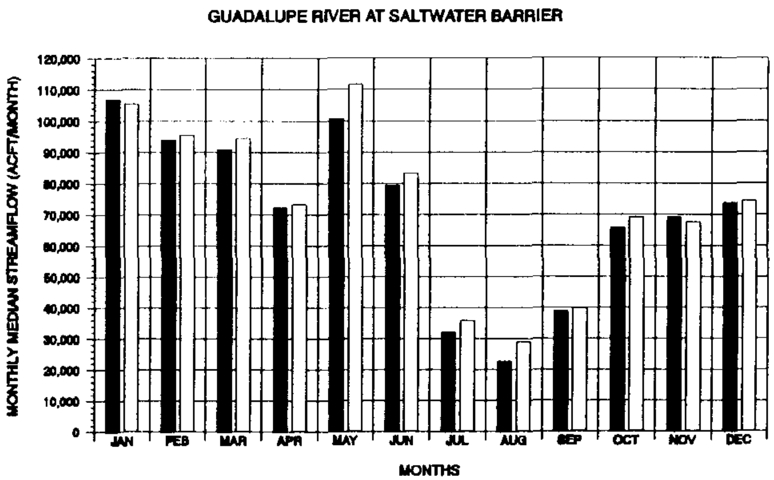
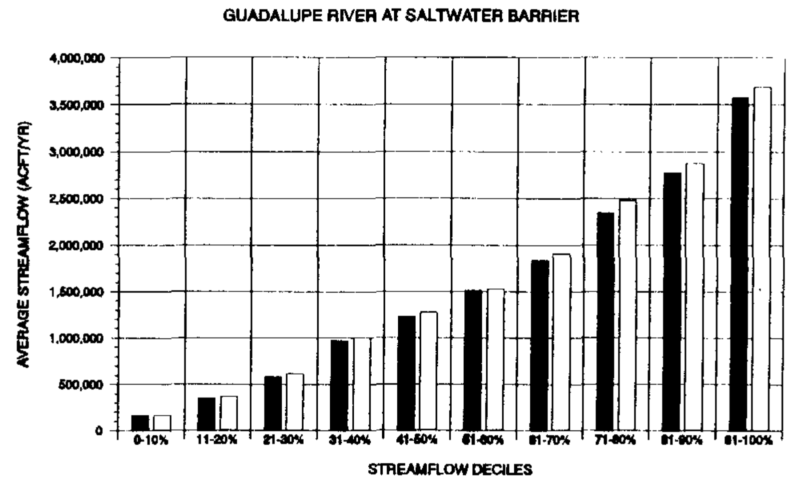
TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

CHANGES IN STREAMFLOW - GUADALUPE RIVER WITH DIVERSIONS AT LAKE DUNLAP ALTERNATIVE G-27

FIGURE 3.40-2





LEGEND:

WITH PROJECT

WITHOUT PROJECT

HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

CHANGES IN STREAMFLOW - GUADALUPE RIVER AT SALT WATER BARRIER WITH DIVERSIONS AT LAKE DUNLAP - ALTERNATIVE G-27

FIGURE 3.40-3

Blackland Prairie and Post Oak Savannah[42,43,44]. The soils in the pipeline corridor range from light-colored, acid sandy loams (upland), dark-gray acid sandy loams and clays (bottomland) to fairly uniform dark-colored calcareous clays[45]. Climax grasses of the Post Oak Savannah are little bluestem, Indian grass, switch grass, purpletop, silver bluestem and Texas wintergrass. The overstory is primarily post oak and blackjack oak. The Blackland Prairies are characterized by these grasses as well as sideoats grama, hairy grama and tall dropseed. Post oak and blackjack oak are typically present as overstory, although only small remnants of this upland woodland are generally present in this ecoregion[46].

The northeastern third of the proposed pipeline corridor is primarily cropland (68 percent), grass, shrub, and brush (18 percent) with the remaining area a mixture of park, woods (8 percent), urban (3 percent) and wetlands (3 percent)[47,48,49]. The majority of the project area is located in cropland. Impacts to terrestrial biological communities can generally be minimized or avoided by careful selection of the pipeline ROW. Less than 0.25 acres of riparian woods bordering the Lake Dunlap shore will be impacted during construction of the river intake structure. Lake Dunlap is used for boating, fishing and camping, so the intake structure should be as imperceptible as possible.

The amounts of water that could be made available on a firm basis for diversion near Lake Dunlap under various Edwards pumping scenarios by releasing stored Canyon Lake water, plus diverting under selected downstream water rights, are shown in Tables 3.40-1

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[42]Omernik, James M. 1986. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers, 77(1): pp. 118-125.

[43]Blair, W.F. 1950. The biotic provinces of Texas. Texas Journal of Science 2(1): pp. 93-117.

[44]Gould, F.W. 1975. The Grasses of Texas. Texas A&M University Press, College Station, Texas.

[45]Soil Conservation Service. 1977. Soil Survey of Guadalupe County, Texas. U.S. Department. Agriculture

[46]Correl, D.S., and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation, Renner, Texas.

[47]McMahan, C.A., R.G. Frye, K.L. Brown. 1982. The Vegetation Types of Texas Including Cropland. Texas Parks and Wildlife Department, Austin, Texas.

[48]U.S. Fish and Wildlife Services. 1991. National Wetland Inventory Series. New Braunfels East, New Braunfels West, Schertz, Longhorn Quadrangles.

[49]USGS, 1990. NAPP Series. EROS Data Center, Sioux Falls, South Dakota.

and 3.40-2. The latter table also discloses the firm water available with and without application of the Trans-Texas criteria for instream flows and bay and estuary inflows to Alternative G-27. The Guadalupe River below Canyon Dam was the subject of an instream flow study during the mid 1980's, at the time a hydroelectric capability was installed, resulting in minimum flow requirements that were honored in developing this alternative. Because the water to be diverted at Lake Dunlap would consist of a dynamic mix of stored, firm water and run of river water, all of which is currently permitted, application of the Trans-Texas criteria will require additional clarification as to what water is subject to the criteria, and how (in a practical sense) they would be applied in this particular situation. At this time we can only say that monthly median flows resulting from meeting the Trans-Texas criteria with Alternative G-27 would fall between the with and without project medians plotted in Figures 3.40-2 and 3.40-3.

Figure 3.40-2 shows existing monthly median streamflows below Canyon Lake (period of record 1934-1989), and the changes anticipated to result from implementation of this alternative without the diversion limits imposed by the Trans-Texas criteria. While both positive and negative changes on the order of 10 to 20 percent are projected for late spring and summer (May-August), substantial decreases (25-50 percent) in monthly median streamflows are expected during the remainder of the year. These changes reflect the retention of water in Canyon Lake that would otherwise have been released to satisfy downstream hydroelectric generating needs, water rights and contracts (Table 3.40-2), coupled with the increase in summer releases for diversion at Lake Dunlap. Figure 3.40-2 shows how streamflows would be redistributed on an annual basis: during dry years, reductions in streamflow would average 5-15 percent in the lowest five deciles, while during wetter years, streamflow could increase about 6 percent[50].

Alterations in streamflow patterns of the magnitudes projected to occur in the reaches below Canyon Dam may result in changes in the average abundances of some aquatic populations, increase interannual variation, and reduce the overall carrying capacity in these reaches during dry years. Existing minimum streamflow requirements below Canyon Dam are expected to be adequate for at least minimal maintenance of the biological community in this reach, since flows during the critical summer period would be least

[50]HDR Engineering, Inc., 1994. Unpublished hydrologic model results. Austin, Texas.

affected. Although the peak summer recreational period would be relatively unaffected, river recreationalists would experience more, or more extended, low flow periods during the early spring and fall as a result of implementation of Alternative G-27. The potential impacts to river recreation and local economies should be examined in detail if this alternative is retained for further consideration.

Projected changes in monthly median flows, and in annual average flows by decile, are presented for the Guadalupe River below the diversion point at Lake Dunlap and at the Saltwater Barrier in Figures 3.40-2 through 3.40-3. Below Lake Dunlap, substantial (>20 percent) reductions in monthly median streamflows could occur throughout the year, with the largest proportional impacts occurring during the driest years. At the Saltwater Barrier (San Antonio Bay inflows), monthly median streamflows would be reduced about 5-10 percent during late spring and summer (May-August), while both positive and negative changes of less than 5 percent would occur during the remaining months. Most of these reductions would occur during wet years, with dry year streamflows being largely unaffected (Figure 3.40-3).

Below Lake Dunlap the substantial reductions in streamflows projected to occur during the driest years, particularly during the historic summer (July-September) low flow period, may adversely affect some biological communities downstream. However, much of the river below IH 35 (70 of the 100 river miles between Lake Dunlap and Gonzales) consists of lentic habitats (impoundments) that would not necessarily experience adverse effects. Reductions in San Antonio Bay inflows would approach 10 percent of the monthly medians only during May and August, and would occur primarily during wet years.

Instream flow studies should be conducted in the reaches below Canyon Dam and Lake Dunlap in order to evaluate potential impacts to the community as a whole, but more particularly to the aquatic species discussed below as being of concern to state and federal resource agencies. Because of the lack of effect on the lower flow ranges at the Saltwater Barrier, impacts to San Antonio Bay as a result of increased length or severity of drought periods do not appear to have great potential for being significant. For example, using a 1934-1989 period of record, the minimum annual flow would have increased from 52,289 to 57,389 acre feet as a result of implementing Alternative G-27. In the same simulation, 25th percentile and median flows at the Saltwater Barrier are shown to decrease by only 3.4 and

1.6 percent, respectively, with only minor variation in seasonal patterns. Since this alternative is a diversion, not an impoundment, its operation will have minimal effects on flood flows[51].

Although the Natural Heritage Program does not report any endangered or threatened species directly along the proposed pipeline corridor, some have been reported in the vicinity[52]. The areas of grasslands, brush, and shrub could be habitat for several endangered or threatened species, such as the Black-capped Vireo, Golden-cheeked Warbler, Texas horned lizard, and Texas garter snake (Appendix B, Tables 6 and 22, Volume 2). Surveys for the presence of protected species would be conducted within the proposed construction corridor where disturbance of potential habitat cannot be avoided.

The Cagle's map turtle, Guadalupe bass, and the blue sucker ranges extend from the Edwards Plateau through the Blackland Prairie to the Coastal Plains in Guadalupe River. Cagle's map turtle has been located as far south as Victoria, Texas on the Coastal Plain. The Guadalupe bass may be found in Lake Dunlap. Streamflow is an important component of its habitat requirements. The Guadalupe bass, best adapted for flowing water, is often found in flowing water near riffles feeding on aquatic insects. Although the Guadalupe bass is found in reservoirs such as Canyon Lake, it may be at a competitive disadvantage with other bass species in more lentic environments[53]. The blue sucker, a large river fish, is a candidate for federal protection with probable occurrence in Guadalupe County, although the presence of several dams in this reach of the Guadalupe suggests that it may no longer be present.

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

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[51]Ibid.

[52]TPWD. 1994. Unpublished data files and maps of the Natural Heritage Program. Resource Protection Division, Austin, Texas. TOES. 1992. Endangered, Threatened, and Watch List of Natural Communities of Texas, Publication 8, Austin, Texas; TOES. 1993. Endangered, Threatened, and Watch List of Texas Plants, Third Revision, Austin, Texas.

[53]Garrett, Gary P. 1991. Guidelines for the Management of Guadalupe Bass. Publication PWD-RP-N3200-367-11/91, Texas Parks and Wildlife Department, Austin, Texas.

(PL93-291). All areas to be disturbed during construction will be first surveyed by qualified professionals for the presence of significant cultural resources.

3.40.4 Water Quality and Treatability

(To be completed in subsequent phases of the study.)

3.40.5 Engineering and Costing

For this alternative, the combined firm water available at Lake Dunlap would be diverted through a new intake and pump station located along the shore of Lake Dunlap and pumped in a transmission line to the proposed North Water Treatment Plant. The diversion rate from the Guadalupe River would vary considerably from month to month with highest use in the summer months needed in order to keep SAWS aquifer pumpage uniform throughout the year. The major facilities required to implement this alternative are:

Reservoir Intake and Pump Station
Raw Water Pipeline to Treatment Plant
Raw Waterline Booster Pump Station
Water Treatment Plant (Level 3, see Table 3.0-4, Volume 2)
Finished Water Pump Station
Distribution System Improvements

The reservoir intake and pump station is sized to deliver a maximum monthly volume of 13,100 acft/month (141 mgd) through a 90 inch diameter pipeline. The operating cost was determined for the total raw water static lift of 425 feet and an annual water delivery of 78,600 acft/yr. Financing the project over 25 years at an 8.0 percent annual interest rate results in an annual expense of $25,060,000 (Table 3.40-3). The annual cost of water purchased from GBRA is $53 per acft, for an annual payment of $2,150,000. Purchase of water using senior water rights of the Calhoun Canal Division is estimated to cost $53 per acft for firm water (same cost as stored water from Canyon Lake). For purchase of 40,000 acft/yr using senior rights, firm availability is estimated to be 37,000 acft/yr at the Saltwater Barrier (see Section 3.23, Volume 2) for an annual cost of $1,960,000. Compensation for CP&L's contract for stored water from Canyon Lake is assumed to be $53 per acft/yr and is included in the annual cost for replacement water for make-up needs at CP&L's Coleto Creek Reservoir. Operation and maintenance costs, including power and purchase of all

Table 3.40-3
Cost Estimate for Guadalupe River Diversion Near Lake Dunlap with Transfer of Downstream Rights (G-27)
(without Trans-Texas In-stream Environmental Criteria Applied to the Transferred Rights)
(Third Quarter - 1994 Prices)

Item	Alternate G-27 Costs
Capital Costs	
Intake and Pump Station	$6,540,000
Transmission Pipeline and Pumping	41,970,000
Treatment Plant	56,240,000
Delivery System [1]	91,240,000
Total Capital Cost	$195,990,000
Engineering, Contingencies, and Legal Costs	57,650,000
Land Acquisition	170,000
Environmental Studies and Mitigation	170,000
Interest During Construction	13,480,000
Total Project Cost	$267,460,000
Annual Costs	
Annual Debt Service	$25,060,000
Annual Operation and Maintenance	10,200,000
Replacement Water Cost for Coleto Creek (Includes Makeup Water from SAWS Return Flows and Purchase of CP&L-GBRA Stored Water Contract)	1,140,000
Purchase of 40,599 acft/yr Canyon Lake Stored Water	2,150,000
Purchase of 40,000 acft/yr under Senior Water Rights from Saltwater Barrier	1,960,000
Annual Power Cost	5,170,000
Total Annual Cost	$45,680,000
Available Project Yield (acft/yr)	78,600
Annual Cost of Water	$581/acft

[1] As described in Section 3.0.2 delivery system improvement costs were determined from studies for delivery of Applewhite Reservoir water and may be lower for a water source on the northwest side of the city.

stored, transferred and replacement water, total $20,620,000. The total annual costs, including debt repayment, interest, operation and maintenance and all water purchases, total $45,680,000, for all facilities. Included in these costs are annual costs for facilities to deliver SAWS reclaimed water from the San Antonio River to replace CP&L's cooling water needs (including compensation for CP&L's Canyon Lake stored water contract) total $1,140,000 as described in Section 3.42.5. For an annual firm yield of 78,600 acft, the resulting annual cost of water developed under this aspect of the SAWS plan is $581 per acft (Table 3.40-3).

An estimate has also been made of the cost to deliver the firm yield available at Lake Dunlap for the same transfers of water rights and stored water with application of the Trans-Texas environmental criteria (i.e. 49,785 acft/yr, Table 3.40-1). For this scenario, the reservoir intake and pump station is sized to deliver a maximum monthly volume of 9,800 acft/month (105 mgd) through a 78 inch diameter pipeline. The operating cost was determined for the total raw water static lift of 425 feet and an annual water delivery of 49,785 acft/yr. The total annual costs, including debt repayment, interest, operation and maintenance and all water purchases, total $36,790,000 (Table 3.40-4) for all facilities. For an annual firm yield of 49,785 acft, the resulting annual cost of water developed under this aspect of the SAWS plan is $739 per acft.

3.40.6 Implementation Issues

An institutional arrangement is needed to implement projects including financing on a regional basis.

<u>Requirements Specific to Transfer of Downstream Rights</u>

1. CP&L and GBRA diversion permits will need to be amended to change the point of diversion. CP&L run-of-the-river permit will need to be transferred.

2. Water to replace the CP&L contract for stored water and run-of-the-river rights, and possibly the GBRA Calhoun Canal rights need to be considered. Refer to Section 3.42 for more discussion of a potential alternative available for replacement water.

<u>Requirements Specific to River Diversion and Transmission Pipeline</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.

Table 3.40-4 Cost Estimate for Guadalupe River Diversion Near Lake Dunlap with Transfer of Downstream Rights (G-27) (with Application of the Trans-Texas In-stream Environmental Criteria Applied to the Transferred Rights) (Third Quarter - 1994 Prices)	
Item	**Alternate G-27 Costs**
Capital Costs	
Intake and Pump Station	$5,970,000
Transmission Pipeline and Pumping	36,990,000
Treatment Plant	41,970,000
Delivery System [1]	73,220,000
Total Capital Cost	$158,150,000
Engineering, Contingencies, and Legal Costs	46,420,000
Land Acquisition	170,000
Environmental Studies and Mitigation	170,000
Interest During Construction	10,900,000
Total Project Cost	$215,810,000
Annual Costs	
Annual Debt Service	$20,220,000
Annual Operation and Maintenance	7,980,000
Replacement Water Cost for Coleto Creek (Includes Makeup Water from SAWS Return Flows and Purchase of CP&L-GBRA Stored Water Contract)	1,140,000
Purchase of 40,599 acft/yr Canyon Lake Stored Water	2,150,000
Purchase of 40,000 acft/yr under Senior Water Rights from Saltwater Barrier	1,960,000
Annual Power Cost	3,340,000
Total Annual Cost	$36,790,000
Available Project Yield (acft/yr)	49,785
Annual Cost of Water	$739/acft

[1] As described in Section 3.0.2 delivery system improvement costs were determined from studies for delivery of Applewhite Reservoir water and may be lower for a water source on the northwest side of the city.

    c. TPWD Sand, Gravel, and Marl permit for river crossings.
    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

1. Detailed study needed of the cost of pumping and transmission pipeline improvements necessary to effectively integrate the new supply into SAWS water supply system.
2. Study needed of cost to convey and distribute water to other area water utilities.

Requirements Specific to Amending the Canyon Lake Permit

1. If this alternative requires exceeding the current permitted average annual diversion from Canyon Lake of 50,000 acft, then a permit amendment will require:
    a. Application to the TNRCC
    b. Hydrologic studies substantiating requested firm yield.
    c. 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.

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3.41 GUADALUPE RIVER DIVERSION NEAR GONZALES WITH TRANSFER OF DOWNSTREAM RIGHTS (G-28)

3.41.1 Description of Alternative

This alternative includes a component of a comprehensive water management plan proposed by the San Antonio Water System[54] (SAWS plan) involving several interrelated water supply and demand management elements which affect the availability and movement of water in both the Edwards Aquifer (including both pumpage and springflows) and throughout the Guadalupe - San Antonio River Basin. This component of the plan involves the diversion of Guadalupe River water near Gonzales. Water potentially available under this alternative would originate from several sources and be delivered to the proposed North Water Treatment Plant in the San Antonio metropolitan area. Water potentially available includes: stored water from Canyon Lake, possible run-of-river water rights and stored water currently used at the Central Power & Light (CP&L) Coleto Creek steam-electric power generating station, and possible run-of-river water rights currently used by GBRA and others at the Saltwater Barrier. Some of these water sources have been studied on a stand-alone basis in previous sections in Volume 2, however, this alternative considers combined quantities of water possibly available from several sources.

Previous studies which are contained in Volume 2 considered water availability from stand alone sources and are briefly summarized herein. Section 3.17 describes the availability of unappropriated water at various points in the Guadalupe Basin, including at Gonzales, and found that no firm yield exists from unappropriated flows without some kind of storage facility. Section 3.23 presents a study of McFaddin Reservoir, a proposed off-channel reservoir located near the Guadalupe - San Antonio river confluence, which might potentially be supplied by the using of senior water rights held by GBRA and others associated with GBRA's Calhoun Canal Division. Further work performed to estimate water availability with the SAWS plan is described in Appendices G and H. Appendix G contains a description of studies made of Canyon Lake firm yield for possible changes in degree of hydropower subordination and/or aquifer management. Appendix H contains a

[54]Proposed Water Resource Plan prepared by the San Antonio Water System and presented to the San Antonio Mayor's 2050 Water Resources Committee, April 27, 1994. The SAWS plan is summarized in Appendix F.

description of analyses using the Guadalupe - San Antonio River Basin Model[55] (GSA Model) to estimate firm water availability with the SAWS plan.

For this alternative (G-28), a program of combined water rights (i.e., stored water from Canyon Lake and transferred senior water rights) is studied for availability to meet peak summer demands of those served by SAWS. The major facilities needed for this alternative include a surface water intake structure and pump station near Gonzales on the Guadalupe River, water transmission pipeline, and treatment plant. A possible location of the facilities is shown on Figure 3.41-1.

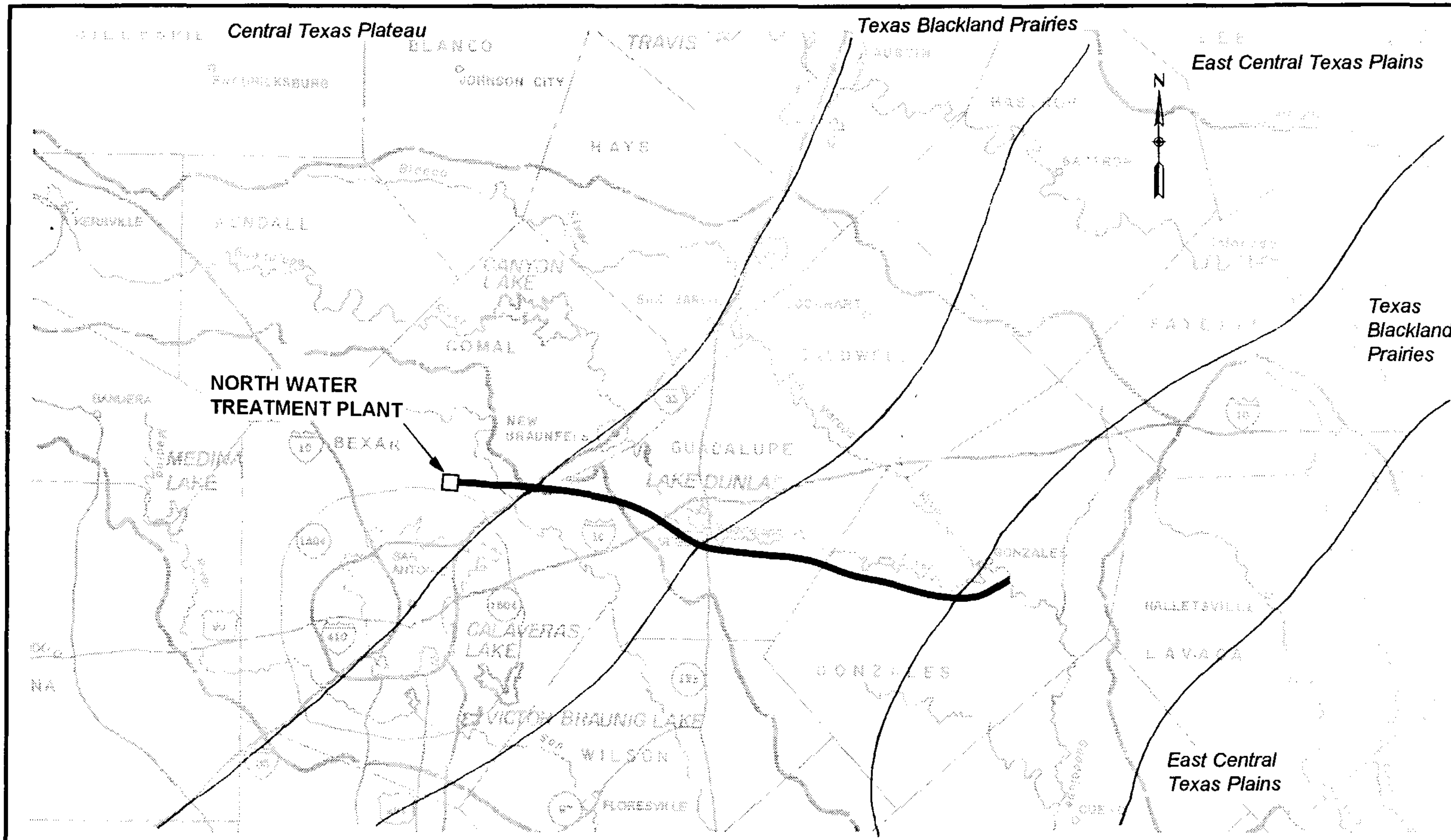
3.41.2 Available Yield

Water potentially available for diversion at Gonzales for this alternative includes purchase of stored water from Canyon Lake (either uncommitted yield or by purchase (or transfer) of CP&L's existing contract for stored Canyon Lake water for make-up water for Coleto Creek Reservoir) and the use of senior downstream rights (i.e., rights senior in time to Canyon Lake) held by either CP&L for make-up water for Coleto Creek Reservoir or by GBRA and others associated with the Calhoun Canal Division.

Canyon Lake Yield

The firm yield of Canyon Lake is defined to be the maximum amount of water the lake could have supplied through the drought of record after allowing for passage of inflows when required for senior downstream water rights (i.e., water rights with priority dates senior to Canyon Lake). The drought of record for Canyon Lake covers a 116 month period of time which begins in July, 1947, and ends in February, 1957. Below Canyon Lake, there are senior water rights totaling more than 225,000 acft/yr (exclusive of hydropower rights) that require passage of lake inflows to meet their rights. Additionally, GBRA holds non-consumptive hydropower rights for approximately 1,300 cfs below New Braunfels which are senior to Canyon Lake and the City of Seguin holds a senior non-consumptive hydroelectric right for 365 cfs. GBRA hydropower rights are currently subordinated to about 600 cfs. When river flows originating below Canyon Lake exceed the requirements of senior water

[55]HDR Engineering, Inc., "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Volumes I, II, and III, Edwards Underground Water District, September, 1993.



Legend

- Basin Divide
- Possible Pipeline Route
- Ecoregion
- Water Treatment Plant

0 10 20 Miles
Scale

HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM /
WEST CENTRAL STUDY AREA

GUADALUPE RIVER DIVERSION NEAR GONZALES ALTERNATIVE G-28

FIGURE 3.41-1

rights including hydropower needs, inflows to the lake can be stored for later release. Springflow from the Edwards Aquifer contributes substantially to the flow of the Guadalupe River and, consequently, provides water to meet a significant portion of downstream water rights, including GBRA and City of Seguin hydroelectric rights. If springflow is decreased, due to dry weather and/or aquifer pumpage, a greater proportion of downstream senior water rights must be met by passage of Canyon Lake inflows making less water available for storage. Because springflow and downstream hydroelectric rights have direct effect on the firm yield of Canyon Lake, firm yield has been estimated for several alternative scenarios of hydroelectric rights subordination and aquifer pumpage. Subordination of hydroelectric rights means that inflows to Canyon Lake are not subject to being released to meet a specified hydroelectric target flowrate downstream of Canyon. Canyon Lake inflows up to 90 cfs, 100 cfs, or 120 cfs depending on month of the year and drought conditions must be passed in accordance with the Federal Energy Regulatory Commission (FERC) requirements for hydroelectric facilities at Canyon Dam. FERC requirements at Canyon Dam were satisfied in all simulations using the GSA Model regardless of the degree of hydropower subordination downstream.

The GSA Model has been modified and applied to compute the uncommitted firm yield of Canyon Lake (diverted at Gonzales) subject to two hydroelectric rights subordination scenarios and three aquifer pumpage scenarios for a total of six combined alternatives. The uncommitted firm yield is the portion of the total firm yield which is not presently allocated to satisfy existing contractual commitments. Table 3.41-1 contains a summary of the Canyon Lake estimated total firm yield and uncommitted firm yield available for diversion at Gonzales. Refer to Appendix G for a detailed presentation of GSA Model modifications and a complete summary of Canyon Lake firm yield analyses.

Table 3.41-1 shows that with a demand on the Edwards Aquifer of 200,000 acft/yr the uncommitted firm yield of Canyon Lake (at Gonzales) would be 24,700 acft/yr with a hydropower requirement of 365 cfs. If hydropower requirements were reduced to 0 cfs, the uncommitted firm yield could be increased to 43,400 acft/yr. This represents a potential 18,700 acft/yr increase in the total firm yield of Canyon Lake.

Table 3.41-1 Canyon Lake Firm Yield Available for Diversion at Gonzales			
Aquifer Demand Scenario	**Hydropower Scenario [2]**	**Total Firm yield at Gonzales (acft/yr)**	**Uncommitted Firm Yield [1] at Gonzales (acft/yr)**
200,000 acft/yr	365 cfs	63,100	24,700
	0 cfs	81,700	43,300
368,000 acft/yr	365 cfs	46,500	8,100
	0 cfs	76,800	38,400
400,000 acft/yr	365 cfs	44,500	6,100
	0 cfs	76,200	37,800

Notes:
[1] Uncommitted firm yield is the portion of the total firm yield of Canyon Lake which has not been contractually committed. Existing contracts total 38,438 acft/yr assuming an average of 6,000 acft/yr delivered to CP&L at Coleto Creek Reservoir.
[2] Hydropower scenario represents the required flowrate for power generation at Lake Dunlap.

Table 3.41-1 also shows that with demands on the Edwards Aquifer of 368,000 acft/yr and 400,000 acft/yr, the uncommitted firm yield of Canyon Lake (at Gonzales) would be 8,100 acft/yr and 6,100 acft/yr respectively, with a hydropower requirement of 365 cfs. If hydropower requirements were reduced to 0 cfs, the uncommitted firm yield could be increased to about 38,000 acft/yr for either aquifer pumpage scenario.

Transfer of Downstream Rights

At the point of diversion for the Calhoun Canal System which is located at the Saltwater Barrier just a few thousand feet downstream of the confluence of the San Antonio and Guadalupe Rivers, GBRA holds interests in six water rights permits (Certificate of Adjudication Nos. 18-5173, 18-5174, 18-5175, 18-5176, 18-5177, and 18-5178). These six permits have diversion rights totalling about 172,500 acft/yr, and are all senior to Canyon Lake. Of these senior rights, it was estimated for planning purposes that up to 40,000 acft/yr could be made available for long-term in basin and/or out-of-basin use and additional quantities could potentially be made available for short-term or temporary use[56].

At the Coleto Creek Project, CP&L presently has 20,000 acft/yr of run-of-the-river diversion rights from the Guadalupe River plus a contract with GBRA averaging 6,000 acft/yr for stored Canyon Lake water, both of which provide make-up water for cooling purposes at Coleto Creek Reservoir. To allow the possible transfer of CP&L's combined Coleto Creek rights from the Guadalupe River and Canyon Lake, potential shortfalls in cooling water needs could potentially be mitigated with SAWS reclaimed water diverted from the San Antonio River. Under this concept a new intake would be constructed at a diversion point near Goliad on the San Antonio River and a new 6.5 mile pipeline constructed to Coleto Creek Reservoir (see Section 3.42, for a more thorough discussion of reclaimed flows available to mitigate transferred water).

Two combinations of potential rights transfers were studied:

(1) The GBRA/CP&L contract averaging 6,000 acft/yr of stored Canyon Lake water, together with the CP&L Coleto Creek run-of-the-river right from the Guadalupe River of 20,000 acft/yr;

(2) Both quantities in (1) plus 40,000 acft/yr of GBRA Calhoun Canal Division water.

The GSA Model was applied to compute firm water availability at Gonzales from diversions under downstream senior water rights combined with a range of stored water allocations from Canyon Lake. Table 3.41-2 summarizes firm availability at Gonzales with use of downstream water rights. Firm availability estimates were made both with and without application of the Trans-Texas Environmental Criteria for Instream Flows. As flows past the Saltwater Barrier were essentially unaffected by diversion under existing rights, consideration of Trans-Texas Environmental Criteria for freshwater inflows to bays and estuaries was unnecessary.

Water transferred under GBRA's Calhoun Canal Division (CCD) rights was made firm to the extent possible by a range of allocations from the presently uncommitted firm yield of Canyon Lake both subject to and independent of Trans-Texas Environmental Criteria. All estimates of firm availability assume that the Canyon Lake firm yield created by the conversion of the CP&L run-of-the-river rights and GBRA contract for Coleto

[56]Memo from GBRA to HDR, 4/18/94.

Table 3.41-2
Firm Availability near Gonzales with Selected Water Rights Transfers [1]

Trans-Texas Environmental Criteria Applied	Portion of Canyon Lake Yield Made Available by GBRA to Firm-Up Other Water (acft/yr)	Firm Availability near Gonzales with Water Rights Transfers (acft/yr)	
		CP&L [2]	CP&L and 40,000 Acft/Yr GBRA CCD Rights
Yes	0	7,232	7,700
	10,000	17,232	18,817
	20,000	27,232	30,112
	35,588 Max [4]	42,820	46,718
No	0	7,232	13,954
	10,000	17,232	33,343
	20,000	27,232	47,359
	35,588 Max [4]	42,820	71,260

[1] Representative of 116 month drought period beginning July, 1947, and ending February, 1957.
[2] Includes both GBRA Canyon Lake contract and CP&L run-of-the-river rights.
[3] For other assumptions used in model runs refer to Appendix H.
[4] Maximum uncommitted firm yield made available by GBRA from Canyon Lake assuming SAWS return flows are fully utilized thereby reducing Canyon Lake firm yield from 38,400 acft/yr to 35,588 acft/yr.

Creek Reservoir makeup water would be allocated to firm-up available run-of-the-river water.

Upon review of Table 3.41-2, it is clear that if Trans-Texas Environmental Criteria for Instream Flows were applied, firm availability would be limited to little more than the Canyon Lake firm yield made available by GBRA and the CP&L transfers. Without these environmental criteria, however, firm availability of up to 71,260 acft/yr could be achieved with diversion under 40,000 acft/yr of GBRA CCD rights. Hence, 71 percent of the rights transferred could be made available on a firm basis at Gonzales.

For environmental analysis and costing of this alternative, the firm availability analyzed includes the transfer or sale of 40,000 acft/yr of GBRA CCD rights, all of CP&L's Coleto Creek rights, and a maximum of 35,588 acft/yr of stored water being made available by GBRA from Canyon Lake. The resulting combined firm availability is 71,260 acft/yr without the application of the Trans-Texas Environmental Criteria for Instream Flows.

Monthly median streamflows and annual streamflows averaged by decile below Canyon Lake, at Gonzales, and at the Saltwater Barrier, are presented in Figures 3.41-2 and 3.41-3 for both existing conditions and with the diversion of the full 71,260 acft/yr of water made available under this alternative. Also shown in Figure 3.41-2 is the Trans-Texas desired monthly instream flow applicable below Gonzales.

3.41.3 Environmental Issues

Alternative G-28, would divert water from the Guadalupe River near the City of Gonzales and convey the water in a pipeline to the proposed North Water Treatment Plant (Figure 3.41-1) in the San Antonio metro area. This alternative employs a portion of the same pipeline route in Bexar County as the Guadalupe River Diversion near Lake Dunlap (Alternative G-27) discussed in Section 3.40.

The intake will be located below the confluence of the San Marcos River and the Guadalupe River in the Blackland Prairie ecoregion (Figure 3.41-1). The transmission pipeline would convey the water west along existing corridors into Guadalupe County. The land use and habitat are typical of the Blackland Prairie[57,58,59]. The proposed North Water Treatment Plant would be located in the Central Texas Plateau ecoregion (Figures 3.41-1)[60]. The soils of the proposed pipeline corridor range from light-colored, acid sandy loams (upland), dark-gray acid sandy loams and clays (bottomland) to fairly uniform dark-colored calcareous clays[61]. The Blackland Prairies are characterized by little bluestem, Indian grass, switch grass, purpletop, silver bluestem, Texas wintergrass as well as sideoats grama, hairy grama and tall dropseed. Post oak and blackjack oak are typically present as

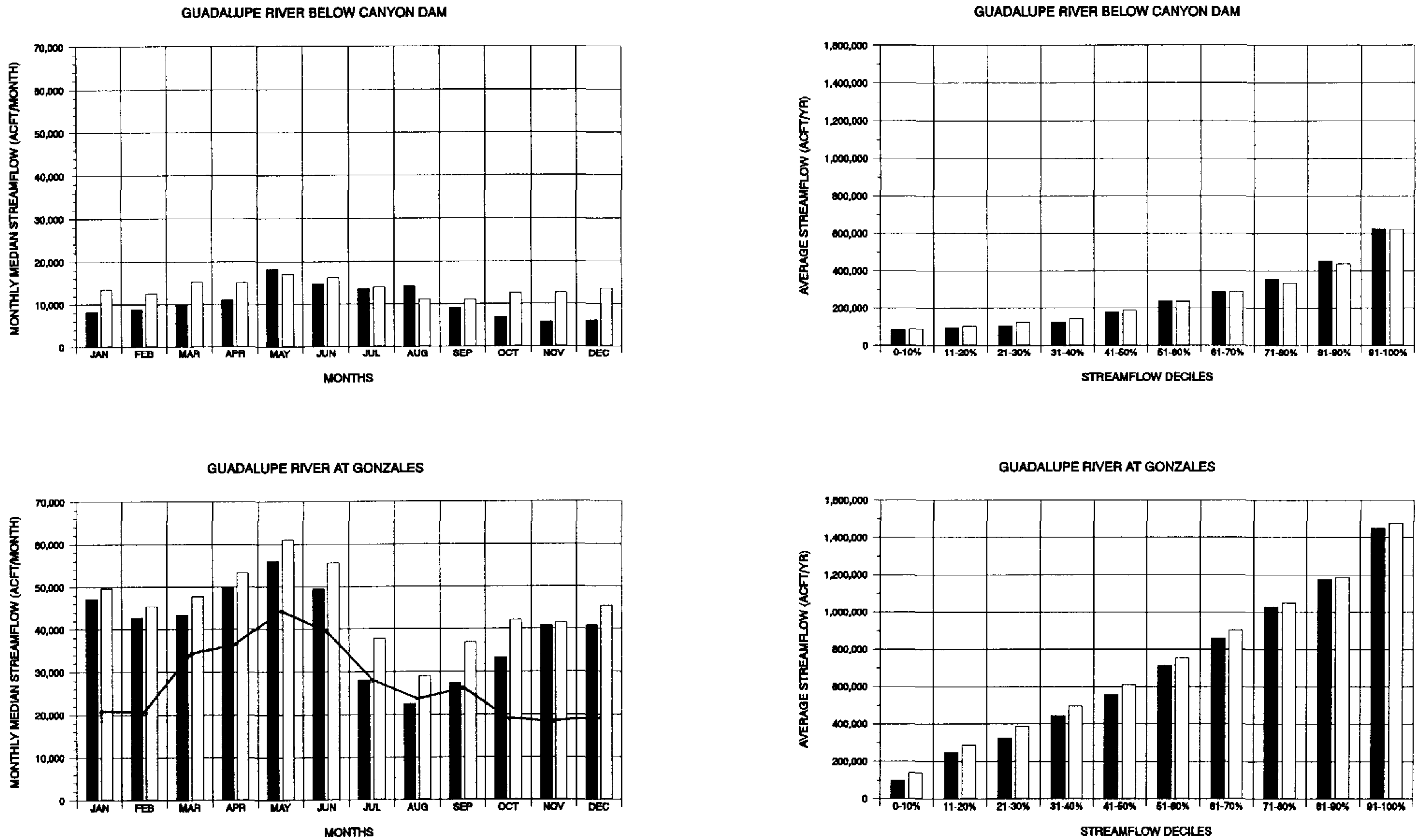
[57]Omernik, James M. 1986. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers, 77(1): pp. 118-125.

[58]Blair, W.F. 1950. The biotic provinces of Texas. Texas Journal of Science 2(1): pp. 93-117.

[59]Gould, F.W. 1975. The Grasses of Texas. Texas A&M University Press, College Station, Texas.

[60]Omernik, James M. 1986. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers, 77(1): pp. 118-125.

[61]Soil Conservation Service. 1978. General Soils Map Gonzales County, Texas. U.S. Department. Agriculture



LEGEND:

WITH PROJECT

WITHOUT PROJECT

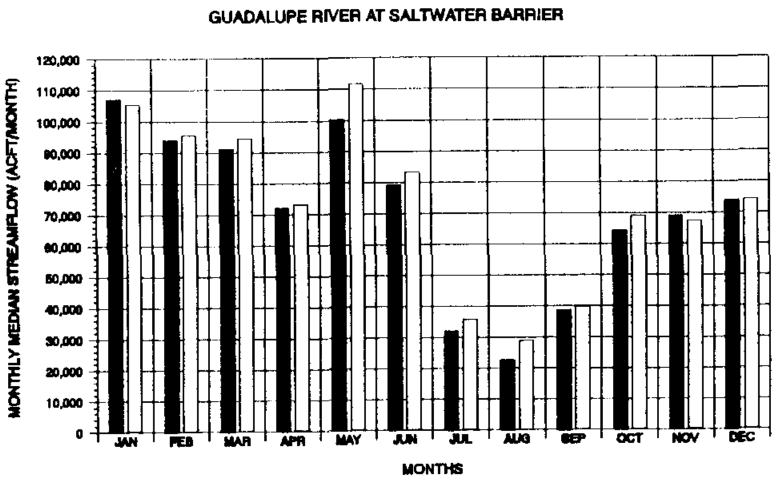
TRANS-TEXAS ENVIRONMENTAL CRITERIA
(FOR GUADALUPE RIVER AT CUERO GAGE)

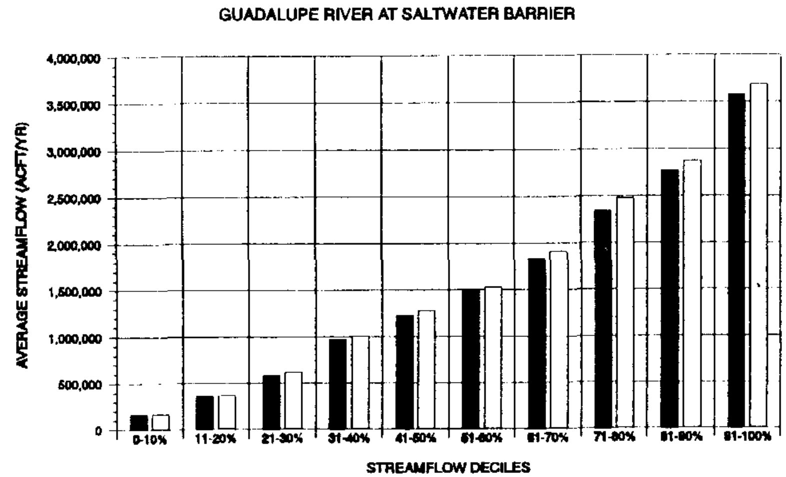
HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

CHANGES IN STREAMFLOW - GUADALUPE RIVER WITH DIVERSIONS NEAR GONZALES AND WATER RIGHTS TRANSFERS - ALTERNATIVE G-28

FIGURE 3.41-2





LEGEND:

WITH PROJECT

WITHOUT PROJECT

HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

CHANGES IN STREAMFLOW - GUADALUPE RIVER AT SALT WATER BARRIER WITH DIVERSIONS AT GONAZLES - ALTERNATIVE G-28

FIGURE 3.41-3

overstory, although only small remnants of this upland woodland are generally present in this ecoregion[62,63].

The proposed North Water Treatment Plant near San Antonio is in the remnant areas of brush, shrub and grassland in northern Bexar County just west of Cibolo Creek[64]. On the eastern edge of the Balcones Escarpment, this rapidly urbanizing area 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[65].

Stream crossings in the proposed corridor are mostly intermittent. Major stream crossings include the Guadalupe River near Seguin and Cibolo Creek, lower perennial 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 and exact impacts can not be determined with out further study.

The pipeline corridor is mostly improved pasture and cropland (60 percent), grass and brush (26 percent) with the remaining area a mixture of park, woods (8 percent), urban (2 percent) and wetlands (4 percent)[66,67]. The majority of the project area is located in cropland. Terrestrial impacts can generally be minimized or avoided by careful selection of the pipeline ROW. Less than 0.25 acres of riparian woods bordering the Guadalupe River shore will be impacted during construction of the river intake structure.

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[62]Omernik, James M. 1986. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers, 77(1): pp. 118-125.

[63]Correl, D.S., and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation, Renner, Texas.

[64]USGS. 1990. NAPP Series 2434, EROS Data Center, Sioux Falls, South Dakota.

[65]TPWD. 1994. Unpublished maps and data files, Natural Heritage Program, Department of Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

[66]McMahan, C.A., R.G. Frye, K.L. Brown. 1982. The Vegetation Types of Texas Including Cropland. Texas Parks and Wildlife Department, Austin, Texas.

[67]U.S. Fish and Wildlife Services. 1991. National Wetland Inventory Series. New Braunfels East, New Braunfels West, Schertz, Longhorn Quadrangles.

The amounts of water that could be made available on a firm basis for diversion below the City of Gonzales, Texas under various Edwards pumping scenarios by releasing stored Canyon Lake water, plus diverting under selected downstream water rights, are shown in Tables 3.41-1 and 3.41-2. The latter table also discloses the water available on a firm basis with and without application of the Trans-Texas criteria for instream flows and bay and estuary inflows to Alternative G-28. The Guadalupe River below Canyon Dam was the subject of an instream flow study during the mid 1980's, at the time a hydroelectric capability was installed, resulting in minimum flow requirements established during the FERC permitting process that were honored in developing this alternative. Because the water to be diverted at Gonzales would consist of a mix of stored water and run of river water, all of which is currently permitted, application of the Trans-Texas criteria will require additional clarification as to what water is subject to the criteria, and how (in a practical sense) they would be applied in this particular situation. At this time we can only predict that monthly median flows resulting from meeting the Trans-Texas criteria with Alternative G-28 would fall between the with and without project medians plotted in the Figures of this section.

Figure 3.41-2 shows existing monthly median streamflows below Canyon Lake (period of record 1934-1989), and the changes anticipated to result from implementation of this alternative without the instream diversion limits imposed by the Trans-Texas criteria. Projected changes in streamflow patterns are very similar to those outlined in the discussion of Alternative G-27 (Section 3.40). Both positive and negative changes on the order of 10 to 20 percent are projected for late spring and summer (May-August), while substantial decreases (35-50 percent) in monthly median streamflows are expected during the remainder of the year. Figure 3.41-2 shows how streamflows would be redistributed on an annual basis: during dry years reductions in streamflow would average 5-15 percent in the lowest five deciles, while during wetter years, streamflow could increase about 6 percent.

Projected changes in monthly median flows, and in annual average flows by decile, are presented for the Guadalupe River below the diversion point at Gonzales and at the Saltwater Barrier in Figures 3.41-2 and 3.41-3. At Gonzales substantial (20-25 percent) reductions in monthly median streamflows would occur during late summer and fall (July through October), with the largest proportional impacts occurring during the driest years (Figure 3.41-2).

At the Saltwater Barrier (San Antonio Bay inflows) streamflow changes as a result of implementation of this alternative would be essentially identical to those outlined in Section 3.40 (Alternative G-27). Monthly median streamflows would be reduced about 5-10 percent during late spring and summer (May-August), while both positive and negative changes of less than 5 percent would occur during the remaining months (Figure 3.41-3). Most of these reductions would occur during wet years, with dry year streamflows being largely unaffected (Figure 3.41-3).

Alterations in streamflow patterns of the magnitudes projected to occur in the reaches below Canyon Dam may result in changes in the average abundances of some aquatic populations, increase interannual variation, and reduce the overall carrying capacity in these reaches during dry years. Existing minimum streamflow requirements established by FERC at Canyon Dam are expected to be adequate for at least minimal maintenance of the biological community in this reach, since flows during the critical summer period would be least affected. Although the peak summer recreational period would be relatively unaffected, river recreationalists would experience more, or more extended, low flow periods during the early spring and fall as a result of implementation of Alternative G-28. The potential impacts to river recreation and local economies should be examined in detail if this alternative is retained for further consideration.

Below Gonzales the substantial reductions in streamflows projected to occur during the driest years, particularly during the historic summer (July-September) low flow period, may adversely affect some biological communities downstream. Reductions in San Antonio Bay inflows would approach 10 percent of the monthly medians only during May and August, and would occur primarily during wet years.

Instream flow studies should be conducted in the reaches below Canyon Dam and Gonzales in order to evaluate potential impacts to the community as a whole, but more particularly to the aquatic species discussed below as being of concern to state and federal resource agencies. Because of the lack of effect on the lower flow ranges at the Saltwater Barrier, impacts to San Antonio Bay as a result of increased length or severity of drought periods do not appear to have great potential for being significant. For example, using a

1934-1989 period of record, the minimum annual flow would have decreased from 52,289 to 50,250 acre feet (4 percent) as a result of implementing Alternative G-28. In the same simulation, 25th percentile and median flows at the Saltwater Barrier are shown to decrease by only 3.4 and 1.6 percent, respectively, with only minor variation in seasonal patterns (Figure 3.41-2). Since this alternative is a diversion, not an impoundment, its operation will have minimal effects on flood flows.

The Cagle's map turtle, Guadalupe bass, and the blue sucker ranges extend from the Edwards Plateau through the Blackland Prairie to the Coastal Plains in Guadalupe River. Cagle's map turtle has been located as far south as Victoria, Texas on the Coastal Plain. Best adapted for flowing water, the Guadalupe bass is often found in flowing water near riffles feeding on aquatic insects and moving water associated fish such as the Texas shiner (*Notropis amabilis*) and channel catfish (*Ictalurus punctatus*). Although the Guadalupe bass is found in reservoirs such as Canyon Lake, it may be at a competitive disadvantage with other bass species in more lentic environments. Populations of Guadalupe bass tend to decline as the river enters the Coastal Plains. In the Guadalupe River, few are found downstream of Luling in Caldwell County[68]. The blue sucker, a large river fish, is a candidate for federal protection with probable occurrence, although the presence of several dams in this reach of the Guadalupe, together with a lack of suitable substrate and flow conditions, suggests that it may no longer be present.

Although the Texas Natural Heritage Program does not report any endangered or threatened species directly along the proposed pipeline corridor, some have been reported in the vicinity[69,70]. The Texas Organization for Endangered Species (TOES) has listed the two-flower stickpea (*Calliandra biflora*) for special consideration and has been mapped by the Natural Heritage Program in the vicinity of a portion of the transmission corridor in Goliad County. This plant is found in shallow, well drained sandy soils of sparsely vegetated

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[68]Garrett, Gary P. 1991. Guidelines for the Management of Guadalupe Bass. Publication PWD-RP-N3200-367-11/91, Texas Parks and Wildlife Department, Austin, Texas.

[69]TPWD. 1994. Unpublished maps and data files, Natural Heritage Program, Department of Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas.

[70]TOES. 1992. Endangered, Threatened, and Watch List of Natural Communities of Texas, Publication 8, Austin, Texas; TOES. 1993. Endangered, Threatened, and Watch List of Texas Plants, Third Revision, Austin, Texas.

grass and shrublands. Another Texas native plant on the TOES watch list is the Texas gourd (*Cucurbita texana*) often found in alluvial soils on river terraces[71]. Although we did not find this species occurrence mapped in the corridor, there is appropriate habitat for this gourd. The areas of grasslands, brush, and shrub could be habitat for several endangered or threatened species, such as the Black-capped Vireo, Golden-cheeked Warbler, Texas horned lizard, and Texas garter snake (Appendix B, Tables 6, 21 and 22, Volume 2). Surveys for the presence of important and protected species would be conducted within the proposed construction corridor.

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.

3.41.4 Water Quality and Treatability

(To be completed in subsequent phases of the study.)

3.41.5 Engineering and Costing

For this alternative, the combined firm water available at Gonzales would be diverted through a new intake and pump station located along the shore of the Guadalupe River and pumped in a transmission line to the proposed North Water Treatment Plant. The diversion rate from the Guadalupe River would vary considerably from month to month with highest use in the summer months needed in order to keep SAWS aquifer pumpage uniform throughout the year. The major facilities required to implement this alternative are:

Reservoir Intake and Pump Station
Raw Water Pipeline to Treatment Plant
Raw Waterline Booster Pump Station
Water Treatment Plant (Level 3, see Table 3.0-4, Volume 2)
Finished Water Pump Station
Distribution System Improvements

[71]TOES. 1993. Endangered, Threatened, and Watch List of Texas Plants, Third Revision, Austin, Texas.

The reservoir intake and pump station is sized to deliver a maximum monthly volume of 12,400 acft (133 mgd) through a 90 inch diameter pipeline. The operating cost was determined for the total raw water static lift of 720 feet and an annual water delivery of 71,260 acft/yr. Financing the project over 25 years at an 8.0 percent annual interest rate results in an annual expense of $33,960,000 (Table 3.41-3). The annual cost of water purchased from GBRA is $53 per acft, for an annual payment of $1,890,000. Purchase of water using senior water rights of the Calhoun Canal Division is estimated to cost $53 per acft for firm water (same cost as stored water from Canyon Lake). For purchase of 40,000 acft/yr using senior rights, firm availability is estimated to be 37,000 acft/yr at the Saltwater Barrier (see Section 3.23, Volume 2) for an annual cost of $1,960,000. Compensation for CP&L's contract for stored water from Canyon Lake is assumed to be $53 per acft/yr and is included in the annual cost for replacement water for make-up needs at CP&L's Coleto Creek Reservoir. Operation and maintenance costs, including power and purchase of all stored, transferred and replacement water, total $24,270,000. The total annual costs, including debt repayment, interest, operation and maintenance and all water purchases, total $58,230,000, for all facilities. Included in these costs are annual costs for facilities to deliver SAWS reclaimed water from the San Antonio River to replace CP&L's cooling water needs (including compensation for CP&L's Canyon Lake stored water contract) total $1,140,000 as described in Section 3.42.5. For an annual firm yield of 71,260 acft, the resulting annual cost of water developed under this aspect of the SAWS plan is $817 per acft (Table 3.41-3).

3.41.6 Implementation Issues

An institutional arrangement is needed to implement projects including financing on a regional basis.

Requirements Specific to Transfer of Downstream Rights

1. CP&L and GBRA diversion permits will need to be amended to change the point of diversion. CP&L run-of-the-river permit will need to be transferred.

2. Water to replace the CP&L contract for stored water and run-of-the-river rights, and possibly the GBRA Calhoun Canal rights need to be considered. Refer to Section 3.42 for more discussion of a potential alternative available for replacement water.

Table 3.41-3
Cost Estimate Summaries for Guadalupe River Diversion Near Gonzales with Transfer of Downstream Rights (G-28)
(Third Quarter - 1994 Prices)

Item	Alternate G-27 Costs
Capital Costs	
Intake and Pump Station	$7,090,000
Transmission Pipeline and Pumping	115,090,000
Treatment Plant	53,160,000
Delivery System [1]	87,350,000
Total Capital Cost	$262,690,000
Engineering, Contingencies, and Legal Costs	$78,050,000
Land Acquisition	420,000
Environmental Studies and Mitigation	420,000
Interest During Construction	20,780,000
Total Project Cost	$362,360,000
Annual Costs	
Annual Debt Service	$33,960,000
Annual Operation and Maintenance	10,710,000
Replacement Water Cost for Coleto Creek (Includes Makeup Water from SAWS Return Flows, including Purchase of CP&L-GBRA Stored Water Contract)	1,140,000
Purchase of 35,588 acft/yr Canyon Lake Stored Water	1,890,000
Purchase of 40,000 acft/yr under Senior Water Rights from Saltwater Barrier	1,960,000
Annual Power Cost	8,570,000
Total Annual Cost	$58,230,000
Available Project Yield (acft/yr)	71,260
Annual Cost of Water	$817/acft

[1] As described in Section 3.0.2 delivery system improvements costs were determined from studies for delivery of Applewhite Reservoir water and may be lower for a water source on the northwest side of the city.

Requirements Specific to River Diversion and Transmission Pipeline:

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 permit for river crossings.
   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

1. Detailed study needed of the cost of pumping and transmission pipeline improvements necessary to effectively integrate the new supply into SAWS water supply system.
2. Study needed of cost to convey and distribute water to other area water utilities.

Requirements Specific to Amending the Canyon Lake Permit

1. If this alternative requires exceeding the current permitted average annual diversion from Canyon Lake of 50,000 acft, then a permit amendment will require:
   a. Application to the TNRCC
   b. Hydrologic studies substantiating requested firm yield.
   c. 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.

3.42 Use of SAWS Reclaimed Water to Replace Potential Water Transfers (L-20)

3.42.1 Description of Alternative

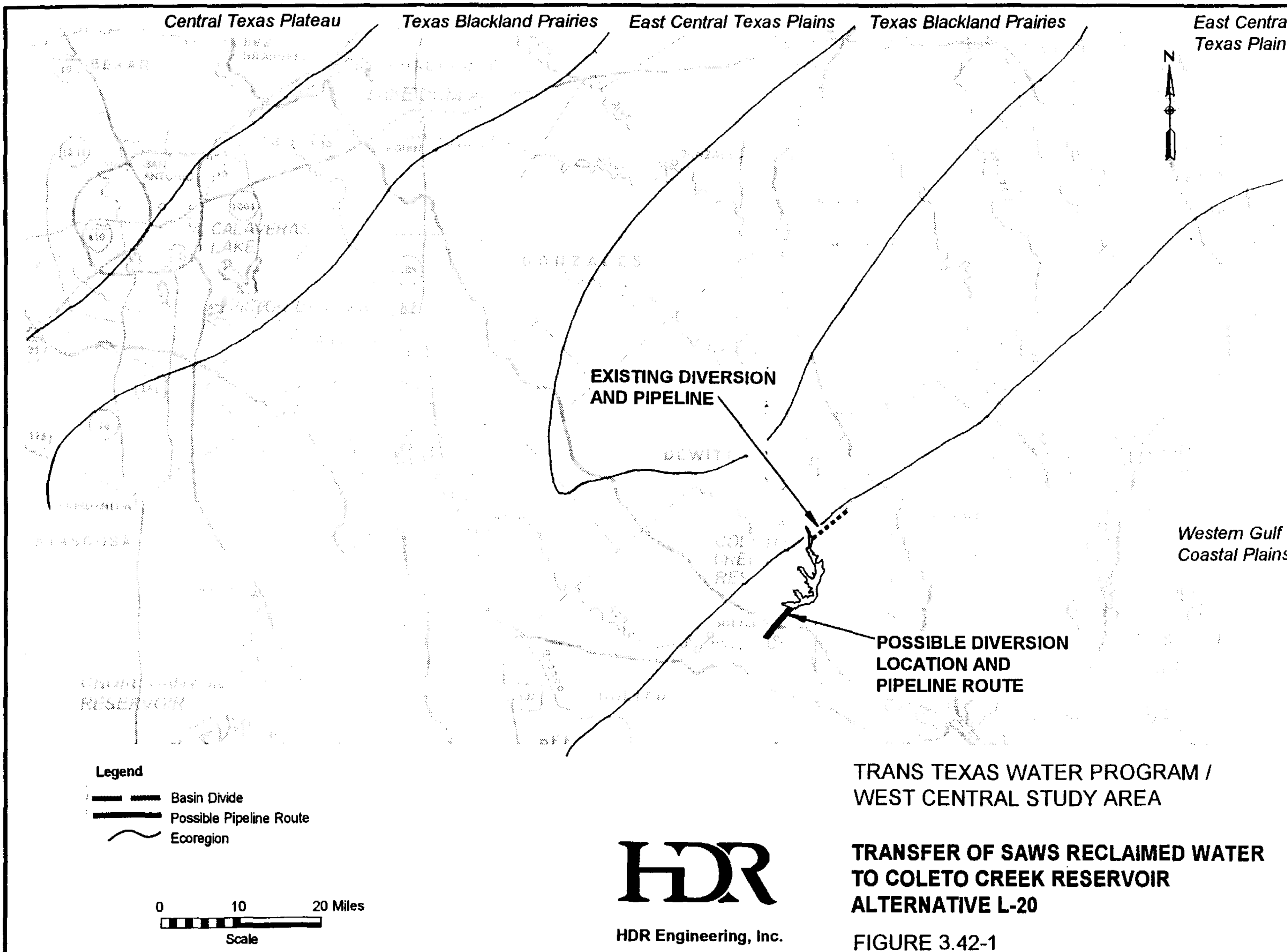
In previous sections, water rights held by Central Power & Light (CP&L) for their Coleto Creek generating station and rights held by GBRA at their Calhoun Canal Division (GBRA CCD) have been studied for potential amendment to allow diversion at Lake Dunlap or near Gonzales. See Section 3.40 Diversion at Lake Dunlap with Transfer of Downstream Rights (G-27) and Section 3.41 Diversion Near Gonzales with Transfer of Downstream Rights (G-28). This alternative considers diverting a portion of SAWS return flow from the San Antonio River near Goliad and transferring it to Coleto Creek Reservoir, thereby mitigating, to the extent possible, the effects of transferring CP&L rights to upstream locations under Alternatives G-27 and G-28. Additionally, mitigation for using GBRA CCD water at locations other than the Saltwater Barrier could be accomplished, in part, with return flows remaining at the Saltwater Barrier after all upstream uses and channel losses are considered including SAWS/SARA tunnel reuse of 18,000 acft/yr, makeup water demands for Braunig and Calaveras Lakes and Coleto Creek Reservoir, and use by existing water rights along the main stem of the San Antonio River.

The major facilities needed for this alternative include a small diversion dam on the San Antonio River, water intake and pump station, a 6.5 mile transmission pipeline to Coleto Creek Reservoir, and a discharge structure near the reservoir. A possible location of the diversion near Goliad and pipeline route to Coleto Creek are shown in Figure 3.42-1.

3.42.2 Available Yield

As indicated in Section 3.2 (Volume 2), a substantial quantity of reclaimed water or return flow is available from SAWS wastewater treatment plants on an annual basis. The Guadalupe - San Antonio River Basin Model[72] (GSA Model) was utilized to quantify excess SAWS return flows delivered to Goliad for potential mitigation of water rights transfers in the lower Guadalupe River Basin. Excess return flows are those remaining after needs at Braunig and Calaveras Lakes, the Central East Infrastructure Project (i.e. "Tunnel

[72]HDR Engineering, Inc., "Guadalupe - San Antonio River Basin Recharge Enhancement Study," Volumes I, II, and III, Edwards Underground Water District, September 1993.



TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

TRANSFER OF SAWS RECLAIMED WATER TO COLETO CREEK RESERVOIR ALTERNATIVE L-20

FIGURE 3.42-1

Reuse" project), and intervening mainstem water rights on the San Antonio River have been satisfied and channel losses are considered. Braunig Lake's makeup needs were first met from its run-of-the-river water right (12,000 acft/yr) and additional makeup needs were met from SAWS return flows.

Currently, make-up water for Coleto Creek Reservoir is provided from run-of-the-river rights and stored water released from Canyon Lake (by contract with GBRA). CP&L holds a diversion permit for 20,000 acft/yr of run-of-the-river water from the Guadalupe River. Under this permit water is diverted at a maximum diversion rate of 35.65 cfs (70.6 acft/day) at a pump station upstream of Victoria. GBRA is under contract with CP&L to release water from Canyon Lake for pump-over to Coleto Creek Reservoir through the same pump station on the Guadalupe River. The contract with GBRA provides for the delivery of a maximum of 18,900 acft in any one-year period and 30,000 acft in any five-year period. An analysis was performed to compare availability of SAWS return flows (delivered to Goliad) to the availability of Guadalupe River water under the existing rights and contract. Availability of Guadalupe River water under the existing rights and contract was estimated for an Edwards aquifer pumpage scenario of 400,000 acft/yr, hydropower requirement of 600 cfs at Lake Dunlap, and return flows at 1988 levels. Table 3.42-1 compares average annual makeup diversion, drought average makeup diversion, and the percent of time that the CP&L makeup water need would not have been fully satisfied from each of the alternative makeup water sources. At times when makeup water needs are not fully met, the steam-electric plant remains in operation, but must operate with the cooling reservoir at a lower surface elevation than desired, possibly resulting in higher reservoir temperatures and lower plant efficiencies.

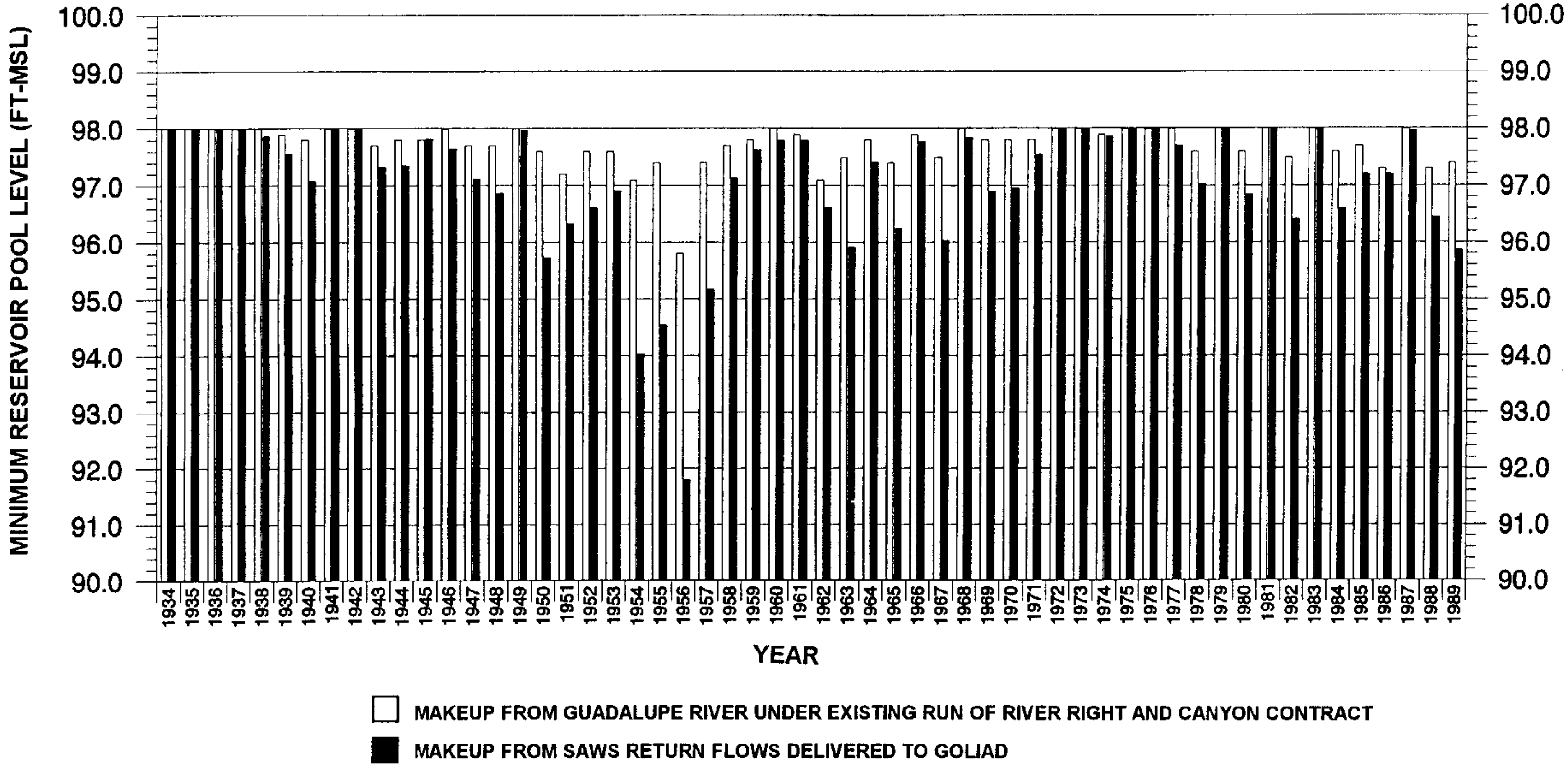
Table 3.42-1 shows that an average of 8,400 acft/yr of makeup water could be diverted from SAWS return flows at Goliad on an average annual basis. This is about 89 percent of the makeup available and diverted under existing conditions. During the drought of record, an average of 12,370 acft/yr of makeup water could be diverted from SAWS return flows at Goliad, which is about 80 percent of the makeup available and diverted under existing conditions. Makeup water available for Coleto Creek Reservoir at Victoria under existing conditions would result in the makeup needs not being fully met 14.6 percent

Table 3.42-1 Makeup Water Availability for Coleto Creek Reservoir		
	Makeup Water Source	
	Guadalupe River Run-of-the-River Rights and Canyon Lake Contract [1]	SAWS Return Flows Delivered to Goliad Via the San Antonio River [2]
Average Annual Makeup Diversion (acft/yr) [3]	9,490	8,400
Drought Average Makeup Diversion (acft/yr) [4]	15,500	12,370
Percent of Time Makeup Needs Not Fully Met [5]	14.6%	23.5%

[1] Represents existing conditions with Coleto Creek Reservoir makeup diversions from Guadalupe River under run-of-the-river water right (20,000 acft/yr) and Canyon Lake contract, 400,000 acft/yr aquifer pumpage scenario, hydropower requirement of 600 cfs at Lake Dunlap, and 1988 return flows.
[2] Represents Coleto Creek Reservoir makeup diversions from SAWS return flows (1988 levels) delivered to Goliad after needs of SAWS/SARA Tunnel Reuse Project, Braunig and Calaveras Lakes, and existing water rights owners along the main stem of the San Antonio River are met.
[3] Represents average annual makeup diversions for the 1934-89 period subject to water availability and a maximum diversion rate of 35.65 cfs.
[4] Represents drought average makeup diversions for the 116 month period beginning in July, 1947 and ending in February, 1957 subject to water availability and a maximum diversion rate of 35.65 cfs.
[5] Percent of time that the makeup need was not fully met due to the limits of water availability or maximum diversion rate.

of the time or 98 months out of the 672 month period analyzed (1934-89). In comparison, makeup water available from SAWS return flows at Goliad would result in the makeup needs not being fully met 23.5 percent of the time or 158 months out of the 672 month period analyzed. The lack of makeup water available from SAWS return flows at Goliad in certain months is largely due to the demands on SAWS return flows for upstream uses including tunnel reuse and Braunig and Calaveras Lakes as well as losses in delivery of reclaimed water down the San Antonio River.

Comparisons were also made of minimum annual Coleto Creek Reservoir pool levels with makeup water from the Guadalupe River at Victoria under existing conditions and with makeup water available from SAWS return flows at Goliad. The results are presented in Table 3.42-2 and Figure 3.42-2. For makeup water supply from SAWS return flows, Table 3.42-2 shows that Coleto Creek Reservoir would operate at or below a one-foot drawdown level about 9.8 percent of time compared to only 0.4 percent of the time for existing conditions. Figure 3.42-2 shows a comparison of minimum annual Coleto Creek Reservoir pool levels for the 1934-89 period for both existing conditions (makeup from Guadalupe River) and with the makeup supply from SAWS return flows from the San Antonio River. The minimum reservoir pool level with the makeup supply from SAWS return flows at



Assumptions:

1. Return flows at 1988 amounts; 400,000 ac-ft/yr aquifer pumpage scenario; hydro requirement of 600 cfs at Lake Dunlap for makeup from Guadalupe River.
2. Return flows at 1988 amounts; 368,000 ac-ft/yr aquifer pumpage scenario; and hydro requirement of 0 cfs at Lake Dunlap for makeup from SAWS return flows.
3. Return flows for Coleto Creek Reservoir make-up water after needs of Braunig/Calaveras reservoirs, Tunnel Reuse and intervening water rights and losses.
4. Maximum diversion rate 35.65 cfs for both sources.

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TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

COMPARISONS OF COLETO CREEK RESERVOIR MINIMUM POOL LEVELS ALTERNATIVE L-20

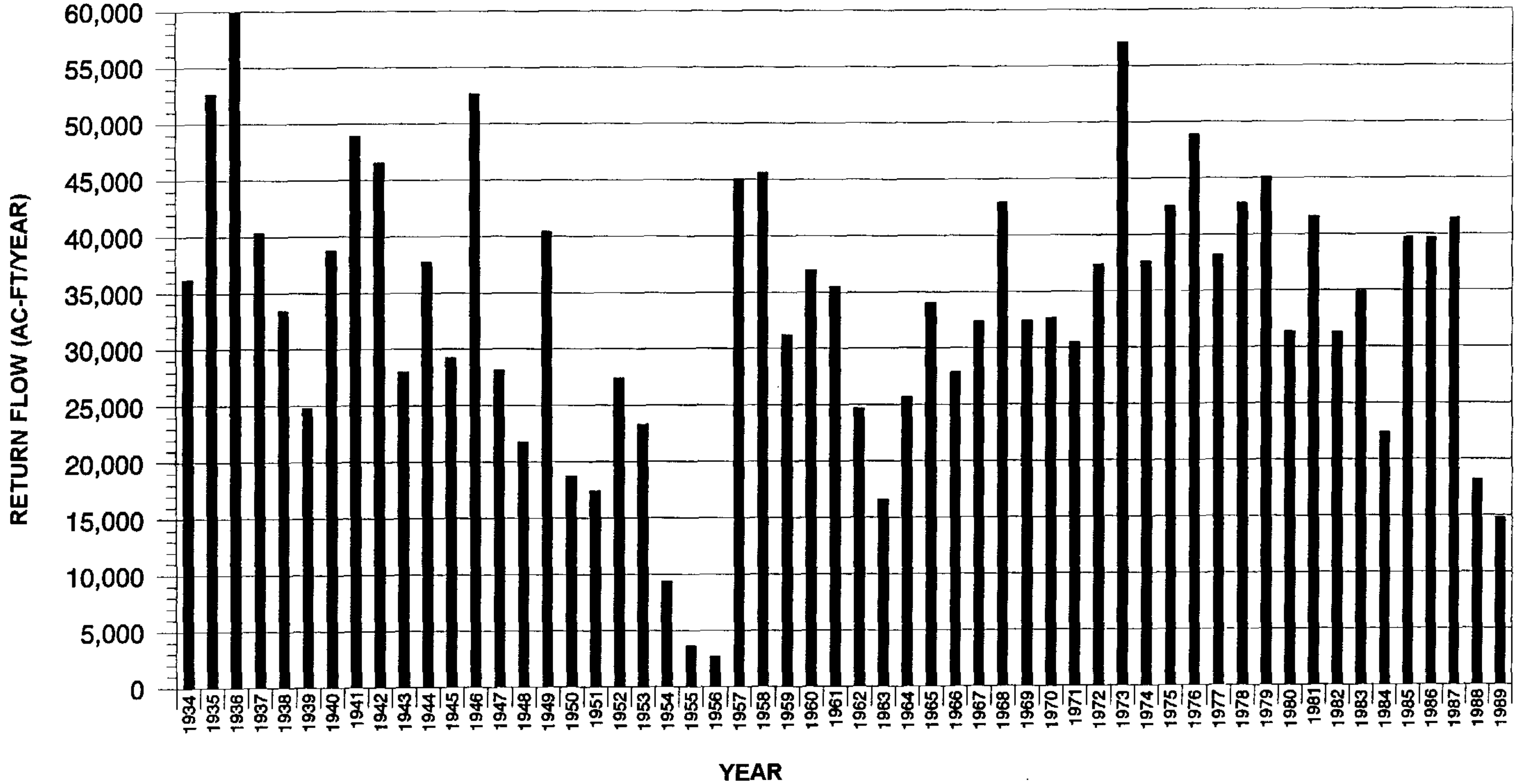
FIGURE 3.42-2

Table 3.42-2 Comparison of Coleto Creek Reservoir Pool Levels						
	Makeup Water from Guadalupe River Rights and Canyon Lake Contract [1]		Makeup Water from SAWS Return Flows Delivered to Goliad [2]		Reservoir Area and Capacity	
Reservoir Pool Level (ft-MSL)	Number of Months at or Below Level [3]	Percent of Time at or Below[4] Level	Number of Months at or Below Level [3]	Percent of Time at or Below[4] Level	Surface Area (acres)	Storage Capacity (acft)
98.0	672	100.0%	672	100.0%	3,100	35,084
97.0	3	0.4%	66	9.8%	2,920	32,074
96.0	1	0.2%	26	3.9%	2,740	29,244
95.0	0	0.0%	11	1.6%	2,570	26,589
94.0	0	0.0%	4	0.6%	2,400	24,104

[1] Represents the existing conditions of Coleto Creek Reservoir makeup diversions from Victoria under the existing run-of-the-river water right (20,000 acft/yr) and Canyon Lake contract. Aquifer demand scenario at 400,000 acft/yr and hydropower subordinated to 600 cfs at Lake Dunlap. The minimum reservoir pool level was 95.8 ft-msl.
[2] Represents the conditions of Coleto Creek Reservoir makeup diversions from SAWS return flows delivered to Goliad after tunnel reuse and Braunig and Calaveras Lakes makeup needs have been met from SAWS return flows. Aquifer demand scenario at 368,000 acft/yr and hydropower subordinated to 0 cfs at Lake Dunlap. The minimum reservoir pool level was 91.8 ft-msl with the diversion rate limited to 35.65 cfs. With a diversion rate of 56 cfs, the minimum pool level would have been about 93.8 ft-msl.
[3] The number of months that the reservoir pool was at or below the indicated level. The 1934-89 period (672 months) was used for the simulations.
[4] The percent of time during the 1934-89 period that the reservoir was at or below the indicated reservoir pool level.

Goliad was found to be 91.8 feet-msl in 1956 as compared to 95.8 feet-msl for existing conditions. If the maximum diversion rate for makeup water supply from SAWS return flows at Goliad were increased from 35.65 cfs to 56 cfs, the minimum reservoir pool level would be approximately 93.8 feet-msl.

The availability of SAWS return flows at the Saltwater Barrier was determined in order to evaluate the potential for mitigation of GBRA water rights transferred from the Saltwater Barrier to upstream locations. Figure 3.42-3 shows the annual total of SAWS return flow available at the Saltwater Barrier after all upstream uses are satisfied to the extent possible. Upstream uses include SAWS/SARA tunnel reuse, makeup demands for Braunig Lake and Calaveras Lake, makeup demands for Coleto Creek Reservoir, and use by existing water rights owners on the main stem of the San Antonio River. The availability of SAWS return flows at the Saltwater Barrier also accounts for channel losses from San Antonio to the Saltwater Barrier. The minimum simulated annual volume of SAWS return flow available at the Saltwater Barrier would have been 2,700 acft in 1956. This is about 2.0 percent of the total annual SAWS return



Assumptions:

1. Return flows at 1988 amounts; 368,000 ac-ft/yr aquifer pumpage scenario; hydro requirement of 0 cfs at Lake Dunlap.
2. Return flow availability after needs of Braunig/Calaveras reservoirs, Tunnel Reuse, Coleto Creek Reservoir, and intervening water rights and losses.

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AVAILABILITY OF SAWS RETURN FLOWS AT SALTWATER BARRIER ALTERNATIVE L-20

FIGURE 3.42-3

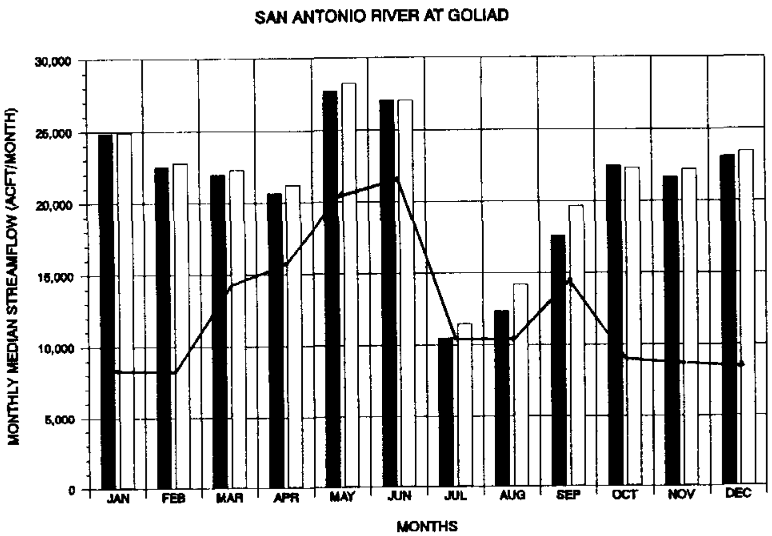
flow of 136,100 acft. For the 1956 condition, upstream uses of SAWS return flow include SAWS/SARA tunnel reuse in the amount of 18,000 acft (13.2 percent), Braunig Lake makeup demand of 17,100 acft (12.6 percent), Calaveras Lake makeup demand of 56,700 acft (38.7 percent), Coleto Creek makeup demand of 14,200 acft (10.4 percent), and existing water right demands of 5,300 acft (3.9 percent) on the mainstem of the San Antonio River. Channel losses between San Antonio and the Saltwater Barrier would have depleted SAWS return flows by 26,100 acft (19.2 percent).

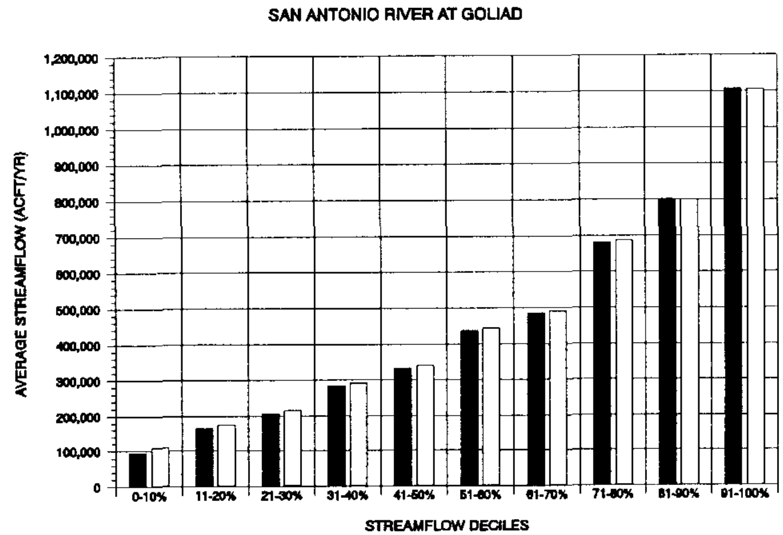
Comparisons of monthly median streamflows and annual streamflows averaged by decile are presented in Figure 3.42-4 for the San Antonio River at Goliad for conditions both with and without the diversion of SAWS return flows for Coleto Creek Reservoir makeup. The streamflow statistics presented are for an aquifer demand of 368,000 acft/yr with the project and 400,000 acft/yr without the project while return flows are set at 1988 levels. The results show a small reduction in the median monthly streamflow in almost all months with the largest reductions of 9 percent, 13 percent, and 11 percent occurring in July, August, and September, respectively. The reduction in the median monthly streamflow was found to be less than 3 percent in all other months. Figure 3.42-4 also shows a reduction in the average annual streamflow in each of the deciles with the project. The largest decrease in average annual streamflow was found to be about 13 percent in the lowest streamflow decile. The impact is less than 1 percent in those years of highest streamflow.

3.42.3 Environmental Issues

The area potentially affected by this alternative includes the San Antonio River south of Goliad, Coleto Creek Reservoir in the Guadalupe River basin and a pipeline corridor between the diversion point and reservoir. This area encompasses a landscape typical of the East Central ?Texas Plains (Figure 3.0-1, Volume 2). Both the San Antonio River and the Guadalupe River in the project area flow through nearly level bottomland hardwood corridor[73]. Coleto Creek Reservoir was completed in 1980 to provide recirculating cooling water for a CP&L electric generating station. Normal pool elevation is 98 feet-msl, spillway elevation is about 107 feet-

[73]USFWS. 1991. National Wetland Inventory Map Series. Fannin and Hensley Lake, Texas Quadrangles. USGS.





LEGEND:

WITH PROJECT

WITHOUT PROJECT

TRANS-TEXAS ENVIRONMENTAL CRITERIA

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CHANGES IN STREAMFLOW - SAN ANTONIO RIVER AT GOLIAD WITH SAWS RETURN FLOWS ALTERNATIVE L-20

FIGURE 3.42-4

msl and top of dam is 120 feet-msl[74]. The littoral of the relatively shallow reservoir is typically flat and seasonally flooded. Lower perennial wetlands with emergent vegetation are present in the area of the proposed discharge point, while higher elevations around the reservoir consist of upland forested knolls of pecan and elms[75,76].

The estimated 23.6 acre construction corridor for the water transmission line assessed as Alternative L-20 traverses areas comprised primarily of mesquite invaded coastal post oak woods, and a forest and grassland mosaic developed on the sandy soils of the Post Oak Savannah (Volume 2; Figure 3.0-2, Figure 3.42-1)[77,78]. The dominant species, post oak, occurs in open stands with a grass ground cover. The vegetation type is either considered to be part of the Eastern Deciduous Forest association or as part of the Prairie association[79,80,81,82,83,84,85]. The latter association is based upon the occurrence of a climax tall grass understory composed of prairie dominants, little bluestem, Indiangrass, and big bluestem. Recent agricultural

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[74]HDR Engineering, Inc. 1994. Pers. Comm. Coleto Creek design drawings.

[75]USFWS. 1991. National Wetland Inventory Map Series. Fannin and Hensley Lake, Texas Quadrangles. USGS.

[76]USGS. 1989. NAPP Photograph 1540-161 dated 2-23-89. EROS Data Center, Sioux Falls, South Dakota.

[77]McMahan, C.A., R.G. Frye, K.L. Brown. 1982. The Vegetation Types of Texas Including Cropland. Texas Parks and Wildlife Department, Austin, Texas.

[78]Gould, F.W. 1975. Texas plants--a Checklist and ecological summary. Texas A&M University. Texas Agricultural Experiment Station. MP-585/Rev. College Station, Texas.

[79]Correll, D.S., and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation, Renner, Texas.

[80]Tharp, B.C. 1939. The vegetation of Texas. Texas Acad. Sci., Anson Jones Press, Houston, Texas.

[81]Braun, E.L., 1950. Deciduous forest of eastern North America. Hafner Publ. Co., Inc. New York.

[82]Kuchler, A.W. 1964. Potential natural vegetation of the conterminous United States. American Geog. Soc. S. Publ. No. 36.

[83]Mahler, W.F. 1980. The mosses of Texas. Southern Methodist University Herbarium, Dallas, Texas.

[84]Weaver, J.E. and F.E. Clements. 1938. Plant Ecology. 2nd Ed. McGraw-Hill Book Co., New York.

[85]Daubenmire, Rexford. 1978. Plant geography with special reference to North America. Academic Press, New York.

practices, such as overgrazing, abandonment from cultivation, and fire control, has contributed to many acres being converted into dense woodland stands of post oak and winged elm.

The only stream to be crossed by the proposed transmission line corridor is Manahuilla Creek, a seasonally intermittent tributary to the San Antonio River[86]. In this reach of the San Antonio River (and Manahuilla Creek) wetlands are generally limited to the streambed itself, as the relatively steep, forested banks support mesic, upland woods dominated by pecan and elm[87]. The post oaks-mesquite savannah occupies about 90 percent of the corridor. Upland hardwood forests, including those along the stream banks, total about 8 percent of the corridor. Developed areas along the transmission line corridor total less than 1 percent and wetlands occupy the remaining 1 percent.

The important species listed in Appendix B, Tables 20 and 44 (Volume 2) for Goliad and Victoria counties apply to the Alternative L-20 area[88]. Three important birds may be found using habitat found in the study area. They are the American Bald Eagle, the White-tailed Hawk, and White-faced Ibis. The American Bald Eagle is known to nest along densely forested corridors of the San Antonio and Guadalupe River bottoms. The rare White-tailed Hawk is found in grasslands and coastal prairie of the Texas Gulf Coast. The White-faced Ibis has been reported as a summer resident in freshwater marshes and hardwood bottomlands south of the project area. Texas scarlet snake, listed as threatened by Texas Parks and Wildlife Department, and the Texas horned lizard, which is also a candidate for federal protection, are the most likely important species to found in upland habitats of the study area. The semi-fossorial Texas scarlet snake is found on sandy soils of East Texas and the central and south Gulf Coast. The Texas horned lizard is a denizen of open, well-drained habitats with sparse cover. Ants, spiders, and isopods are included in their diets. The decline of Texas horned lizard populations is associated

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[86]USFWS. 1991. National Wetland Inventory Map Series. Fannin and Hensley Lake, Texas Quadrangles. USGS.

[87]McMahan, C.A., R.G. Frye, K.L. Brown. 1982. The Vegetation Types of Texas Including Cropland. Texas Parks and Wildlife Department, Austin, Texas.

[88]Texas Parks and Wildlife Department, Unpublished 1994. September, 1994, Data and map files of the Natural Heritage Program, Resource Protection Division, Austin, Texas.

with the invasion of fireants, agricultural practices and urbanization[89]. This statewide species preferred habitat is open, flat terrain with bare ground.

Important aquatic species known to the San Antonio River and Guadalupe River include the Guadalupe bass and Cagle's map turtle. Both species are reported in the Guadalupe River basin around Victoria[90,91,92].

Populations of Guadalupe bass tend to decline as the river enters the Coastal Plains. The proposed diversion dam on the San Antonio River, surface intake and pump station would likely effect an estimated two acres of riverine wetlands. The transmission line from the San Antonio River diversion to Coleto Creek is estimated to be about 6.5 miles long, and to require a 30 foot construction corridor, within which an estimated 21 acres of post oak and grassland mosaic vegetation and 0.25 acres of intermittent streambed may be disturbed. The proposed discharge structure at Coleto Creek would disturb about a quarter acre of palustrine wetlands with emergent vegetation. With all major facilities included, the total area potentially disturbed during construction will be about 26 acres. A ten foot right of way (ROW), totaling 7.9 acres free of woody vegetation, would be maintained for the life of the proposed transmission line. The small diversion dam and intake at San Antonio River, about half an acre, would permanently affect water diversion and riverine wetlands for the life of the project. The associated pump station may affect an estimated quarter acre of post oak uplands for the life of the project. The discharge structure would permanently affect an estimated quarter acre of littoral zone in vegetated wetlands of Coleto Creek Reservoir. The location of the proposed alternative facilities and transmission line alignment are now only generally specified (Figure 3.42-1).

The primary long term effect on Coleto Creek Reservoir will be increased fluctuations in water surface elevation. Alternative L-20 would replace the Guadalupe River water with SAWS reclaimed effluent. The reservoir would operate at or below a one foot drawdown level about 9.8 percent of the time, and would experience drawdowns greater than 4 feet 0.6 percent

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[89]Price, A., W. Donaldson, and J. Morse. 1993. Final Report As Required by the Endangered Species Act, Section 6, Texas Project No. E-1-4. Texas Parks and Wildlife Department, Austin, Texas.

[90]Gary P. Garrett. 1991. Guidelines for the Management of Guadalupe Bass. TPWD Austin, Texas.

[91]Haynes, David and Ronald R. McKown. 1974. A new species of map turtle (Genus *Graptemys)* from the Guadalupe River System in Texas. Tulane Studies in Zoology and Botany, Vol. 18, Num. 4. pp. 143-152.

[92]Killebrew, Flavius C. and Dan A. Porter. 1991. Testudines, *Graptemys caglei*. Herp Review: 22(1), p. 24.

of the time (Table 3.42-2, Figure 3.42-2). Although substantially less stable than historical water surface elevations, the changes in elevation that would accompany implementation of this alternative do not appear to exceed a rate of about 2 feet/year except during extreme drought periods. This would not substantially affect fish reproduction in shallow water. Potential effects on reservoir water quality and recreational use of the reservoir are not addressed in this phase of the study, but should be addressed if this alternative is considered further.

While changes in monthly median streamflows in the San Antonio River below the Goliad diversion during most months would be quite small, the historically lowest flow months (July through September) would exhibit median flow reductions of 8-13 percent[93] (Figure 3.42-4). Figure 3.42-4 shows flow reductions distributed relatively evenly over all but the highest annual flow deciles, with the largest proportional reduction (13.2 percent) in the lowest flow decile (Figure 3.42-4). Reductions in minimum flows would average about 13 percent, and range as high as 39 percent during the summer months. On the other hand, flow reductions in both monthly 25th percentile and median flows would be much less, averaging 7.5 and 0.9 percent[94], respectively, on an annual basis. Changes of this magnitude in streamflow regime may have some detectable effects on lotic communities, so an evaluation of the potential for these impacts to occur, and their predicted nature, and extent, should be conducted if this alternative is considered further.

Protected species that appear most likely to be encountered during construction of this alternative include the American Bald Eagle, White-faced Ibis, Texas scarlet snake and the Texas horned lizard in forested and upland areas. Potential conflicts with the birds and reptiles should be easily avoidable with appropriate habitat and important species surveys. Cagle's map turtle and the Guadalupe bass may be present in the project area. Potential conflicts should be avoidable by employing appropriate habitat and important species surveys (including instream flow evaluations) and appropriate construction techniques.

A cultural resources survey of all public property, including easements held by public entities, to be disturbed during construction is required by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resources Code of 1977). Any sites located would be tested for

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[93]HDR Engineering, Inc., 1994. Unpublished hydrologic model results. Austin, Texas.

[94]Ibid.

significance and eligibility for the National Register. Disturbance of significant sites should be avoided to the extent possible.

3.42.4 Water Quality and Treatability

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

3.42.5 Engineering and Costing

For this alternative, SAWS return flows would be diverted at a location on the San Antonio River downstream of Goliad and pumped to Coleto Creek Reservoir to provide makeup water for steam-electric cooling needs to replace the run-of-the-river and stored water contracts currently in place for Guadalupe River water. Facilities needed to implement this alternative include:

Small Diversion Structure in the San Antonio River
Surface Water Intake
Pump Station
Transmission Pipeline
Discharge Structure in the Coleto Creek Reservoir

<u>Cost of Purchased Water Under Water Trades</u>

The San Antonio Water System (SAWS) would supply reclaimed water to CP&L to replace to the extent possible the current make-up water sources for Coleto Creek Reservoir. Replacement of CP&L's run-of-the-river diversion right would be compensated for by SAWS making reclaimed water available. Additionally, SAWS would compensate CP&L for the cost of the facilities to provide that water. Because the diversion right would be replaced with other water, no direct payment is anticipated to CP&L for their run-of-the-river water right and SAWS would not be paid by CP&L for providing reclaimed water.

Currently, CP&L holds a contract with GBRA to purchase up to 30,000 acft in any five year period of stored water from Canyon Lake which is equivalent to an annual volume of 6,000 acft. Two alternative approaches could be considered to modify the stored water purchase contract. The contract between CP&L and GBRA could be maintained in force, in which case SAWS would reimburse CP&L for the payments to GBRA and SAWS would then divert the Canyon Lake stored water at Lake Dunlap or Gonzales. Alternatively, the CP&L-GBRA contract could be cancelled and replaced by a contract between SAWS and GBRA, in which case

SAWS would pay GBRA directly for stored water. Under either payment option, the cost to SAWS has been estimated at $320,000 per year which is based on the current cost of Canyon Lake water and this cost is included in the following cost estimate.

Cost of Facilities

The pump station capacity for the new intake located on the San Antonio River is set at 35.65 cfs, matching the capacity of the existing diversion facility on the Guadalupe River supplying makeup water to Coleto Creek Reservoir. The new pipeline to Coleto Creek Reservoir would be 36 inches in diameter and 6.5 miles in length. The operating cost was determined for a static lift of 70 feet and an annual water delivery of 8,400 acft/yr. Financing the project over 25 years at an 8 percent annual interest rate results in an annual cost of $600,000 (Table 3.42-3). Average annual operation and maintenance costs, including power, total $220,000. Compensation for water purchased by SAWS under the CP&L/GBRA Canyon contract is estimated to be $320,000 acft/yr. Total annual costs, including debt repayment, interest, water contract purchase, and operation and maintenance, total $1,140,000. For an annual firm yield of 8,400 acft, the resulting annual cost of makeup water is $136 per acft (Table 3.42-3). The annual cost of this component of the SAWS plan is included as part of the cost of Alternatives G-27 and G-28 (diversions at Lake Dunlap and Gonzales) which include diversions of the Canyon Lake and Guadalupe River water made available under this replacement option.

3.42.6 Implementation Issues

Requirements Specific to Use of Coleto Creek Reservoir:

1. Studies need to be performed to determine if the reduced make-up water supply available from reclaimed water presents a problem for the operation and efficiency of CP&L's generating station and for the operation of GBRA's recreation operations at the reservoir. If additional make-up water supplies are needed, other water is potentially available from: increased SAWS return flows; maintaining a portion of CP&L's contract with GBRA for purchase of stored water; temporary releases of reclaimed water stored in Braunig and/or Calaveras; temporary make-up from groundwater supplies; construction of a larger capacity pump station and pipeline; or some combination of these options.
2. If reservoir levels are decreased, pumping costs at the plant as well as reservoir water temperatures will increase.

Table 3.42-3 Cost Estimate Summaries for Transfer of SAWS Reclaimed Water to Coleto Creek Reservoir (L-20) (Third Quarter - 1994 Prices)	
Item	**Alternate L-25 Costs**
Capital Costs	
Channel Dam, Intake and Pump Station	$1,720,000
Transmission Pipeline and Discharge Structure	2,890,000
Total Capital Cost	$4,610,000
Engineering, Contingencies, and Legal Costs	1,440,000
Land Acquisition	60,000
Environmental Studies and Mitigation	60,000
Interest During Construction	250,000
Total Project Cost	$6,420,000
Annual Costs	
Annual Debt Service	$600,000
Annual Operation and Maintenance	80,000
Annual Power Cost	140,000
Compensation for CP&L-GBRA Canyon Lake Contract	320,000
Total Annual Cost	$1,140,000
Annual Water Delivery (acft/yr)	8,400
Annual Cost of Water	$136 per acft

3. Contract between CP&L and GBRA for delivery of Canyon Lake water would be either:
    a. maintained in force and SAWS would reimburse CP&L for use of the stored water; or,
    b. cancelled and SAWS would negotiate a purchase contract for stored water with GBRA.
4. CP&L's run-of-the-river diversion permit on the Guadalupe River would be either abandoned or transferred allowing SAWS to pursue permits for diversion of the water at either Lake Dunlap or Gonzales.
5. Studies should be performed of water quality issues (i.e. nutrient and dissolved solids loadings and possibly others) for use of San Antonio return flows as makeup up water at Coleto Creek Reservoir.

Requirements Specific to River Diversion and Transmission Pipeline:

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 permit for river crossings.
   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 Obtaining Permit to Divert Return Flows:

1. Necessary permits:
   a. Bed-and-Banks transfer permit from TNRCC

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APPENDIX E

SUMMARY TABLES OF POTENTIAL WATER SUPPLY ALTERNATIVES

TABLE ES-11
SUMMARY OF POTENTIAL WATER SUPPLY ALTERNATIVES FOR THE
TRANS-TEXAS WATER PROGRAM WEST CENTRAL STUDY AREA - VOLUME 3

Alternative		Firm Water Supply[1] (Acft/Yr)	Unit Cost of Additional Water (1994 Dollars) ($/Acft/Yr)					Environmental Issues/Special Concerns
			Natural Recharge	Imported Recharge		Treatment & Municipal Distribution	Other	
				Without Treatment	With Treatment			
	GBRA REGIONAL WATER SUPPLY PLANS							
G-23	Canyon Lake Area Water Supply							(a) Projected year 2050 water demand. (b) Cost for delivery of wholesale water supply for year 2020 demands.
A	Areas Adjacent to Canyon Lake	5,441 (a)				$995 (b)[2]		
B	Smithson Valley, Bulverde, and Oak Village North Areas	2,095 (a)				$1,467 (b)[2]		
G-24	Wimberley and Woodcreek Water Supply from Canyon Lake	2,424 (a)				$950 (b)[2]		(a) Projected year 2050 water demand. (b) Cost of wholesale delivery to Wimberley/Woodcreek combined with Canyon Lake Regional system (Alt. G-23A) for year 2020 demands.
G-25	Northeast Hays and Northwest Caldwell Counties Water Supply from Near Lake Dunlap	4,310 (a)				$1,204 (b)[2]		(a) Projected year 2050 water shortage. (b) Cost for delivery of wholesale water supply for year 2020 demands.
G-26	Mid-Cities (IH-35 and Highway 78) Water Supply from Near Lake Dunlap	24,294 (a) 16,757 (b) 41,051				$477 (c)[2]		(a) Comal/Guadalupe Co. area projected year 2050 water shortage. (b) Northeast Bexar Co. area projected year 2050 water shortage. (c) Cost for delivery of wholesale water supply for year 2020 demands.

(1) WATER SUPPLY VALUES FOR EACH ALTERNATIVE ARE ON A STAND-ALONE BASIS AND CANNOT BE ADDED TO OTHER ALTERNATIVES IN THEIR PRESENT FORM.

(2) Costs for supply systems in the GBRA planning areas, which have capacity to meet peak demands, are typically higher when compared to alternatives in Volume 2, which are mostly larger projects with uniform annual delivery rates.

Note: Alternatives are classified into four categories: Natural Recharge is recharge to the aquifer with water originating from the Edwards Plateau catchment, recharge zone, or from springs originating from the Edwards. Natural recharge to the aquifer can be accomplished through an injection well or recharge zone. Imported Recharge is recharge to the aquifer with all or a portion of the water originating from sources other than those listed under Natural Recharge, regardless of the delivery system into the aquifer. Treatment and Distribution considers alternatives which would include conventional water treatment, or just disinfection in the case of Carrizo water. Distribution costs will be based on costs as estimated in previous studies for delivery to the SAWS system. Other use includes demand reduction by conservation, reclaimed water reuse, transfer of water through purchase or lease, and treatment of brackish water by demineralization.

TABLE ES-11 (continued)
SUMMARY OF POTENTIAL WATER SUPPLY ALTERNATIVES FOR THE
TRANS-TEXAS WATER PROGRAM WEST CENTRAL STUDY AREA - VOLUME 3

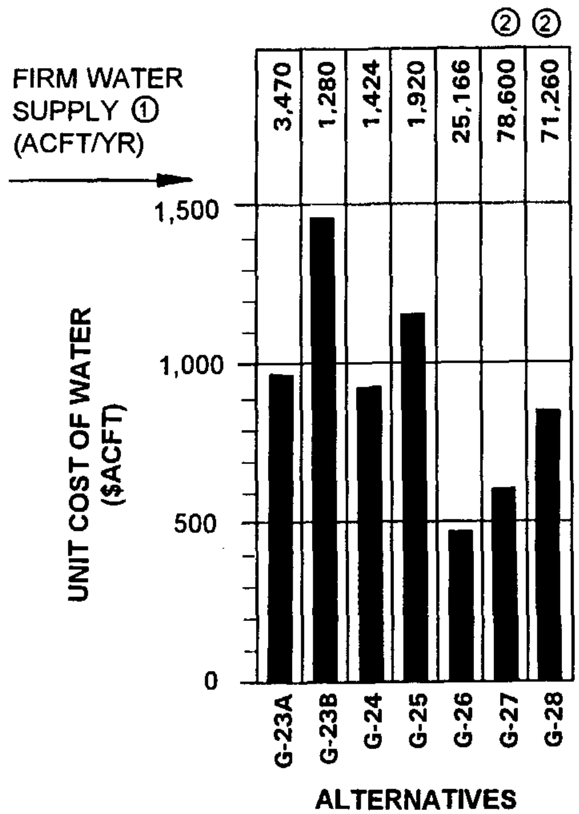
Alternative		Firm Water Supply[1] (Acft/Yr)	Unit Cost of Additional Water (1994 Dollars) ($/Acft/Yr)					Environmental Issues/Special Concerns
			Natural Recharge	Imported Recharge		Treatment & Municipal Distribution	Other	
				Without Treatment	With Treatment			
G-27	Guadalupe River Diversion Near Lake Dunlap with Transfer of Downstream Rights	78,600 (a) 49,785 (b)				$581 (a) $739 (b)		(a) Includes cost of SAWS reclaimed water for Coleto Creek makeup. Instream environmental criteria not applied. (b) Includes cost of SAWS reclaimed water for Coleto Creek makeup. Instream environmental criteria applied.
G-28	Guadalupe River Diversion Near Gonzales with Transfer of Downstream Rights	71,260(a)				$817		(a) Includes cost of SAWS reclaimed water for Coleto Creek makeup. Instream environmental criteria not applied.
L-20	Use of SAWS Reclaimed Water to Replace Potential Water Transfer	8,400	Costs are included in Alternatives G-27 and G-28 (Guadalupe River Diversions with Water Rights Transfer)					

(1) WATER SUPPLY VALUES FOR EACH ALTERNATIVE ARE ON A STAND-ALONE BASIS AND CANNOT BE ADDED TO OTHER ALTERNATIVES IN THEIR PRESENT FORM.

(2) Costs for supply systems in the GBRA planning areas, which have capacity to meet peak demands, are typically higher when compared to alternatives in Volume 2, which are mostly larger projects with uniform annual delivery rates.

Note: Alternatives are classified into four categories: Natural Recharge is recharge to the aquifer with water originating from the Edwards Plateau catchment, recharge zone, or from springs originating from the Edwards. Natural recharge to the aquifer can be accomplished through an injection well or recharge zone. Imported Recharge is recharge to the aquifer with all or a portion of the water originating from sources other than those listed under Natural Recharge, regardless of the delivery system into the aquifer. Treatment and Distribution considers alternatives which would include conventional water treatment, or just disinfection in the case of Carrizo water. Distribution costs will be based on costs as estimated in previous studies for delivery to the SAWS system. Other use includes demand reduction by conservation, reclaimed water reuse, transfer of water through purchase or lease, and treatment of brackish water by demineralization.

TREATMENT AND DISTRIBUTION ALTERNATIVES IN VOLUME 3



NOTES:

- FOR DESCRIPTION OF EACH ALTERNATIVE SEE TABLE ES-11.

① WATER SUPPLY VALUES FOR EACH ALTERNATIVE ARE ON A STAND ALONE BASIS AND CANNOT, IN MANY CASES, BE ADDED TO OTHER ALTERNATIVES IN THEIR PRESENT FORM.

② REPRESENTS WATER AVAILABILITY FROM SEVERAL SOURCES.

NOTE:

ALTERNATIVES G-23, G-24, G-25 AND G-26 (ALTERNATIVE SUPPLIES FOR GBRA PLANNING AREAS) ARE COSTS OF TREATED WATER DELIVERED ON A WHOLESALE BASIS AND DO NOT INCLUDE THE OPERATING COSTS OF THE DISTRIBUTION SYSTEM. THE ALTERNATIVES INCLUDE COSTS TO MEET PEAK DEMANDS AND ARE TYPICALLY HIGHER COMPARED TO ALTERNATIVES IN VOLUME 2, WHICH ARE MOSTLY LARGER PROJECTS WITH UNIFORM ANNUAL DELIVERY RATES.

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SUMMARY OF UNIT COSTS AND FIRM WATER SUPPLY FOR TREATMENT AND DISTRIBUTION ALTERNATIVES IN VOLUME 3

FIGURE ES - 12A

APPENDIX F

SAWS PROPOSED WATER RESOURCE PLAN

Appendix F
San Antonio Water System
Proposed Water Resource Plan

In April, 1994, the San Antonio Water System proposed a regional water resources plan[1] (SAWS plan) as a framework from which to reduce the City's dependence on the Edwards Aquifer. The plan was formulated on five key items affecting the City's water supply and demand. Those key items are:

- Conservation
- Reuse of Reclaimed Water
- Lease of Irrigation Water Rights
- Acquisition of Guadalupe River Water by Trading Reclaimed Water
- Enhanced Recharge of the Aquifer

The SAWS plan involves several interrelated elements which could affect the availability and movement of water in both the Edwards Aquifer and throughout the Guadalupe - San Antonio River Basin. The San Antonio River Authority and the Guadalupe-Blanco River Authority joined with SAWS in requesting an engineering and environmental evaluation of portions of the plan at the same reconnaissance level as other Phase I alternatives. The following is an overview of some of the key elements of the plan.

Aquifer Demand Management

A key component of the plan is an Edwards Aquifer demand management plan that, if implemented, would reduce both annual and seasonal peak pumpage resulting in increases in springflows. The SAWS plan assumes that Senate Bill 1477[2] (or an equivalent bill) will eventually be put in place, thereby regulating Edwards Aquifer water production through wells which would contribute toward increasing springflows. The SAWS plan proposes a coordinated program of reducing per capita water use through water conservation, reduction in demand for aquifer water by substituting reclaimed water for some uses, and leasing of irrigation rights.

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[1]Proposed Water Resource Plan prepared by the San Antonio Water System and presented to the San Antonio Mayor's 2050 Water Resources Committee, April 27, 1994.

[2]Senate Bill 1477, 1993 Texas Legislature, creating the Edwards Aquifer Authority with jurisdiction to regulate aquifer usage in Uvalde, Medina, Bexar counties, and parts of Atascosa, Comal, Guadalupe, Hays, and Caldwell counties. At the time of this report the creation of the Edwards Aquifer Authority is still in question as various legal issues regarding its creation are unresolved.

Reclaimed water use would be implemented throughout the year to reduce base loads, while demands during periods of reduced springflows would be reduced by stringent conservation practices. Water demands would be controlled through a regional authority regulating groundwater pumpage for municipal and irrigation use such as envisioned in SB 1477.

By implementing the aquifer management elements of the SAWS plan, it has been estimated that total aquifer pumpage could be reduced to 368,000 acft/yr, which is eight percent below the year 2008 limit of 400,000 acft/yr contained in SB 1477. Table F-1 contains a possible allocation of aquifer pumpage among the major aquifer users for a total annual pumpage of 400,000 acft/yr as allowed by SB 1477 based on percentages of uses as occurred in 1989. The distribution shown in Table F-1 for total aquifer pumpage was used in the Phase 1 studies.

Table F-2 contains the SAWS alternative aquifer pumping scenario with a total annual pumpage of about 368,000 acft/yr. The SAWS pumpage scenario has been used in the Phase 1 analyses to estimate total aquifer pumpage and is frequently referred to as the "SAWS 368,000 acft/yr aquifer pumpage scenario" or "SAWS aquifer pumpage scenario." Changes under this plan (as compared to the 400,000 acft/yr baseline scenario) included an increase in SAWS proposed annual pumpage from 139,165 acft/yr to 157,320 acft/yr an increase of 18,155 acft/yr (13 percent) with a corresponding leveling of SAWS monthly demands so that SAWS summer demands are reduced by as much as 15 percent or 2,392 acft/month in August. (Note: Historically, SAWS peak annual pumpage was 176,600 acft (1989) with a peak monthly pumpage of 18,622 acft.) The higher SAWS annual pumpage under their 368,000 acft/yr plan is more than offset by SAWS leasing of irrigation pumpage rights totalling 50,000 acft/yr (i.e., 20,000 acft/yr in Uvalde County and 30,000 acft/yr in Medina County). Additionally, the SAWS plan includes the construction of four new recharge structures in the Nueces River Basin which would increase average annual recharge to the aquifer by about 45,000 acft/yr and average drought recharge by about 9,000 acft/yr (see Table F-3). Annual water use by other aquifer users was assumed to remain constant at 120,405 acft/yr in both pumpage scenarios. Figure F-1 shows a comparison of total monthly aquifer pumpage for the 400,000 acft/yr scenario and the 368,000 acft/yr scenario with stacked bars for each type of water use.

Table F-1
EDWARDS AQUIFER BASELINE PUMPAGE SCENARIO - 400,000 ACFT/YR

MONTH	SAWS PUMPAGE	UVALDE CO. IRRIGATORS	MEDINA CO. IRRIGATORS	TOTAL IRRIGATORS	OTHERS	TOTAL AQUIFER PUMPAGE
JAN	8515	3758	1859	5617	8262	22394
FEB	7567	1880	929	2809	7901	18277
MAR	9702	7516	2789	10305	9041	29048
APR	11118	6577	3254	9831	9585	30534
MAY	13297	5637	4647	10284	10700	34281
JUN	12689	14092	6971	21063	11196	44948
JUL	15360	17850	6506	24356	12421	52137
AUG	15731	14092	8366	22458	12527	50716
SEP	13492	10334	5112	15446	11411	40349
OCT	12101	7516	3718	11234	10217	33552
NOV	9398	2818	1394	4212	8359	21969
DEC	10195	1880	929	2809	8785	21789
TOTAL	139165	93950	46474	140424	120405	399994

Table F-2
SAWS ALTERNATIVE
EDWARDS AQUIFER PUMPAGE SCENARIO - 368,000 ACFT/YR

MONTH	SAWS PUMPAGE	UVALDE CO. IRRIGATORS	MEDINA CO. IRRIGATORS	TOTAL IRRIGATORS	OTHERS	TOTAL AQUIFER PUMPAGE
JAN	12928	2958	659	3617	8262	24807
FEB	11550	1479	329	1808	7901	21259
MAR	13339	5916	989	6905	9041	29285
APR	13202	5176	1154	6330	9585	29117
MAY	13339	4437	1647	6084	10700	30123
JUN	13202	11092	2471	13563	11196	37961
JUL	13339	14050	2306	16356	12421	42116
AUG	13339	11092	2966	14058	12527	39924
SEP	13202	8134	1812	9946	11411	34559
OCT	13339	5916	1318	7234	10217	30790
NOV	13202	2218	494	2712	8359	24273
DEC	13339	1479	329	1808	8785	23932
TOTAL	157320	73947	16474	90421	120405	368146

Table F-3 Summary of Recharge Enhancement Projects							
				Average Conditions		Drought Conditions	
Recharge Project	Capacity (acft)	Surface Area (ac)	Annual Cost ($)	Recharge Enhancement (acft/yr)	Cost/Unit Recharge Enhancement ($/acft/yr)	Recharge Enhancement (acft/yr)	Cost/Unit Recharge Enhancement ($/acft/yr)
Lower Sabinal	8,750	454	1,335,379	16,442	81	2,358	566
Lower Verde	3,600	334	590,084	4,850	122	1,719	343
Lower Hondo	2,800	232	1,218,701	6,779	180	1,193	1,022
Lower Frio	17,500	1,099	3,258,211	17,064	191	3,980	819
Total	32,650	2,119	6,402,375	45,135		9,250	
Average					142		692

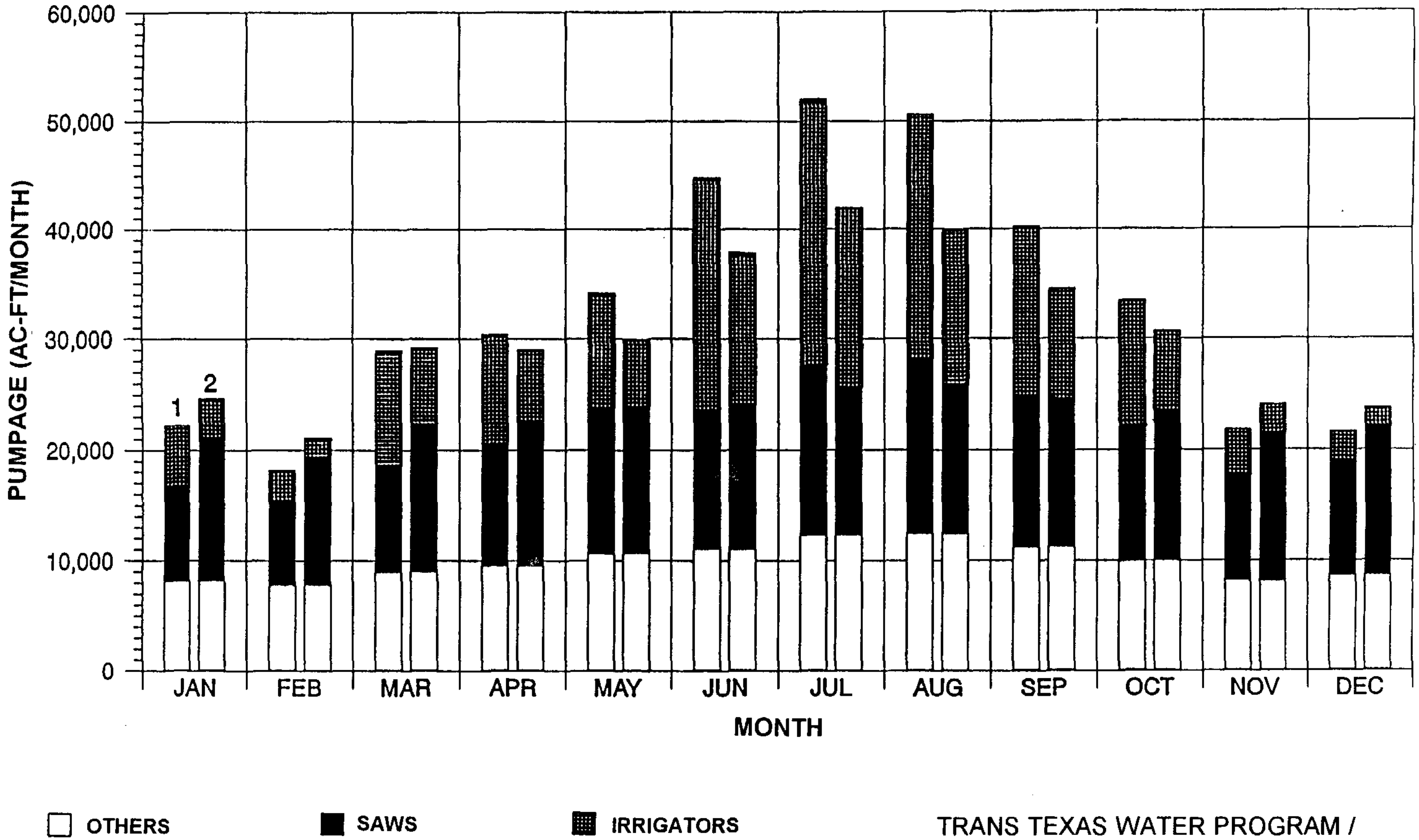
*Program includes projects with a Cost/Unit Recharge Enhancement for Average Conditions less than $192/acft/yr ($0.59/1,000 gallons).

Springflow

The SAWS aquifer pumpage scenario was incorporated into the TWDB Edwards Aquifer Model to obtain estimates of springflow at Comal, San Marcos, and other springs. The results of the simulated springflows from the TWDB Edwards Aquifer Model for all pumpage scenarios were adjusted to account for the difference in the model's simulated historical springflows and observed springflows. Compared to the 400,000 acft/yr pumpage scenario, Comal springflows would increase by an average of about 46 cfs over the entire 1934-89 period simulated and about 29 cfs during the 1947-56 drought period. Figure F-2 compares simulated Comal springflow during the 1947-56 critical drought period for the 400,000 acft/yr aquifer pumpage scenario and SAWS plan pumpage of 368,000 acft/yr. Figure F-3 shows the average monthly increase in Comal springflow resulting from the decrease in aquifer pumpage from the 400,000 acft/yr scenario to the 368,000 acft/yr scenario plotted at the same scale as Figure F-1. Figure F-4 presents estimated San Marcos springflow for the 400,000 acft/yr aquifer pumpage scenario and SAWS plan pumpage of 368,000 acft/yr.

Water Trades

The aquifer demand management plan proposed by SAWS places a uniform monthly pumping load on the aquifer for municipal use that requires peak municipal water demands to be met from other sources. To meet the peak demands, the SAWS plan would divert surface water from the Guadalupe River possibly near Lake Dunlap or Gonzales. Water potentially available from several sources would be diverted throughout the year but mostly during summer peak demand months for delivery to the San Antonio area. The water potentially available includes possible run-of-the-river water and stored water transfers from the Central Power & Light Coleto Creek electric generating station, from GBRA water rights associated with the Calhoun Canal Division, and stored water from Canyon Lake. To mitigate for the water rights transferred from the Coleto Creek project and potentially the Calhoun Canal, the SAWS plan proposes to transfer San Antonio reclaimed water down the San Antonio River to Goliad and then divert it to Coleto Creek Reservoir as make-up water for cooling purposes. (Note: In the SAWS Proposed Water Resource Plan, the Applewhite Reservoir was originally part of a storage and delivery system to utilize reclaimed water and would have increased the quantity of firm water available to potential downstream users. However, after the failure of the Applewhite referendum in August, 1994, Applewhite Reservoir was removed from further study.) In the Phase 1 analyses for this Volume 3 report (which were performed after the failure of the Applewhite referendum), reuse of reclaimed water within the Bexar County area was limited to 18,000 acft/yr for the tunnel reuse project, and to requirements for make-up water at Braunig and Calaveras Reservoirs.



1 - Monthly demands for 400,000 ac-ft/year baseline demand
2 - Monthly demands for 368,000 ac-ft/year demand based on SAWS plan)

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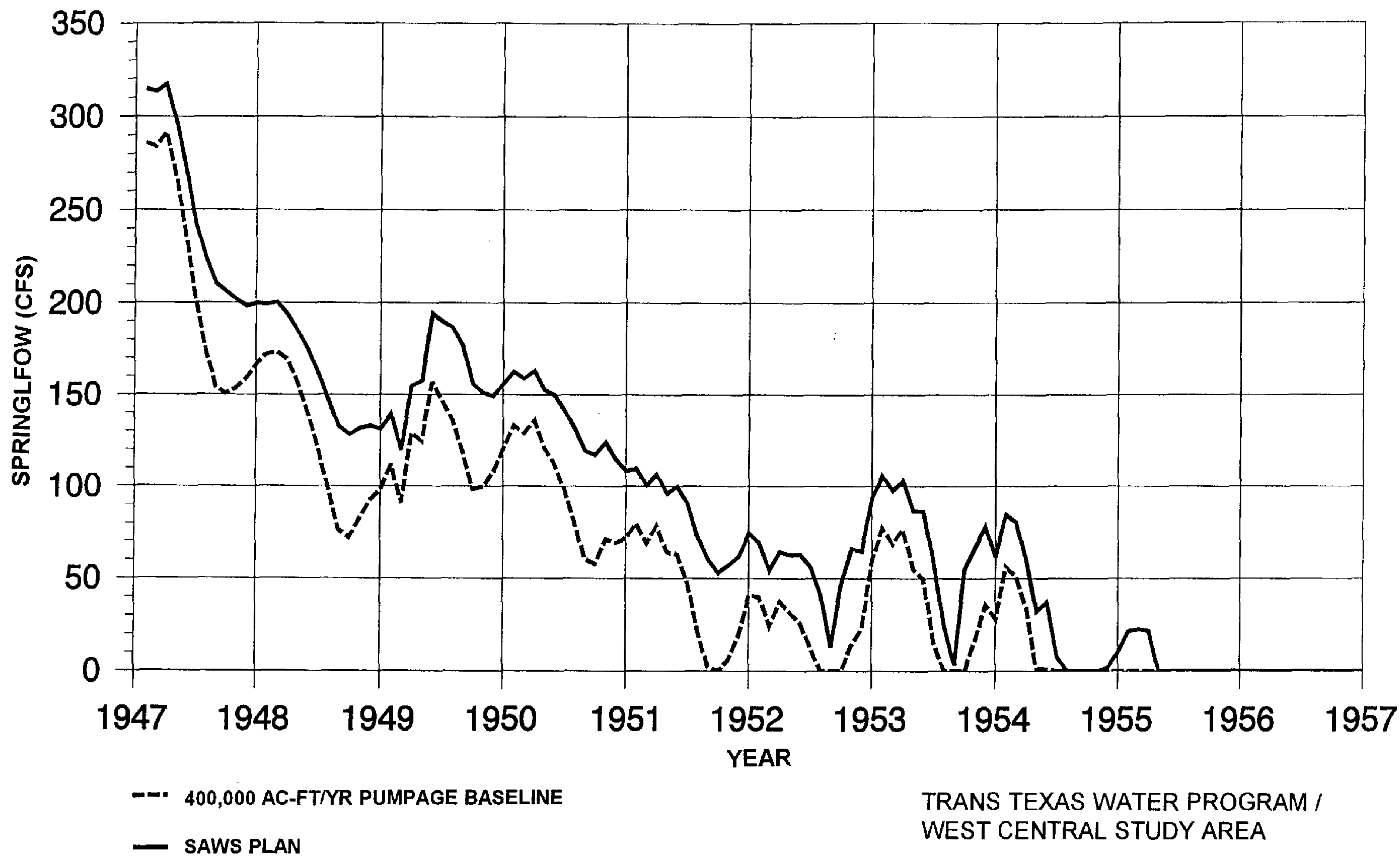
COMPARISON OF EDWARDS AQUIFER PUMPAGE PLANS - ALL USES

FIGURE F-1



NOTE:

THE RESULTS OF THE SIMULATED SPRINGFLOWS FROM THE TWDB EDWARDS AQUIFER MODEL WERE ADJUSTED TO ACCOUNT FOR THE DIFFERENCE IN THE MODEL'S SIMULATED HISTORICAL SPRINGFLOWS AND OBSERVED SPRINGFLOWS.

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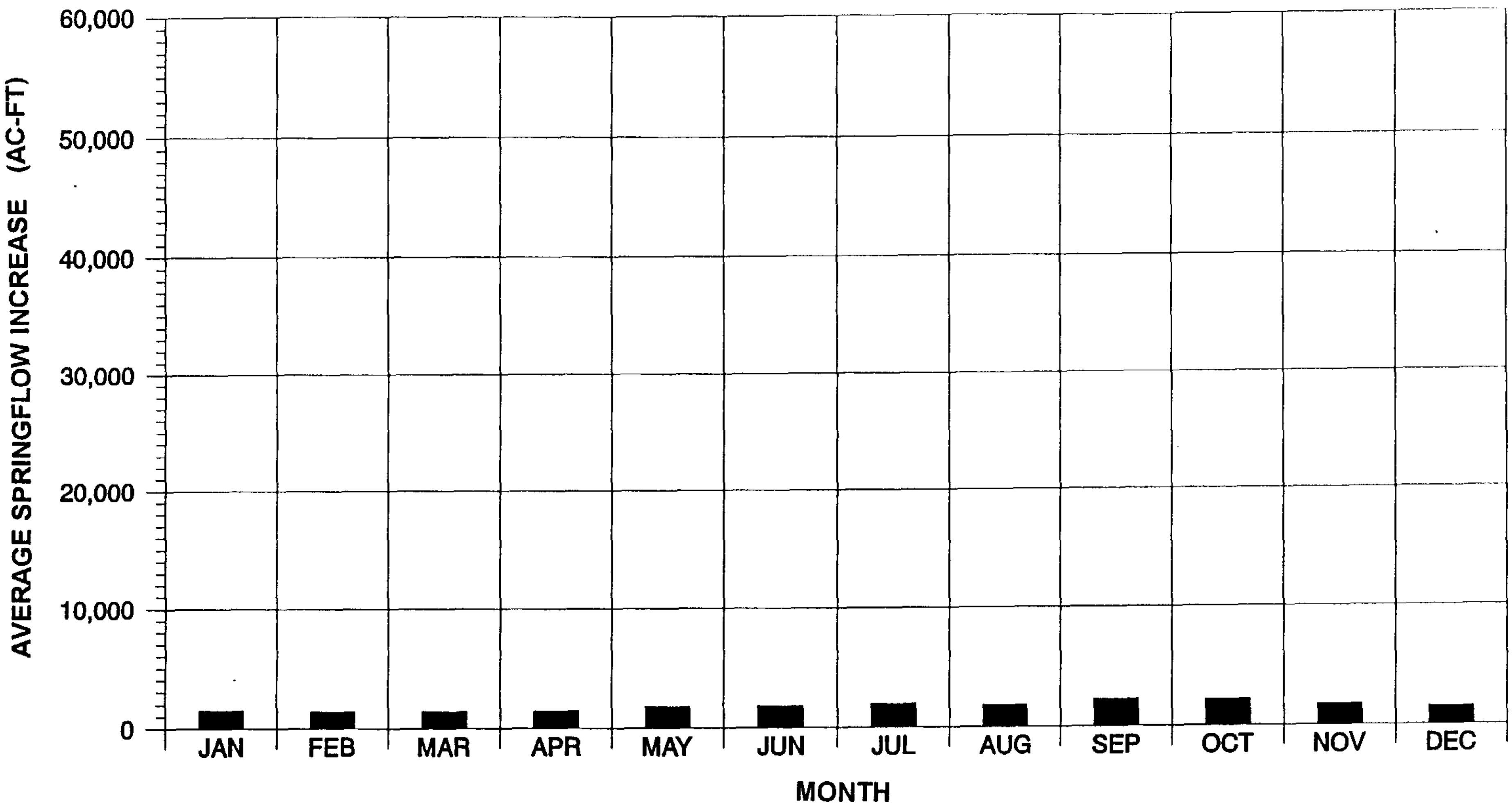
COMAL SPRINGFLOW COMPARISON FOR ALTERNATE PUMPAGE PLANS

FIGURE F-2



SAWS Plan vs. 400,000 ac-ft/yr pumpage baseline
averages based on 1947-56 period.

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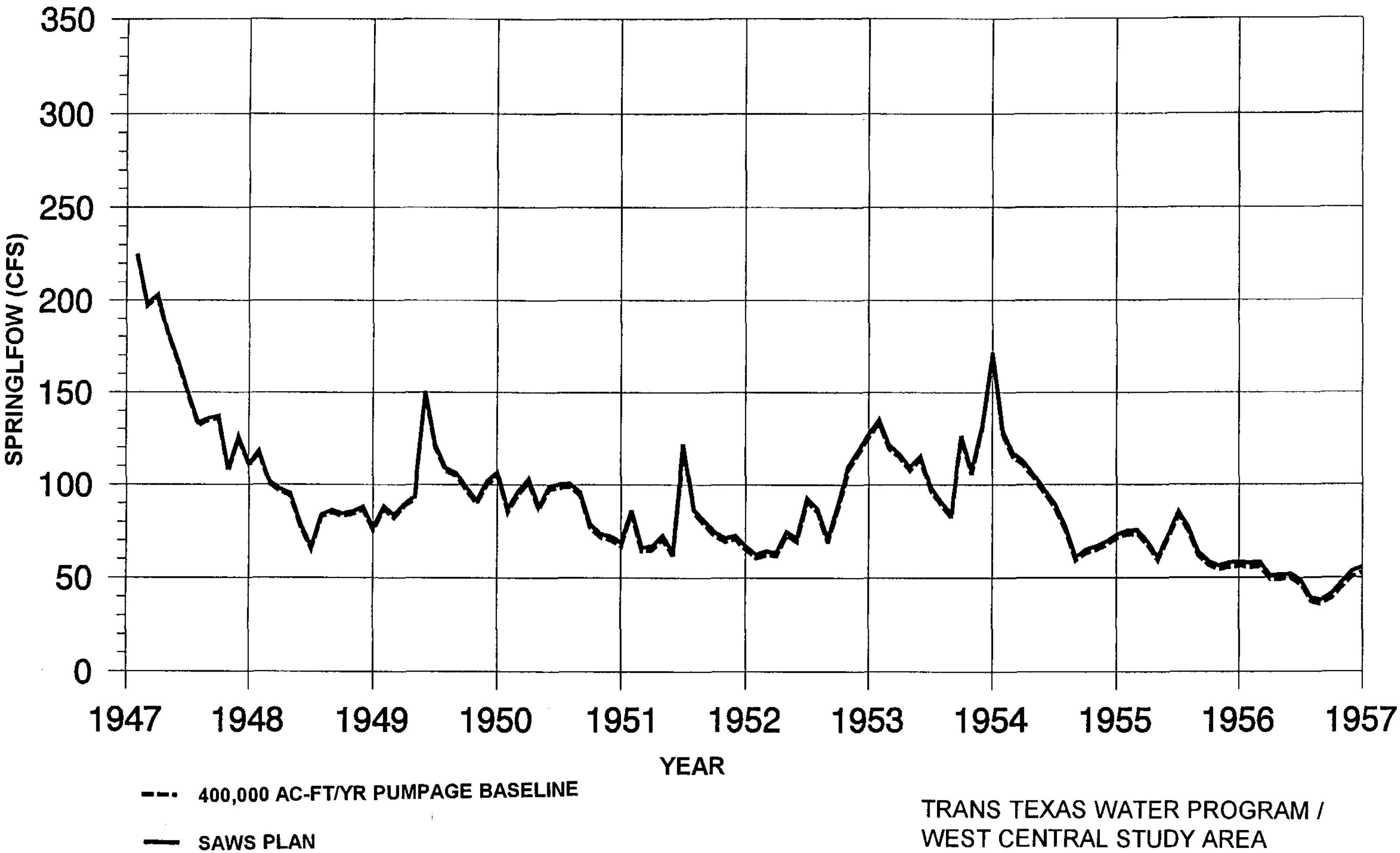
INCREASES IN COMAL SPRINGFLOW WITH SAWS PLAN

FIGURE F-3



NOTE:

THE RESULTS OF THE SIMULATED SPRINGFLOWS FROM THE TWDB EDWARDS AQUIFER MODEL WERE ADJUSTED TO ACCOUNT FOR THE DIFFERENCE IN THE MODEL'S SIMULATED HISTORICAL SPRINGFLOWS AND OBSERVED SPRINGFLOWS.

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SAN MARCOS SPRINGFLOW COMPARISON FOR ALTERNATE PUMPAGE PLANS

FIGURE F-4

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APPENDIX G

CANYON LAKE FIRM YIELD

Appendix G

Canyon Lake Firm Yield

Introduction

The calculation of the firm yield of Canyon Lake is a complex function of many interrelated factors and assumptions including hydropower subordination, Edwards Aquifer pumpage and resultant springflow, reservoir operation policy, point(s) of diversion, and channel losses incurred in delivery of water for a variety of types of use. All of these factors are in addition to the basic, highly variable hydrologic factors of inflow and net evaporation. The firm yield of Canyon Lake is dependent on senior water right requirements and streamflows below the lake which requires the use of a model with the capability to simulate basin-wide conditions. The Guadalupe - San Antonio River Basin Model[1] (GSA Model), which has the capability to simulate basin-wide streamflow conditions, was modified and utilized to compute the firm yield of Canyon Lake.

Guadalupe - San Antonio River Basin Model

The GSA Model was originally created as part of a study to evaluate Edwards Aquifer recharge and the potential for recharge enhancement projects in the Guadalupe - San Antonio River Basin. The primary objective of the original model was to determine water available for new recharge enhancement projects which would be junior in priority to all other existing water rights in the basin. The original model had the capability to simulate existing reservoirs in the river basin, including Canyon Lake, and to simulate streamflow conditions for various Edwards Aquifer pumpage and resultant springflow scenarios. The GSA Model employs a monthly time step proceeding with flow calculations in an upstream to downstream order simulating recharge, channel losses, water rights, return flows, and reservoir operations. Changes in upstream flow from the natural flow at each

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1 HDR Engineering, Inc., "Guadalupe - San Antonio River Basin Recharge Enhancement Study," Volumes I, II, and III, Edwards Underground Water District, September, 1993.

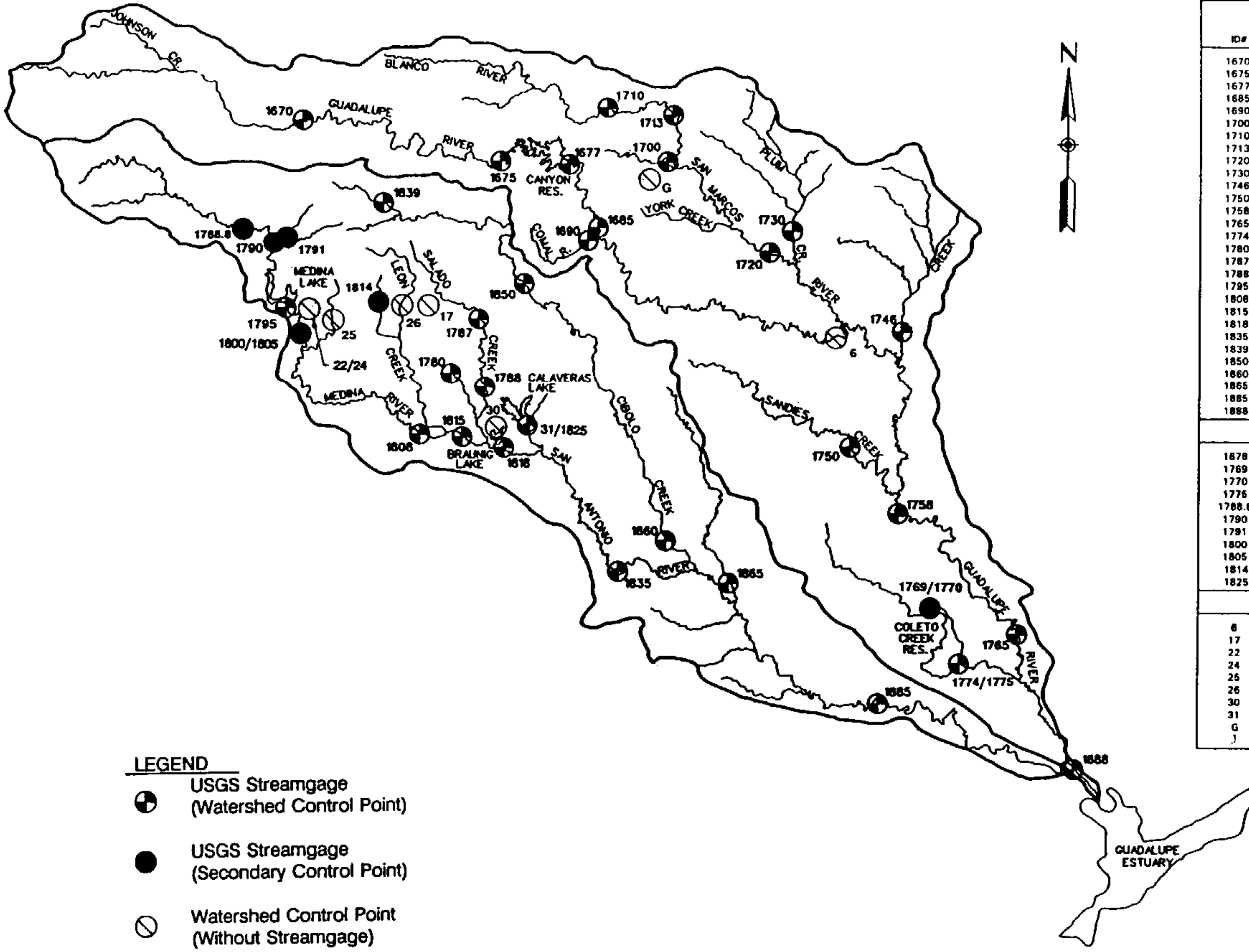
model control point are translated to the next downstream control point using delivery equations specified for each stream segment. Calculations are performed at each of the 38 watershed control points located throughout the river basin as shown in Figure G-1 beginning in the headwaters of the Guadalupe River near Comfort (ID# 1670), continuing downstream to Victoria (ID# 1765), moving to the headwaters of the San Antonio River Basin near Medina Lake (ID# 1795), continuing downstream to Goliad (ID# 1885), and finally combining flows from both the Guadalupe and San Antonio Rivers at the Saltwater Barrier near Tivoli (ID# 1888). These control points were generally established at streamflow gaging stations, existing reservoirs, and other locations near the downstream limits of the Edwards Aquifer recharge zone.

One of the most complicated aspects of GSA Model development was the determination of operational releases (inflow passage and/or releases from storage) at Canyon Lake necessary to satisfy senior water rights, contractual obligations, hydropower requirements, and Federal Energy Regulatory Commission (FERC) guidelines. There are five primary steps the model executes in order to determine monthly operational releases for Canyon Lake.

Step 1: The first step is the calculation of required inflow passage or release for senior water rights (non-yield release). The release for senior water rights is limited to a maximum of the inflow to Canyon Lake.

Step 2: Once the non-yield release is determined, the model computes the yield release. The yield release may include both inflows and storage and represents the quantity of water which would have to be released to satisfy contractual obligations in full (with the exception of CP&L at Coleto Creek Reservoir which is delivered only as needed) and senior water rights to the extent they could be satisfied with the non-yield release. It is assumed that releases for contractual obligations must be sufficient to deliver full contracted amounts to the points of diversion so that any losses in delivery are included as part of the firm yield at Canyon Lake.

Step 3: The third step in the modeling of Canyon Lake operations is the calculation of inflow passage necessary to comply with FERC Guidelines. These guidelines specify instream flow minima of 100 cfs (June-January) and 120 cfs (February-May) to be maintained in non-drought conditions to the extent inflows, as measured at the USGS streamflow gage located near Spring Branch (ID# 1675), are available. In the event of 45 consecutive days of



ID#	STREAM NAME, LOCATION	DRAINAGE AREA (SQ.MI.)	PERIOD OF RECORD
STREAMGAGES USED AS WATERSHED CONTROL POINTS			
1670	GUADALUPE R., COMFORT	839	6/39 12/89
1675	GUADALUPE R., SPRING BRANCH	1315	7/22-12/89
1677	CANYON LAKE	1432	7/62 12/89
1685	GUADALUPE R., ABOVE COMAL R.	1518	1/28-12/89
1690	COMAL R., NEW BRAUNFELS	130	1/28-12/89
1700	SAN MARCOS SPR., SAN MARCOS	N/A	6/56-12/89
1710	BLANCO R., WIMBERLEY	355	7/28-12/89
1713	BLANCO R., KYLE	412	6/56-12/89
1720	SAN MARCOS R., LULING	838	5/39-12/89
1730	PLUM C., LULING	309	4/30-12/89
1746	PEACH C., DILWORTH	460	8/59-9/79
1750	SANDIES C., WESTHOFF	549	8/59-12/89
1758	GUADALUPE R., CUERO	4934	9/20-11/35, 1/64-12/89
1765	GUADALUPE R., VICTORIA	5198	12/34-12/89
1774	COLETO CREEK RESERVOIR	494	2/80-12/89
1780	SAN ANTONIO R., SAN ANTONIO	41.8	3/39-12/89
1787	SALADO C., SAN ANTONIO, UPPER	137	10/60-12/89
1788	SALADO C., SAN ANTONIO, LOWER	189	10/60-12/89
1795	MEDINA LAKE	634	4/13-12/89
1808	MEDINA R., SOMERSET	967	10/70-12/89
1815	MEDINA R., SAN ANTONIO	1317	8/39-12/89
1818	SAN ANTONIO R., ELMENDORF	1743	10/62-12/89
1835	SAN ANTONIO R., FALLS CITY	2113	5/25-12/89
1839	CIBOLO C., BOERNE	68.4	3/62-12/89
1850	CIBOLO C., SELMA	274	4/46-12/89
1860	CIBOLO C., FALLS CITY	827	10/30-12/89
1865	ECLETO C., RUNGE	239	4/62-12/89
1885	SAN ANTONIO R., GOLIAD	3921	3/39-12/89
1888	GUADALUPE R., TIVOLI	10128	9/65-12/89
STREAMGAGES USED AS SECONDARY CONTROL POINTS			
1678	GUADALUPE R., SATTLER	1436	3/60-12/89
1769	COLETO C., SCHROEDER	357	10/78-12/89
1770	COLETO C., SCHROEDER	369	10/52-9/79
1776	COLETO C., VICTORIA	514	7/39-9/54, 6/78-12/89
1788.8	MEDINA R., BANDERA	427	10/82-12/89
1790	MEDINA R., PIPE CREEK	474	10/22-6/36, 10/62-9/82
1791	RED BLUFF C., PIPE CREEK	56.3	4/66-11/81
1800	MEDINA CANAL	N/A	4/22-4/34, 7/57-12/89
1805	MEDINA R., RIOMEDINA	650	2/53-9/73
1814	HELOTES C., HELOTES	16	6/66-12/89
1825	CALAVERAS C., ELMENDORF	77.2	10/54-9/71
WATERSHED CONTROL POINTS WITHOUT STREAMGAGES			
6	LAKE WOOD (H-6)	2103	1/80-12/89
17	OLMOS C., EDWARDS	8.3	N/A
22	DIVERSION LAKE SUBWATERSHED	15.6	N/A
24	DEEP C., EDWARDS	13.1	N/A
25	SAN GERONIMO C., EDWARDS	68.3	N/A
26	LEON C., EDWARDS	99.7	N/A
30	BRAUNIG LAKE	9.4	2/63-12/89
31	CALAVERAS LAKE	65.0	1/71-12/89
G	SINK, PURGATORY, YORK, AND ALLIGATOR CREEKS	94.0	N/A

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WATERSHED CONTROL POINT AND STREAMGAGE LOCATION MAP

FIGURE G-1

inflow less than 90 cfs, drought conditions apply and the instream flow requirement below Canyon Lake is reduced to passage of inflows up to 90 cfs until the reservoir level exceeds 909.0 ft-msl.

Step 4: The fourth step in the modeling of Canyon Lake operations is calculation of inflow passage for hydropower generation (hydro release). The GSA Model determines the Canyon Lake inflow passage necessary to maintain a specific flowrate at Lake Dunlap. Flows at Lake Dunlap are based on the sum of the monthly flows at control points on the Guadalupe and Comal Rivers near New Braunfels. No releases from Canyon Lake storage are made strictly for the purposes of hydropower generation.

Step 5: Ultimately, the maximum of the yield, FERC, and hydro release is selected as the monthly operational release from Canyon Lake and flows are simulated at all control points throughout the river basin.

The original GSA Model was adequate for computing water potentially available for recharge enhancement or other purposes using the monthly time step. However, for computing Canyon Lake firm yield, the monthly time step employed by the model did not adequately represent the daily variation of Canyon Lake operational releases. Therefore, a daily analysis of Canyon Lake inflows, specifically as they pertain to hydropower and FERC requirements, was necessary in order to obtain an accurate assessment of Canyon Lake operational releases.

GSA Model Enhancements and Assumptions

A series of enhancements were introduced into the GSA Model in order to more accurately define the operational releases for Canyon Lake. These enhancements included:

- A revision to Canyon Lake inflow in September, 1952 to reflect the special circumstances related to one significant storm event.
- A daily analysis of Canyon Lake inflows using historical daily gaged flows at Spring Branch for determining inflow passage requirements for hydropower and FERC requirements.
- The capability to specify the diversion of Canyon Lake firm yield at any control point downstream of Canyon Lake.

- An iterative solution process for calculating the Canyon Lake firm yield.

- A revision to the makeup diversion simulation for Coleto Creek Reservoir to include special provisions included in the CP&L run-of-the-river water right and Canyon Lake contract.

- Updated existing Canyon Lake contracts and water rights in the Guadalupe - San Antonio River Basin.

The monthly inflow to Canyon Lake in September, 1952 was revised in the GSA Model to reflect the special circumstances surrounding this major storm event. The accuracy of defining this event is particularly important because of its occurrence during the critical drought and because of its direct effect on the firm yield of Canyon Lake. Estimates of Canyon Lake inflow prior to July, 1962 were based on a regression equation using flows for the Guadalupe River at Spring Branch (ID# 1675) and potential intervening runoff between Spring Branch and Canyon Dam as independent variables. The coefficient of determination for this regression equation which was based on actual Canyon Lake inflow computed by mass balance for the July, 1962 through December, 1989 period is 0.99 indicating that 99 percent of the variation in Canyon Lake inflow can be explained by the equation. It was discovered, however, that the regression equation provided a less than adequate estimate of Canyon Lake inflow for the flood event which occurred in September, 1952 due, in large part, to the concentration of unusually intense precipitation downstream of the Spring Branch gage. An alternative method which incorporated measured runoff between Spring Branch and New Braunfels as well as differences in areal precipitation and soil cover complex above and below Canyon Dam was utilized to compute the revised Canyon Lake inflow for this month. The revised Canyon Lake natural inflow for September, 1952 is 163,596 acft and is approximately 30,000 acft greater than the original estimate.

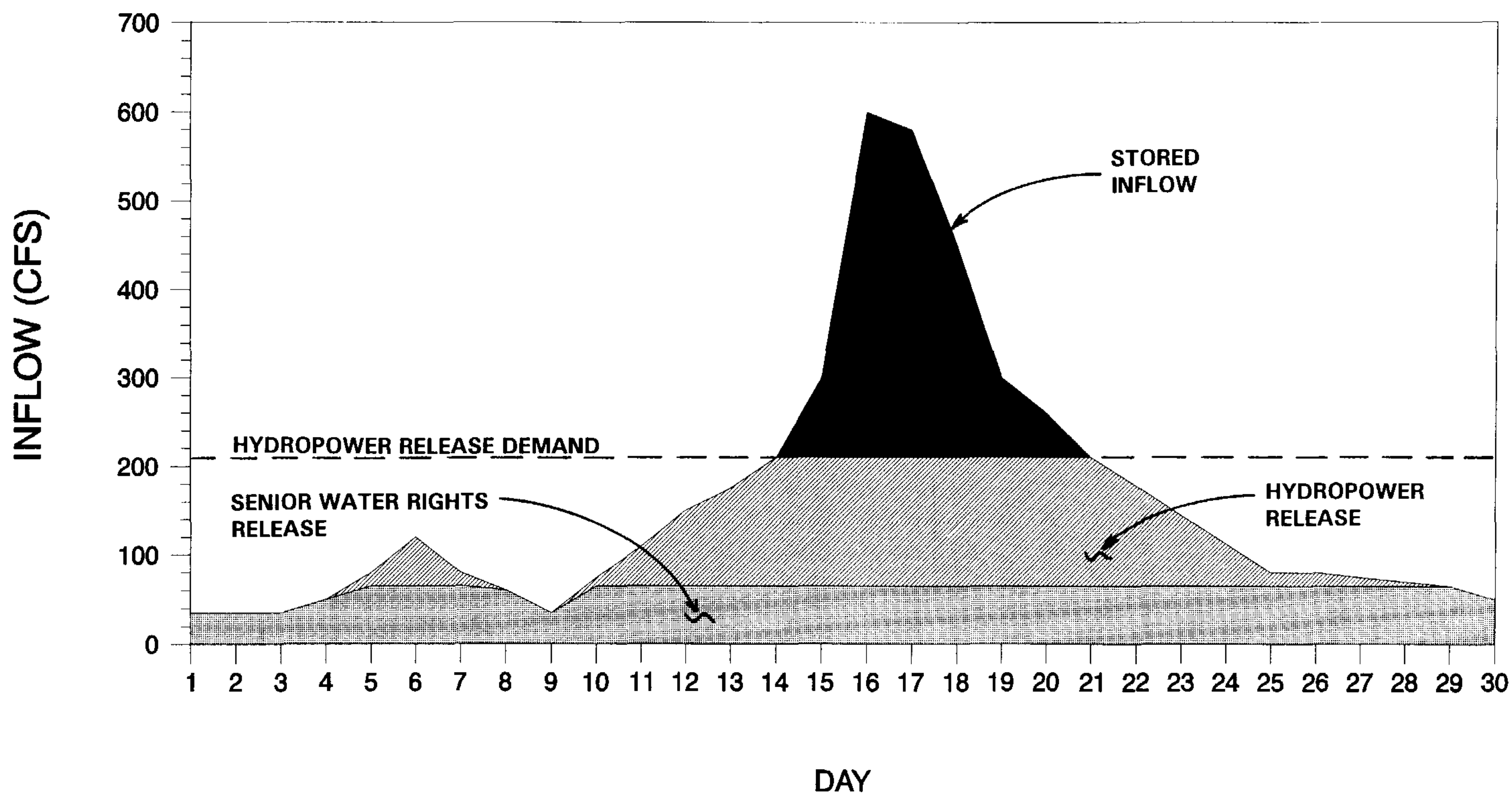
A daily analysis of Canyon Lake inflows using historical gaged flows at Spring Branch was incorporated into the GSA Model to more accurately determine required inflow passage for hydropower and FERC requirements. Daily inflow to Canyon Lake was computed using the total monthly inflow, which includes adjustments for upstream water rights and return flows, and disaggregating it using the daily distribution of monthly flows as measured at the

Spring Branch gage. The monthly volume of inflow required to be passed for downstream senior water rights is distributed on a daily time step based on the pattern of inflow for the month. The monthly volume for releases of storage to meet contractual obligations was assumed to occur uniformly throughout the month. Passage of daily inflow as required by FERC was determined using the daily flow at Spring Branch directly as specified by FERC. Downstream hydropower requirements at Lake Dunlap for passage of daily inflow were based on the total monthly flow for the Guadalupe and Comal Rivers at New Braunfels. The total monthly flow at this location was assumed to occur uniformly during the month and a daily deficit for hydropower was determined as the difference between the flow requirement at Lake Dunlap (i.e. 365 cfs, 600 cfs, etc.) and the combined daily flow for the Guadalupe and Comal Rivers at New Braunfels. Any deficits for hydropower were satisfied to the extent possible by passage of Canyon Lake inflow. The required operational releases computed on the daily time step were summed to a total monthly operational release for Canyon Lake. The monthly total was used by the model to simulate monthly flows at all control points in the river basin. A graphical example of this daily analysis of Canyon Lake inflows is shown in Figure G-2.

The capability to specify the diversion point for Canyon Lake firm yield at any control point at or downstream of Canyon Lake was incorporated into the GSA Model. This modification was accomplished by specifying the Canyon Lake firm yield as a contractual obligation with a municipal type monthly demand distribution. This feature allowed the model to account for the required operational releases to meet demands at a downstream control point including delivery losses.

An iterative solution process for calculating the Canyon Lake firm yield was included in the model. The half-interval method was used for solving for the firm yield of Canyon Lake at any control point at or downstream of Canyon Lake.

The methodology for modelling the makeup diversion from the Guadalupe River for Coleto Creek Reservoir under CP&L's run-of-the-river water right and Canyon Lake contract was revised to more accurately model the specific provisions in the water right and contract. CP&L currently holds a 20,000 acft/yr run-of-the-river water right diverted from the Guadalupe River near Victoria. This water right is senior to Canyon Lake but junior



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CANYON LAKE DAILY INFLOW ANALYSIS

FIGURE G-2

to those water rights associated with the Calhoun Canal Division at the Saltwater Barrier. The priority of the Calhoun Canal Division water rights with respect to the CP&L run-of-the-river water right was incorporated into the GSA Model so that, if a deficit existed at the Saltwater Barrier, no diversion under CP&L's water right could take place.

Several provisions exist in the Canyon Lake contract for cooling water makeup diversions to Coleto Creek Reservoir. Diversion of stored water from Canyon Lake released for makeup at Coleto Creek Reservoir occurs at the same diversion point, using the same facilities, as CP&L's run-of-the-river water right. Makeup needs for Coleto Creek Reservoir are computed each month with makeup demands met to the extent possible from the run-of-the-river water right. If makeup demands cannot be satisfied from the run-of-the-river water right, then they are met from the Canyon Lake contract subject to the provisions of the contract. There are two provisions in the Canyon Lake contract for Coleto Creek Reservoir which limit makeup diversions under the contract which were incorporated into the GSA Model:

1) During any calendar year, the quantity of water to be released from Canyon Lake conservation storage and delivered to the diversion point shall not exceed 18,900 acft.

2) During any five consecutive calendar-year period, no more than 30,000 acft from Canyon Lake conservation storage shall be delivered to the diversion point.

Water rights and Canyon Lake contracts were updated in the model. Recent Canyon Lake contracts and amendments to existing contracts were included as well as new water rights. New water rights include 20,000 acft/yr for municipal use by the City of Victoria to be taken from the Guadalupe River near Victoria. The SAWS/SARA Tunnel Reuse Project, which is expected to divert SAWS return flows and consume approximately 18,000 acft/yr in accordance with a typical monthly demand pattern for irrigation use, was also included.

Comparison of Canyon Lake Firm Yield Results

Comparisons were made of Canyon Lake firm yield computed using the GSA Model to those presented by EH&A[2]. Based on historical springflows and diversion of Canyon Lake firm yield near New Braunfels, comparable total yield estimates for various hydropower requirements at Lake Dunlap are summarized in Table G-1. The maximum difference in the firm yield estimates was about nine percent. In general, differences between HDR and EH&A yield estimates can be attributed to minor differences in drought inflows and to the GSA Model accounting for channel losses which were not addressed by EH&A.

Table G-1
Comparison of Canyon Lake Firm Yield Estimates

Hydropower Flow Requirement at Lake Dunlap	HDR Canyon Lake Firm Yield[1] (acft/yr)	EH&A Canyon Lake Firm Yield[1] (acft/yr)	Percent Difference
600 cfs	47,400	50,000	5.5%
365 cfs	60,500	66,000	9.1%
0 cfs	94,400	86,000	-8.9%

Note:
1) Firm yield estimates based on historical springflows with diversion of all firm yield assumed to occur near New Braunfels.

Canyon Lake Firm Yield Estimates

The firm yield of Canyon Lake was computed for various combinations of Edwards Aquifer pumpage scenarios, hydropower requirements, and points of diversion. Three Edwards Aquifer pumpage scenarios were considered including pumpage of 200,000 acft/yr, 368,000 acft/yr, and 400,000 acft/yr. The results of the simulated springflows from the TWDB Edwards Aquifer Model for all pumpage scenarios were adjusted to account for the

[2] Espey, Huston & Associates, Inc., "Engineering Analyses and Hydrologic Modeling to Determine the Effects of Subordination of Hydropower Water Rights," Guadalupe-Blanco River Authority, March, 1993.

difference in the model's simulated historical springflows and observed springflows. Two hydropower requirements at Lake Dunlap, 0 cfs and 365 cfs, were considered. Firm yield was computed for each of the Edwards Aquifer pumpage scenarios for both hydropower requirements and for three points of diversion. The three points of diversion included Canyon Lake, Lake Dunlap, and near Gonzales.

Several contracts have been signed between GBRA and various entities for water supply from Canyon Lake. These contracts divert their portions of the Canyon Lake firm yield at various locations downstream of Canyon Lake. The point of diversion and total demand for each of these contracts impacts the operational releases and remaining firm yield of Canyon Lake. Therefore, the firm yield of Canyon Lake computed was separated into two components: the "committed yield" and the "uncommitted yield." The committed yield is the amount of Canyon Lake firm yield already obligated through contracts having specified points of diversion. The uncommitted yield is the amount of Canyon Lake firm yield computed to be available at a particular point of diversion in addition to the amount that has already been committed by existing Canyon Lake contracts totalling 38,438 acft/yr. The combined total of committed and uncommitted firm yield is the total firm yield for Canyon Lake. A summary of existing Canyon Lake contracts and their annual diversion rates used in this study is provided in Table G-2.

Due to the consideration of scenarios involving the subordination of hydropower water rights from the current level of 600 cfs at Lake Dunlap to 365 cfs and 0 cfs, various assumptions regarding downstream water rights were required. Water rights which are presently junior in priority to Canyon Lake are for the most part satisfied by Canyon Lake inflows because of the 600 cfs hydropower flow requirement. Further subordination of hydropower to Canyon Lake firm yield would involve the conversion of a non-consumptive use (hydropower) to a consumptive use (Canyon Lake firm yield). Therefore, water rights downstream of Lake Dunlap which are presently junior to Canyon Lake (total of 23,471 acft/yr) were considered as senior water rights in the GSA Model for scenarios involving hydropower subordination in order to insure that these rights were met by passage of Canyon Lake inflows to the extent which they would have been based on a 600 cfs

Table G-2
Summary of Canyon Lake Contracts

Contract Owner	Type of Use	Annual Diversion (acft/yr)	GSA Model Diversion Point
Henk Paving Company, Inc.	Industrial	1	Canyon Lake
Goldbeck	Irrigation	1	Canyon Lake
Cunningham	Irrigation	2	Canyon Lake
Kleck	Municipal	1	Canyon Lake
Propst	Municipal	1	Canyon Lake
Salge	Municipal	1	Canyon Lake
Welch	Municipal	1	Canyon Lake
DuBose	Municipal	2	Canyon Lake
Stanaland	Municipal	2	Canyon Lake
Yacht Club	Municipal	4	Canyon Lake
Comal County Fair Assoc., Inc.	Industrial	1	Lake Dunlap
Southbank Property Owners Assoc.	Irrigation	1	Lake Dunlap
Comal ISD	Irrigation	2	Lake Dunlap
Cooper	Irrigation	2	Lake Dunlap
Zurovec	Irrigation	4	Lake Dunlap
Erben	Irrigation	5	Lake Dunlap
Whitewater Sports	Municipal	1	Lake Dunlap
Maricopa Lodge	Municipal	5	Lake Dunlap
Murrell	Municipal	10	Lake Dunlap
Crystal Clear WSC	Municipal	500	Lake Dunlap
Southwest Texas State University	Municipal	500	Lake Dunlap
City of San Marcos	Municipal	5,000	Lake Dunlap
New Braunfels Utilities	Municipal	6,720	Lake Dunlap
Canyon Regional Water Authority*	Municipal	8,740	Lake Dunlap
ACME Brick Company	Industrial	25	Lake Wood
Standard Gypsum Corp.	Industrial	140	Lake Wood
Structural Metals, Inc.	Industrial	600	Lake Wood
Ind. Golf Assn.	Irrigation	2	Lake Wood
Missildine	Irrigation	10	Lake Wood
Chapparal Country Club, Ltd.	Irrigation	15	Lake Wood
Gonzales County WSC	Municipal	700	Lake Wood
Springs Hill WSC	Municipal	1,500	Lake Wood
City of Seguin	Municipal	2,000	Lake Wood
DuBose	Industrial	5	Cuero
Central Power & Light	Industrial	6,000	Victoria
ISP Tech	Industrial	40	Saltwater Barrier
Carbon Graphite	Industrial	334	Saltwater Barrier
BP Chemicals, Inc.	Industrial	1,100	Saltwater Barrier
Union Carbide C&P	Industrial	2,400	Saltwater Barrier
Calhoun County Rural WSC	Municipal	560	Saltwater Barrier
City of Port Lavaca	Municipal	1,500	Saltwater Barrier
Total		38,438	

*Pending

hydropower requirement.

Summaries of uncommitted and total Canyon Lake firm yield for various combinations of Edwards Aquifer pumpage, hydropower subordination, and point of diversion are presented in Table G-3 and Figure G-3. For hydropower subordination to 365 cfs, a dramatic decrease in firm yield occurs from an Edwards Aquifer pumpage scenario of 200,000 acft/yr to 368,000 acft/yr and 400,000 acft/yr. This large decrease in firm yield is primarily due to significant reductions in flow from Comal Springs which contributes to the hydropower requirements at Lake Dunlap. This reduction in flow from Comal Springs requires more frequent and larger passages of Canyon Lake inflow to satisfy hydropower requirements, thereby decreasing the firm yield of Canyon Lake. For hydropower subordination to 0 cfs, the decrease in firm yield for the various Edwards Aquifer pumpage scenarios is not as dramatic. When the hydropower requirement is reduced to 0 cfs at Lake Dunlap, Canyon Lake inflow passages are dependent on senior water rights and FERC requirements, and the impact of the reduction in springflow is not as prominent.

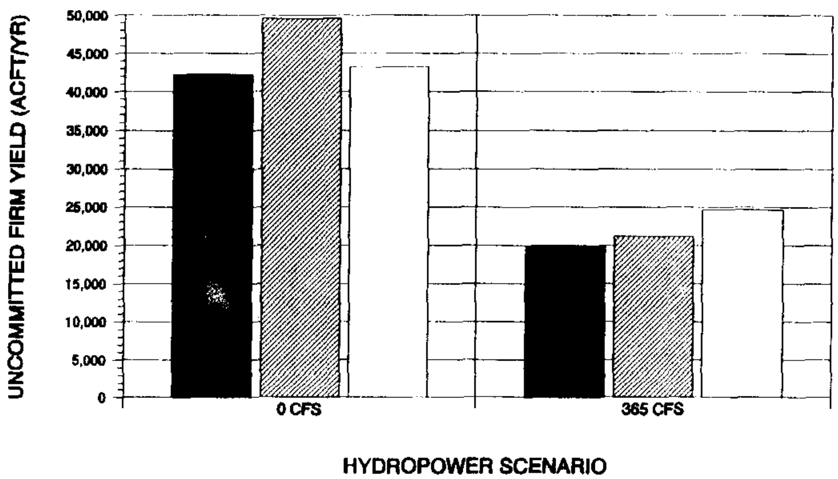
The point of diversion of the uncommitted firm yield influences the total Canyon Lake firm yield available. For a hydropower scenario of 365 cfs, the diversion of uncommitted firm yield at Gonzales provides the greatest firm yield. Diversion of the uncommitted firm yield at Gonzales is subject to some delivery losses from Canyon Lake to Gonzales and the estimated losses are included in the yield analysis. More importantly, however, the Gonzales diversion takes advantage of using yield releases to contribute toward meeting hydropower and FERC requirements. By using yield releases to contribute toward satisfying hydropower and FERC requirements, the amount of Canyon Lake inflow that can be stored is increased translating into an increase in firm yield. On the other hand, diversion of the uncommitted firm yield directly from Canyon Lake does not take advantage of utilizing yield releases from Canyon Lake to meet hydropower or FERC requirements and, therefore, produces the least firm yield. Diversion of the firm yield at Lake Dunlap does not take advantage of utilizing yield releases to contribute toward satisfying hydropower requirements, but it does utilize yield releases to contribute toward satisfying FERC requirements. For subordination of hydropower to 0 cfs, the optimal location for diversion of uncommitted firm yield is Lake Dunlap. Diversion of the uncommitted firm yield at Lake Dunlap takes advantage of using yield releases to meet FERC requirements and, at the same time, minimizes delivery losses. Although diversion of the uncommitted firm yield

Table G-3
Summary of Canyon Lake Firm Yield Results

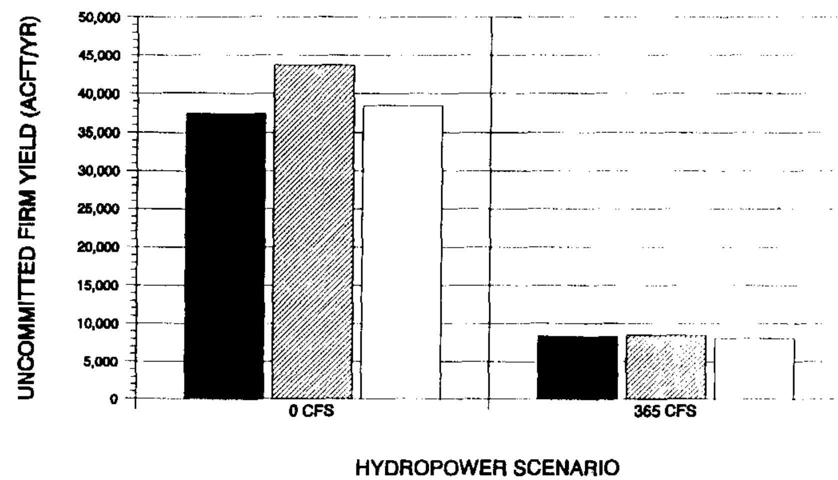
		Canyon Lake Diversion Point		Lake Dunlap Diversion Point		Gonzales Diversion Point	
Aquifer Demand Scenario[3]	**Hydropower Scenario[1]**	**Uncommitted Firm Yield[2] (acft/yr)**	**Total Firm Yield[3] (acft/yr)**	**Uncommitted Firm Yield[2] (acft/yr)**	**Total Firm Yield[3] (acft/yr)**	**Uncommitted Firm Yield[2] (acft/yr)**	**Total Firm Yield[3] (acft/yr)**
200,000 acft/yr	365 cfs	20,000	58,400	21,200	59,600	24,700	63,100
	0 cfs	42,300	90,700	49,600	88,000	43,300	81,700
368,000 acft/yr	365 cfs	8,300	46,700	8,500	46,900	8,100	46,500
	0 cfs	37,400	75,800	43,800	82,200	38,400	76,800
400,000 acft/yr	365 cfs	6,500	44,900	6,600	45,000	6,100	44,500
	0 cfs	36,700	75,100	43,100	81,500	37,800	76,200

Notes:
1) Hydropower Scenario represents the desired flowrate for power generation at Lake Dunlap. Both hydropower scenarios imply subordination of Guadalupe-Blanco River Authority hydropower rights to Canyon Lake.
2) Uncommitted firm yield is the portion of the total firm yield of Canyon Lake which has not been contractually committed. Existing contracts total 38,438 acft/yr assuming an average of 6,000 acft/yr delivered to Central Power & Light Company at Coleto Creek Reservoir. Results are presented for diversion of the uncommitted firm yield directly from Canyon Lake, from Lake Dunlap near New Braunfels, or from the Guadalupe River below the San Marcos River confluence near Gonzales.
3) Total firm yield is the sum of the uncommitted firm yield and existing contracts (38,438 acft/yr).
4) The results of the simulated springflows from the TWDB Edwards Aquifer Model for all pumpage scenarios were adjusted to account for the difference in the model's simulated historical springflows and observed springflows.

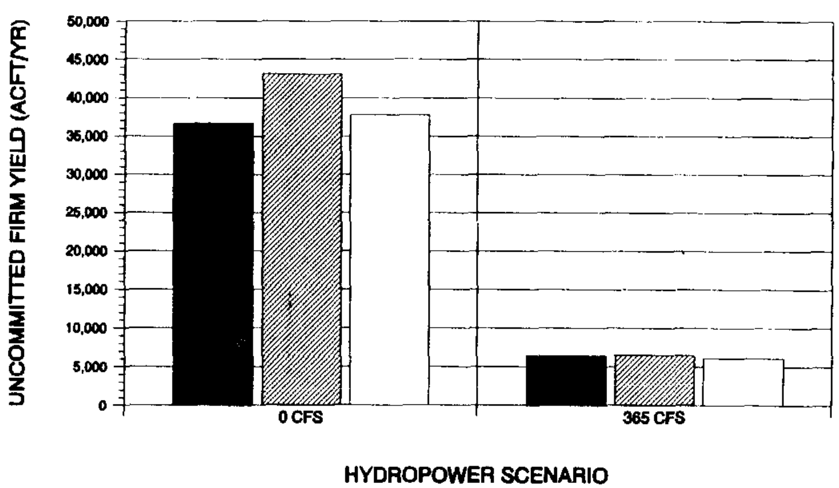
AQUIFER DEMAND SCENARIO: 200, 000 ACFT/YR



AQUIFER DEMAND SCENARIO: 368,000 ACFT/YR (SAWS 2050)



AQUIFER DEMAND SCENARIO: 400,000 ACFT/YR



DIVERSION POINT

- CANYON LAKE
- LAKE DUNLAP
- GONZALES

NOTE:

THE RESULTS OF THE SIMULATED SPRINGFLOWS FROM THE TWDB EDWARDS AQUIFER MODEL WERE ADJUSTED TO ACCOUNT FOR THE DIFFERENCE IN THE MODEL'S SIMULATED HISTORICAL SPRINGFLOWS AND OBSERVED SPRINGFLOWS.

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CANYON LAKE
UNCOMMITTED FIRM YIELD SUMMARY

FIGURE G-3

cfs hydropower scenario also takes advantage of using yield releases to meet FERC requirements, the greater delivery losses to Gonzales appear to result in an overall decrease in the total firm yield when compared to the Lake Dunlap diversion point.

The impact of utilizing SAWS return flows to meet the makeup demands of Braunig, Calaveras, and Coleto Creek Reservoirs on the firm yield of Canyon Lake was analyzed. The quantity of water potentially available from conversion of CP&L's Canyon Lake contract and run-of-the-river water right to Canyon Lake firm yield was also estimated. For these analyses, only a scenario including hydropower subordination to 0 cfs and Edwards Aquifer pumpage of 368,000 acft/yr was considered. As shown in Table G-4, the impact of excluding SAWS return flows on the firm yield of Canyon Lake is a reduction of 3,200 acft/yr at the Lake Dunlap diversion point or 2,800 acft/yr at the Gonzales diversion point. These analyses also showed that conversion of CP&L's Canyon Lake contract (used for makeup diversion to Coleto Creek Reservoir) to firm yield diverted at Lake Dunlap or Gonzales would increase the uncommitted firm yield by 6,300 acft/yr or 5,600 acft/yr, respectively. Conversion of CP&L's water right near Victoria (20,000 acft/yr) to firm yield diverted at Lake Dunlap or Gonzales would add an additional 1,900 acft/yr or 1,600 acft/yr, respectively.

Table G-4
Summary of Canyon Lake Firm Yield Results
Edwards Aquifer Pumpage Scenario of 368,000 acft/yr[7]
Hydropower Requirement of 0 cfs

Scenario	Lake Dunlap Diversion Point			Gonzales Diversion Point		
	Uncommitted Firm Yield (acft/yr)[1]	**Total Firm Yield (acft/yr)[2]**	**Change in Uncommitted Firm Yield (acft/yr)**	**Uncommitted Firm Yield (acft/yr)[1]**	**Total Firm Yield (acft/yr)[2]**	**Change in Uncommitted Firm Yield (acft/yr)**
SAWS Return Flows Included[3]	43,800	82,200	--------	38,400	76,800	--------
SAWS Return Flows Excluded[4]	40,600	79,000	-3,200	35,600	74,000	-2,800
Conversion of CP&L's Coleto Creek Contract[5]	46,900	79,300	6,300	41,200	73,600	5,600
Transfer of CP&L's Water Right[6]	48,800	81,200	1,900	42,800	75,200	1,600

Notes:
1) Uncommitted firm yield is the portion of the total firm yield of Canyon Lake which has not been contractually committed. Existing contracts total 38,438 acft/yr assuming an average of 6,000 acft/yr delivered to Central Power & Light Company at Coleto Creek Reservoir. Results are presented for diversion of the uncommitted firm yield from Lake Dunlap near New Braunfels and the Guadalupe River below the San Marcos River near Gonzales.
2) Total firm yield is the sum of the uncommitted firm yield and existing contracts (38,438 acft/yr). When the CP&L Coleto Creek Reservoir contract is converted to Canyon Lake firm yield, the total existing contracts is reduced to 32,438 acft/yr.
3) Present conditions of SAWS return flows in the San Antonio River contributing to streamflow at the Saltwater Barrier.
4) Includes utilization of SAWS return flows for meeting the makeup needs of Braunig, Calaveras, and Coleto Creek Reservoir. Assumes all SAWS return flows are utilized.
5) Includes utilization of all SAWS return flows and conversion of CP&L's Coleto Creek contract from Canyon Lake to firm yield at Lake Dunlap and Gonzales.
6) Includes utilization of all SAWS return flows, conversion of CP&L's Coleto Creek contract from Canyon Lake to firm yield, and transfer of CP&L's run of the river water right (20,000 acft/yr) to Canyon Lake firm yield.
7) The results of the simulated springflows from the TWDB Edwards Aquifer Model for the pumpage scenario of 368,000 acft/yr were adjusted to account for the difference in the model's simulated historical springflows and observed springflows.

APPENDIX H

WATER RIGHTS TRANSFERS AND FIRM AVAILABILITY ANALYSES

Appendix H
Water Transfers and Firm Availability Analyses

Introduction

One of the key aspects of a water plan recently proposed by the San Antonio Water System (SAWS) is the development of a surface water supply from the Guadalupe River to supplement available supplies from the Edwards Aquifer. It is envisioned that this surface water supply would be diverted from a point along the Guadalupe River near Lake Dunlap or near Gonzales and that the supply would be comprised of enhanced springflows (Appendix F), Canyon Lake firm yield (Appendix G), use of existing run-of-the-river water rights transferred upstream from the Saltwater Barrier near Tivoli, and possibly unappropriated water. Methods and assumptions applied and results obtained in the quantification of firm water availability from the combined utilization of these potential surface water sources are presented in this Appendix H.

Background and Assumptions

The Guadalupe-Blanco River Authority (GBRA) has ownership interest in at least six water rights associated with the Calhoun Canal Division which divert from the Guadalupe River downstream of the San Antonio River confluence and upstream of the Saltwater Barrier. These permits (Certificate of Adjudication Nos. 18-5173 through 18-5178) are senior to Canyon Lake and total about 172,500 acft/yr. Communications with GBRA indicate that up to 40,000 acft/yr might be made available for long-term in-basin and/or out-of-basin use and that up to an additional 40,000 acft/yr might potentially be made available for short-term or temporary use. Hence, 40,000 acft/yr (18,400 acft/yr municipal and 21,600 acft/yr industrial) and 80,000 acft/yr (36,800 acft/yr municipal and 43,200 acft/yr industrial) of the GBRA Calhoun Canal Division rights were selected for consideration of potential transfer to either Lake Dunlap or Gonzales.

In order to maximize the uncommitted firm yield of Canyon Lake which could be made available to firm-up diversions under the GBRA Calhoun Canal Division (CCD) rights at upstream locations, GBRA and other hydropower rights as well as Central Power & Light

Company (CP&L) once-through cooling rights near Victoria were subordinated to Canyon Lake. Subordination, in this case, means that inflows to Canyon Lake would not be required to be released to meet permitted hydropower flow rates downstream of Canyon Lake or CP&L once-through cooling rights near Victoria, but instead would be available for storage in Canyon Lake. As hydropower subordination results in the conversion of a non-consumptive use to storage or consumptive use, water rights junior to Canyon Lake located on the mainstem of the Guadalupe downstream of Lake Dunlap (including the recent application by the City of Victoria) were assumed to be senior to Canyon Lake. All other water rights with the exception of those upstream of and junior to Canyon Lake were included in these analyses.

Furthermore, it was assumed that CP&L needs for makeup cooling water could be satisfied by delivery of SAWS treated effluent to a point on the San Antonio River near Goliad and diverted into Coleto Creek Reservoir (Section 3.42). This water replacement scenario would allow CP&L's existing 20,000 acft/yr run-of-the-river right and 6,000 acft/yr (average) contract with GBRA to be converted into Canyon Lake firm yield. This conversion could result in an increase in uncommitted Canyon Lake firm yield of 8,157 acft/yr at Lake Dunlap or 7,232 acft/yr at Gonzales. As the conversion could be accomplished by amendment or abandonment of the CP&L run-of-the-river right and termination or transfer of the GBRA contract, it was assumed that Trans-Texas or other instream flow criteria (except those related to the hydropower operations at Canyon Dam) were not applicable. SAWS treated effluent was excluded from all firm availability analyses in order to avoid overestimation of water available for diversion under existing rights located below the confluence of the Guadalupe and San Antonio Rivers and to acknowledge the possibility that SAWS effluent could be considered to be property of SAWS and be traded or used for mitigation purposes.

The Edwards Aquifer pumpage scenario proposed by SAWS results in an average annual pumpage of 368,000 acft/yr which represents a reduction of 32,000 acft/yr from the 400,000 acft/yr pumpage scenario outlined in Senate Bill 1477. The 368,000 acft/yr pumpage scenario incorporates water conservation, lease of irrigation rights in Medina and Uvalde Counties, four proposed recharge enhancement projects in the Nueces River Basin, and summer "peak shaving" through surface water importation from the Guadalupe River. The Texas Water Development Board (TWDB) has applied their Edwards Aquifer model to simulate the combined effects of the various aspects of the SAWS pumpage scenario and produced revised sets of springflows for Comal, San Marcos, and other smaller springs. Changes between the simulated springflows under the 368,000 acft/yr pumpage scenario (Appendix F) and those which occurred historically have been incorporated in the Guadalupe - San Antonio River Basin Model (GSA Model) and used in the estimation of Canyon Lake firm yield and firm water availability at Lake Dunlap and Gonzales. As presented in Appendix G, the firm yield of Canyon Lake is about 600 acft/yr to 2,000 acft/yr greater under the 368,000 acft/yr pumpage scenario than under the 400,000 acft/yr pumpage scenario depending upon the degree of hydropower subordination.

Methodology

Firm availability for diversions at Lake Dunlap or Gonzales is defined to be the maximum diversion which can be obtained in every year during the 1934-89 period in accordance with a fixed monthly demand pattern utilizing a combination of water available under existing rights transferred from downstream, unappropriated flow, and Canyon Lake firm yield. The methodology employed to quantify each component of water available and to combine these components into a composite firm yield is described in the following paragraphs.

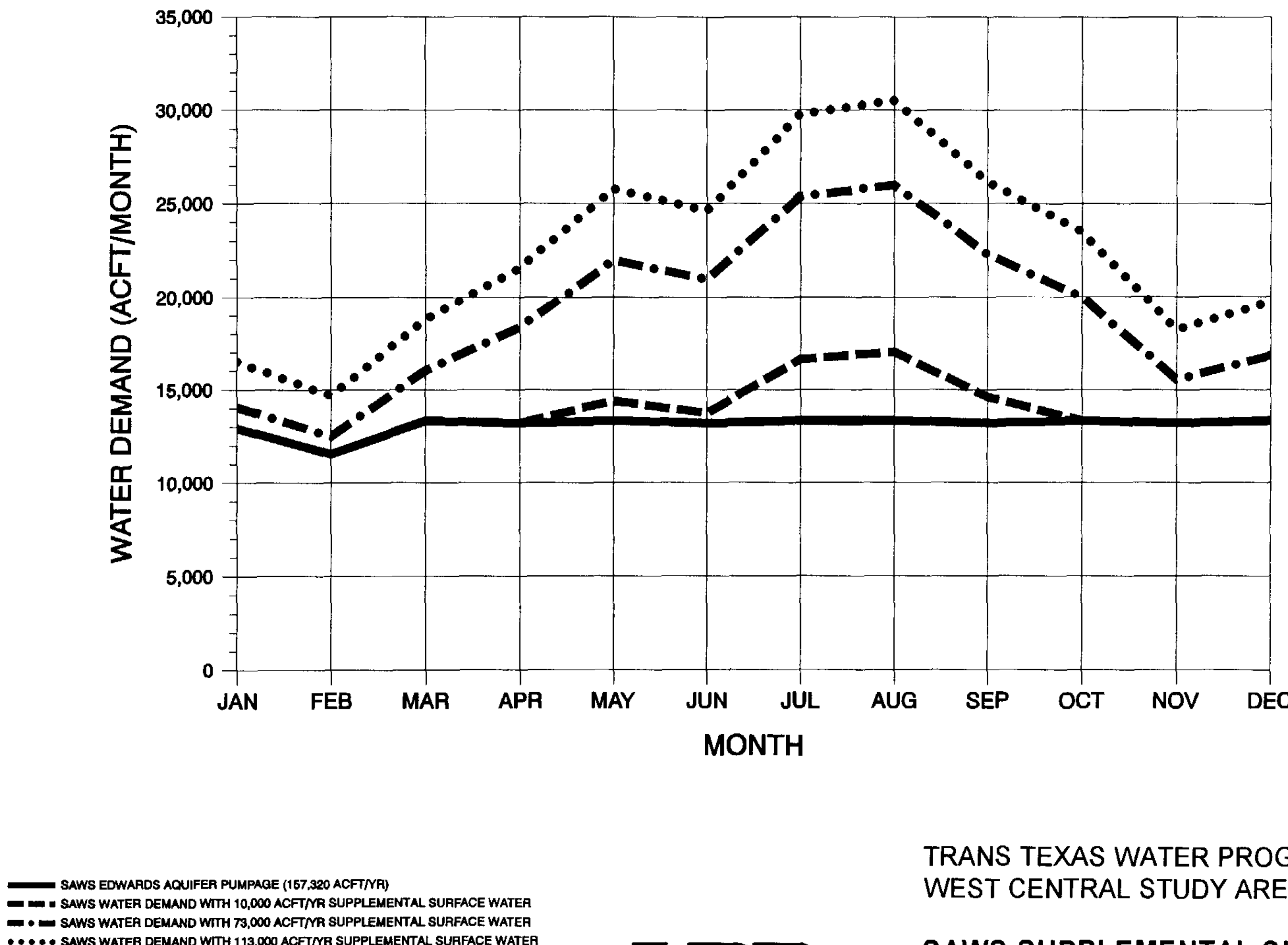
The GSA Model was used to compute the uncommitted firm yield of Canyon Lake if diverted at Lake Dunlap or Gonzales subject to the assumptions outlined in the previous subsection and to simulate resulting streamflows throughout the Guadalupe - San Antonio River Basin. Monthly flows passing Canyon Dam and flowing over the Saltwater Barrier were extracted from the output summaries for use in determining water available for upstream diversion under either 40,000 acft/yr or 80,000 acft/yr of GBRA CCD water rights. Since the flows passing Canyon Dam in this simulation are representative of storage releases and inflow passage necessary to satisfy contractual obligations and GBRA CCD rights presently diverted at the Saltwater Barrier, respectively, it was assumed that these flows would not change if diversions under the senior rights were to be made at Lake

Dunlap or Gonzales instead. In addition, the flows passing the Saltwater Barrier in this simulation were assumed equivalent to the unappropriated flow at the Saltwater Barrier.

After modifications to facilitate simulation of unique 56-year sequences of monthly flows passing Canyon Dam and/or exports from selected control points, the GSA Model was used to compute monthly water availability at Lake Dunlap and Gonzales under both 40,000 acft/yr and 80,000 acft/yr of GBRA CCD rights by simulating the export of all unappropriated flow at the Saltwater Barrier and excluding the selected portion of the GBRA CCD rights. Water availability under the GBRA CCD rights was computed both with and without Trans-Texas Environmental Criteria for Instream Flows although application of such criteria to diversions made under existing water rights is an issue which has not yet been clarified within the Trans-Texas Water Program. Consideration of Trans-Texas Environmental Criteria for Freshwater Inflows to Bays and Estuaries was not necessary as flows over the Saltwater Barrier remain essentially unchanged.

The GSA Model was used to compute monthly unappropriated flows available at Lake Dunlap and Gonzales by including unappropriated flows at the Saltwater Barrier and exporting water available under the selected portion of the GBRA CCD rights from either Lake Dunlap or the Guadalupe River near Gonzales. Availability of unappropriated flows was computed both with and without Trans-Texas Environmental Criteria for Instream Flows and for Freshwater Inflows to Bays and Estuaries. Water diverted under existing GBRA CCD rights and from unappropriated flows was then combined to obtain gross water availability.

Although gross water availability is highly variable from month to month, actual quantities of water diverted from the Guadalupe River for SAWS and/or others will most likely adhere to a seasonal variation pattern with the greatest demands occurring during the summer months. This is particularly true with respect to potential diversions by SAWS as it is their intent to make their Edwards Aquifer pumpage more uniform by maximizing importation of surface water in the summer months. Figure H-1 illustrates an approximation of SAWS intended utilization of supplemental surface water to level off Edwards Aquifer pumpage. SAWS supplemental surface water demand patterns as shown in Figure H-1 were used in the estimation of firm availability.



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SAWS SUPPLEMENTAL SURFACE WATER DEMAND PATTERNS

FIGURE H-1

Because water available at Lake Dunlap or Gonzales under the GBRA CCD rights and/or unappropriated flow is so highly variable, portions of the uncommitted yield of Canyon Lake were made available to meet monthly demands as necessary to obtain an estimate of firm availability. Firm availability was calculated using a spreadsheet analysis considering run-of-the-river water and "banked storage" in Canyon Lake during the July, 1947 through February, 1957 critical drought period. The procedure incorporated in the spreadsheet is illustrated in Figure H-2 and summarized as follows:

1) Select portion of firm yield of Canyon Lake made available to firm-up run-of-the-river water at specified diversion point (Lake Dunlap or Gonzales).

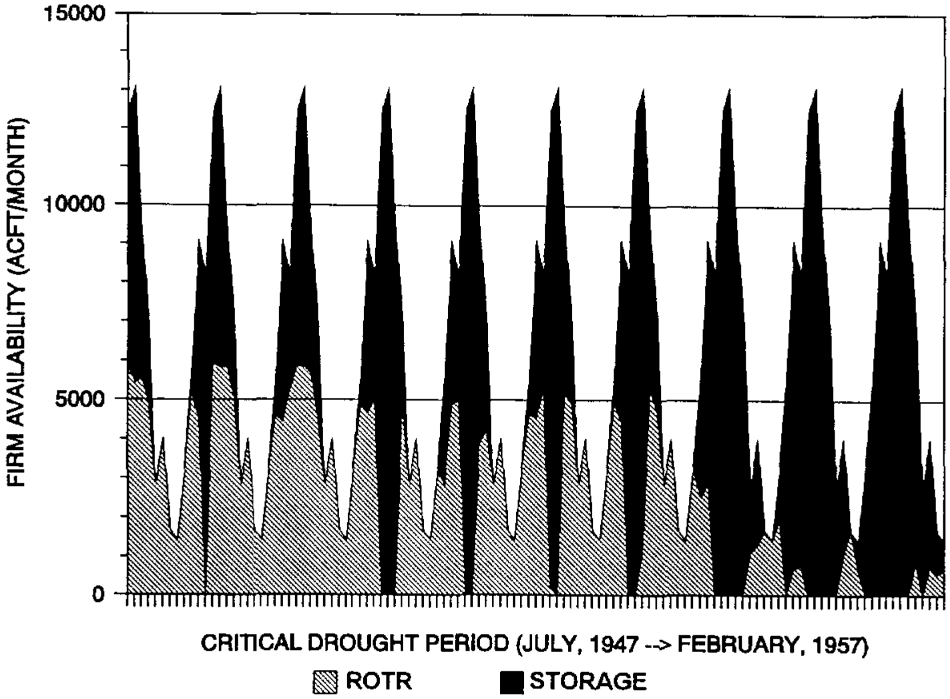
2) Select trial estimate of combined annual firm availability.

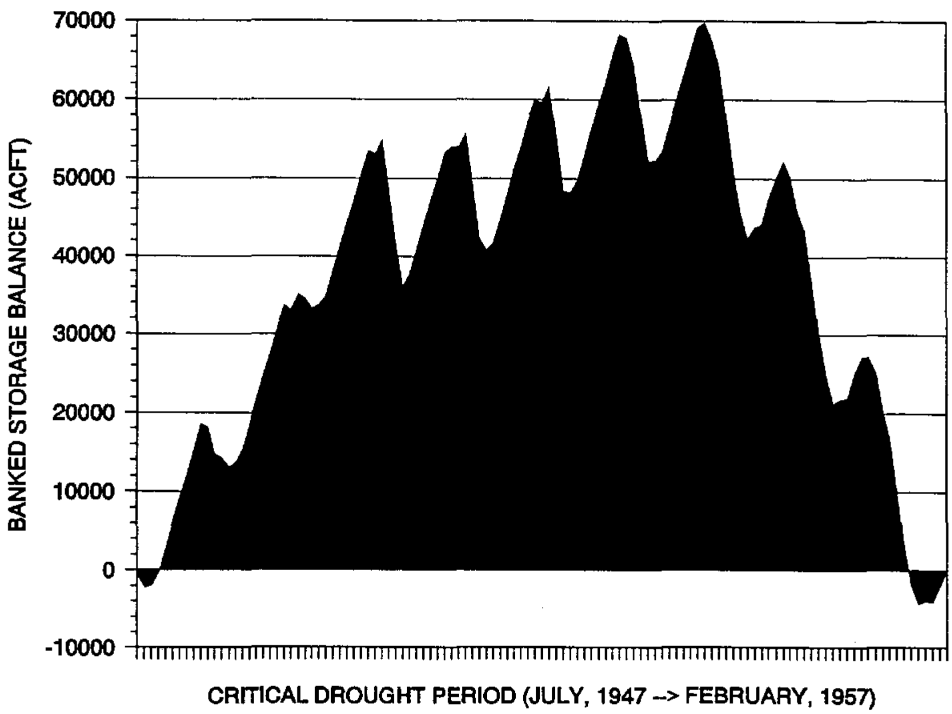
3) Compute monthly portion of estimated annual firm availability based on corresponding SAWS supplemental surface water demand pattern.

4) Satisfy monthly portion of estimated annual firm availability to the extent possible from available run-of-the-river water first, and then utilize releases from a Canyon Lake banked storage account for the remainder. Increase or decrease the banked storage account balance in Canyon Lake as appropriate in each month.

5) Repeat steps 3 and 4 for each month during the critical drought. If the banked storage account balance is negative (or overdrawn) at the end of the critical drought, return to step 2 and select a reduced trial estimate. If the banked storage account balance is positive at the end of the critical drought, return to step 2 and select an increased trial estimate. When the banked storage account balance at the end of the critical drought is approximately zero, annual firm availability has been determined.

As is apparent in Figure H-2, run-of-the-river water is a significant component of the firm availability during the first seven years of the critical drought permitting the accrual of a sizeable banked storage account balance. During the final three years of the critical drought, however, banked storage becomes the dominant component of firm availability. While any channel losses affecting delivery of stored water to Lake Dunlap or Gonzales are adequately accounted for, increased evaporation losses due to banked storage are not adequately accounted for in this methodology. Preliminary analyses indicate that a more accurate accounting for evaporation losses could reduce the estimates of firm availability





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EXAMPLE ILLUSTRATION OF FIRM AVAILABILITY CALCULATION

FIGURE H-2

presented herein by about 4 percent. It is recommended that modifications necessary to allow computation of firm availability within the GSA Model (thereby more accurately accounting for evaporation losses on banked storage) be undertaken in a subsequent phase of the Trans-Texas Water Program.

Results

Firm availability was estimated at Lake Dunlap and near Gonzales based on diversions under 40,000 acft/yr and 80,000 acft/yr of GBRA Calhoun Canal Division rights made firm to the extent possible by a range of allocations from the uncommitted firm yield of Canyon Lake both subject to and independent of Trans-Texas Environmental Criteria. Firm availability was also computed considering the potential diversion of unappropriated flows in addition to water available under existing rights. Comprehensive summaries of estimated firm availability at Lake Dunlap and near Gonzales are included in Tables H-1 and H-2 as well as in Figures H-3 through H-6. All estimates of firm availability assume that the portion of Canyon Lake firm yield resulting from the conversion of the CP&L run-of-the-river rights and GBRA contract for Coleto Creek Reservoir makeup water to Canyon Lake firm yield would be allocated to firm-up available run-of-the-river water.

Following are a few key observations made upon review of the firm availability estimates presented herein:

1) When Trans-Texas Environmental Criteria are applied, firm availability is limited to little more than the Canyon Lake firm yield.

2) When Trans-Texas Environmental Criteria are not applied, firm availability is greater at Lake Dunlap than near Gonzales under the 40,000 acft/yr transfer of GBRA CCD rights primarily because delivery losses between Lake Dunlap and Gonzales are avoided.

3) When Trans-Texas Environmental Criteria are not applied, firm availability is greater near Gonzales than at Lake Dunlap under the 80,000 acft/yr transfer of GBRA CCD rights considering unappropriated flow because of the larger contributing watershed area and additional springflow above Gonzales.

4) SAWS supplemental surface water demand patterns which are heavily concentrated in the summer months tend to limit utilization of run-of-the-river water available under existing rights or from unappropriated flow during the other months of the year.

Table H-1
Firm Availability at Lake Dunlap [1]

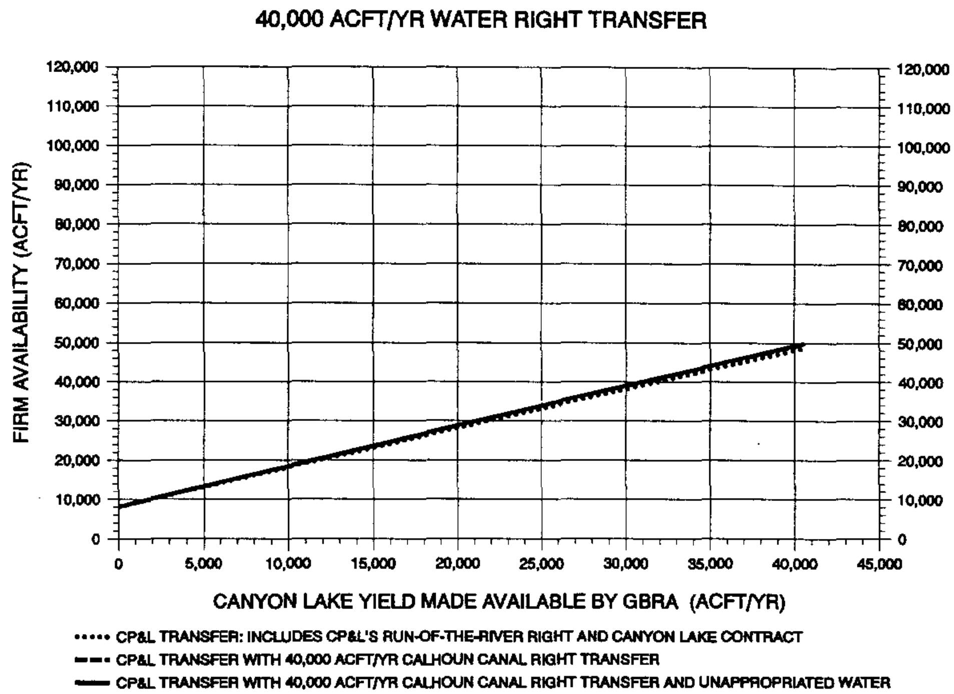
Trans-Texas Environmental Criteria Applied	Portion of Canyon Lake Yield Made Available by GBRA to Firm-Up Other Water (acft/yr)	Firm Availability at Lake Dunlap with Water Rights Transfers (acft/yr)			Combined Firm Availability at Lake Dunlap with Water Rights Transfers and Unappropriated Water (acft/yr)	
		CP&L [2]	CP&L and 40,000 Acft/Yr GBRA CCD Rights	CP&L and 80,000 Acft/Yr GBRA CCD Rights	CP&L and 40,000 Acft/Yr GBRA CCD Rights	CP&L and 80,000 Acft/Yr GBRA CCD Rights
Yes	0	8,157	8,157	8,157	8,157	8,157
	10,000	18,157	18,405	18,405	18,405	18,405
	20,000	28,157	28,780	28,780	28,780	28,780
	40,599 Max	48,756	49,785	49,952	49,952	49,952
No	0	8,157	14,703	17,914	14,703	17,914
	10,000	18,157	33,657	41,591	35,694	41,591
	20,000	28,157	49,680	62,549	58,479	62,662
	40,599 Max	48,756	78,600	96,715	94,495	99,648

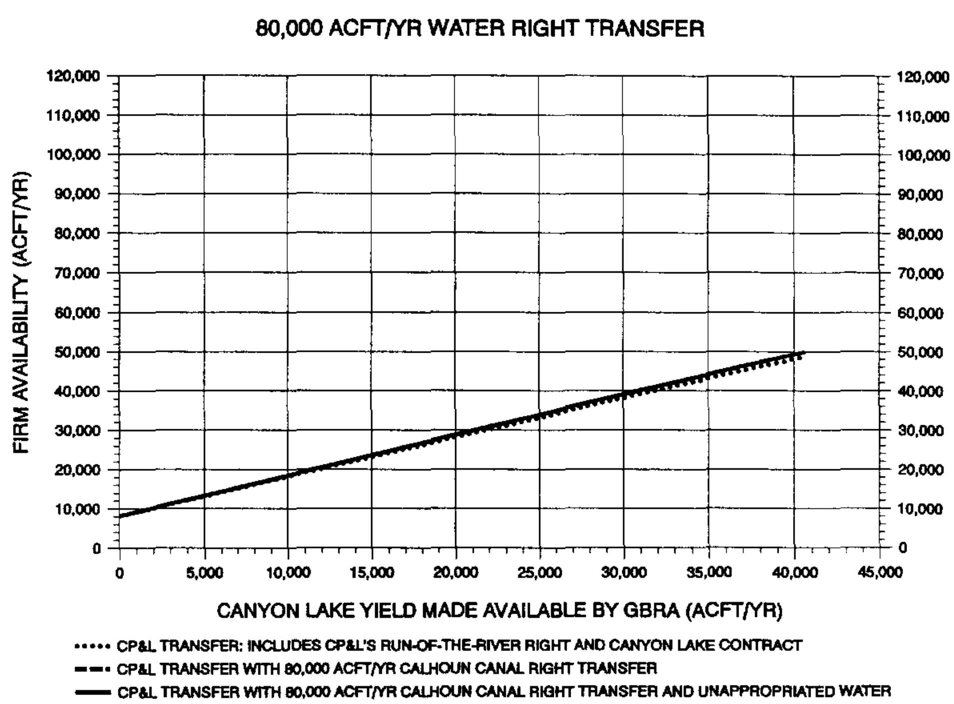
[1] Based on 116 month critical drought period beginning July, 1947 and ending February, 1957.
[2] Includes conversion of 6,000 acft/yr GBRA contract and 20,000 acft/yr run-of-the-river rights to Canyon Lake firm yield.

Table H-2
Firm Availability at Gonzales [1]

Trans-Texas Environmental Criteria Applied	Portion of Canyon Lake Yield Made Available by GBRA to Firm-Up Other Water (acft/yr)	Firm Availability at Gonzales with Water Rights Transfers (acft/yr)			Combined Firm Availability at Gonzales with Water Rights Transfers and Unappropriated Water (acft/yr)	
		CP&L [2]	CP&L and 40,000 Acft/Yr GBRA CCD Rights	CP&L and 80,000 Acft/Yr GBRA CCD Rights	CP&L and 40,000 Acft/Yr GBRA CCD Rights	CP&L and 80,000 Acft/Yr GBRA CCD Rights
Yes	0	7,232	7,700	7,700	7,700	7,700
	10,000	17,232	18,817	18,876	18,817	18,876
	20,000	27,232	30,112	30,358	30,112	30,358
	35,588 Max	42,820	46,718	48,051	46,979	48,051
No	0	7,232	13,954	16,675	13,954	17,613
	10,000	17,232	33,343	44,320	37,369	44,320
	20,000	27,232	47,359	70,953	65,059	74,298
	35,588 Max	42,820	71,260	99,612	106,243	116,035

[1] Based on 116 month critical drought period beginning July, 1947 and ending February, 1957.
[2] Includes conversion of 6,000 acft/yr GBRA contract and 20,000 acft/yr run-of-the-river rights to Canyon Lake firm yield.





TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

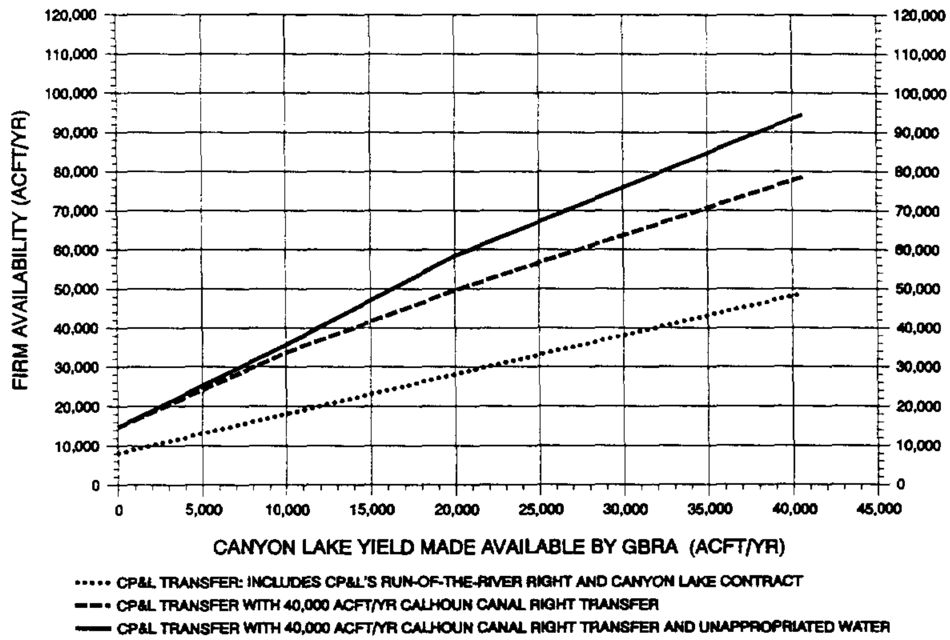
HDR

HDR Engineering, Inc.

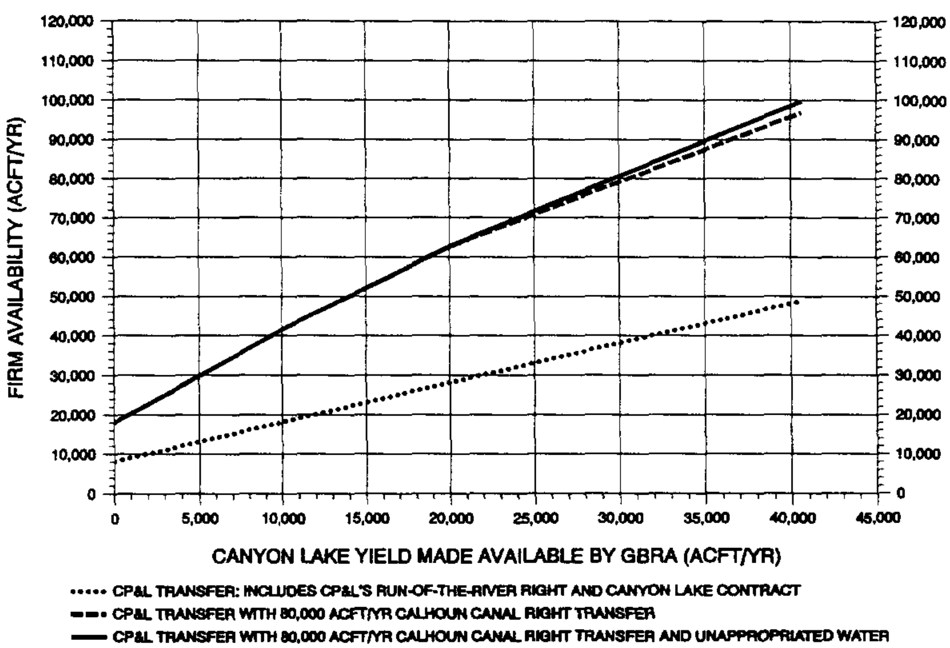
FIRM AVAILABILITY NEAR LAKE DUNLAP WITH TRANS-TEXAS ENVIRONMENTAL CRITERIA

FIGURE H-3

40,000 ACFT/YR WATER RIGHT TRANSFER



80,000 ACFT/YR WATER RIGHT TRANSFER



TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

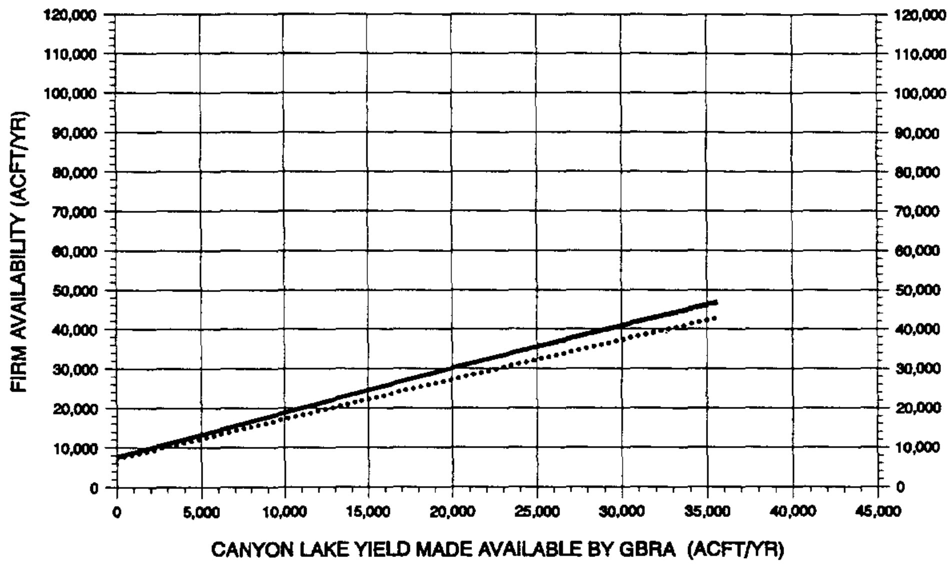
HDR

HDR Engineering, Inc.

FIRM AVAILABILITY NEAR LAKE DUNLAP WITHOUT TRANS-TEXAS ENVIRONMENTAL CRITERIA

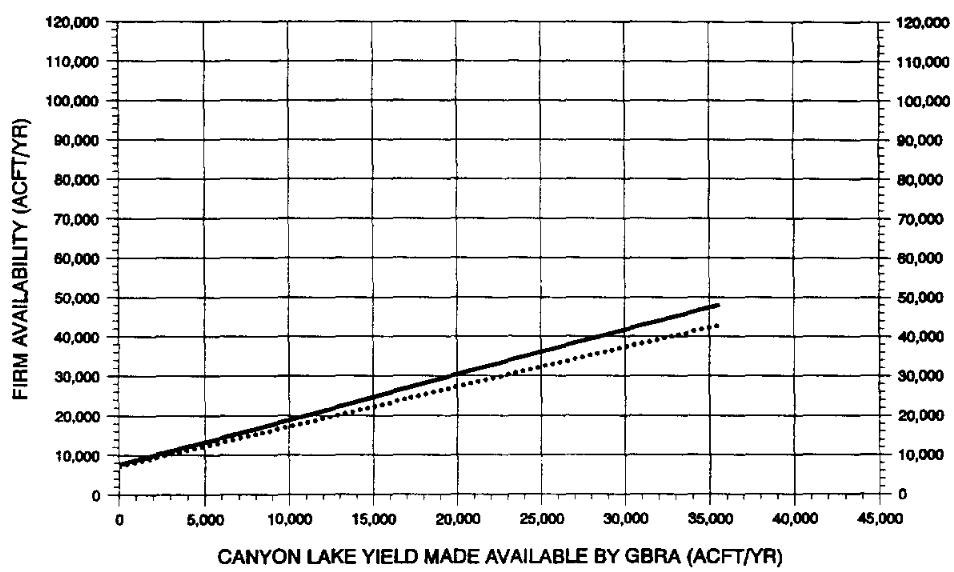
FIGURE H-4

40,000 ACFT/YR WATER RIGHT TRANSFER



CP&L TRANSFER: INCLUDES CP&L'S RUN-OF-THE-RIVER RIGHT AND CANYON LAKE CONTRACT
CP&L TRANSFER WITH 40,000 ACFT/YR CALHOUN CANAL RIGHT TRANSFER
CP&L TRANSFER WITH 40,000 ACFT/YR CALHOUN CANAL RIGHT TRANSFER AND UNAPPROPRIATED WATER

80,000 ACFT/YR WATER RIGHT TRANSFER



CP&L TRANSFER: INCLUDES CP&L'S RUN-OF-THE-RIVER RIGHT AND CANYON LAKE CONTRACT
CP&L TRANSFER WITH 80,000 ACFT/YR CALHOUN CANAL RIGHT TRANSFER
CP&L TRANSFER WITH 80,000 ACFT/YR CALHOUN CANAL RIGHT TRANSFER AND UNAPPROPRIATED WATER

HDR

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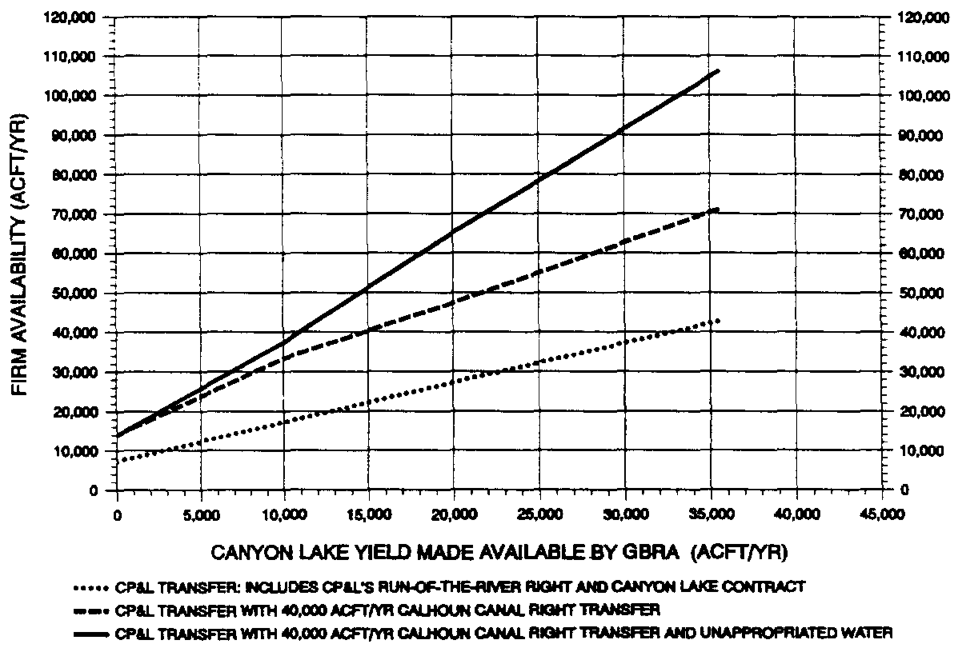
TRANS TEXAS WATER PROGRAM /
WEST CENTRAL STUDY AREA

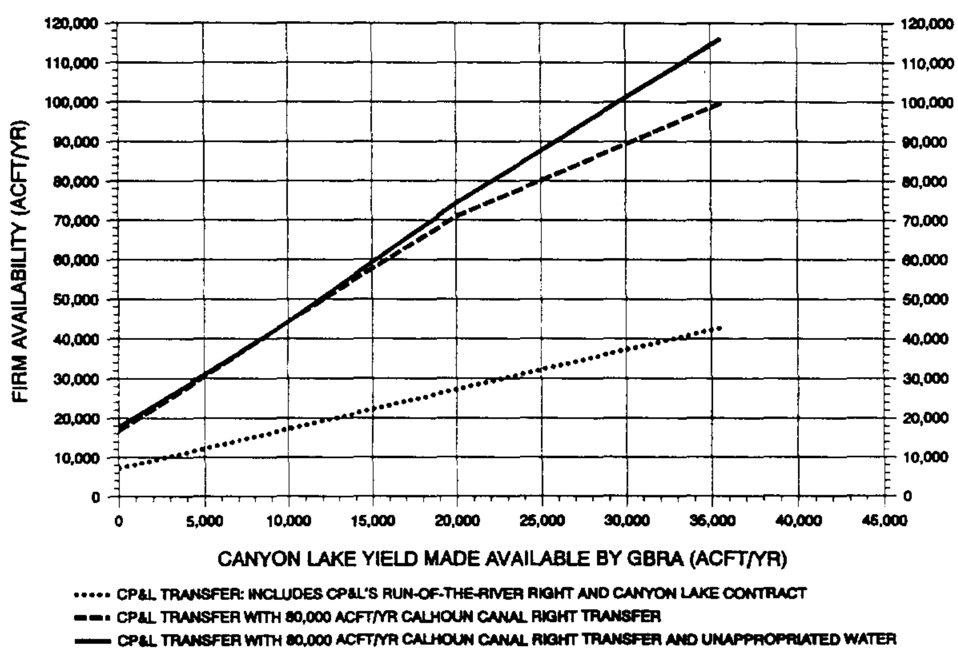
FIRM AVAILABILITY NEAR GONZALES WITH TRANS-TEXAS ENVIRONMENTAL CRITERIA

FIGURE H-5

40,000 ACFT/YR WATER RIGHT TRANSFER



80,000 ACFT/YR WATER RIGHT TRANSFER



TRANS TEXAS WATER PROGRAM / WEST CENTRAL STUDY AREA

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FIRM AVAILABILITY NEAR GONZALES WITHOUT TRANS-TEXAS ENVIRONMENTAL CRITERIA

FIGURE H-6

APPENDIX I

ERRATA

To: Recipients of Phase I Interim Report

From: David Wheelock

Date: November 13, 1994

Subject: Errata Sheets
Phase I Interim Report
West Central Study Area
Trans-Texas Water Program

HDR

Memorandum

The attached sheets from the Phase I Interim Report are being reissued with revisions to correct minor errors inadvertently contained in the original printing of the report. The following is a listing of the sheet numbers, contents, and revisions made.

Page Number	Page Contents	Description of Revisions
2-14	Table 2-3 Population Projections for River Basins and Adjacent Areas	Year 2050 (last column of table) projections added to replace missing digits in previous printing.
2-64	Table 2-18 Municipal Water Demand Projections for River Basins and Adjacent Areas	Year 2050 (last column of table) projections added to replace missing digits in previous printing.
2-67	Table 2-19 Industrial Water Demand Projections for River Basins and Adjacent Areas	Year 2050 (last column of table) projections added to replace missing digits in previous printing.
2-82	Table 2-24 Total Water Demand Projections for River Basins and Adjacent Areas	Year 2050 (last column of table) projections added to replace missing digits in previous printing.
2-85	Table 2-25 1990 Groundwater Use -- 33 County West Central Area	Total groundwater use (last column of table) data added to replace missing digits in previous printing.
2-86	Table 2-26 1990 Surface Water Use -- 33 County West Central Area	Total groundwater use (last column of table) data added to replace missing digits in previous printing.
3-224	Figure 3.13-3 Changes in Streamflow, Medina Lake, Alternative S-13	Units of vertical axis of Streamflow Decile graphs changed from "Acft/Month" to "Acft/Year".
3-261	Figure 3.15-3 Changes in Streamflow, Cibolo Reservoir, Alternative S-15	Label of vertical axis of Streamflow Decile graphs changed from "Monthly Median Streamflow, Acft/Month" to "Average Streamflow, Acft/Year".

3-279	Figure 3.16-3 Changes in Streamflow, Goliad Reservoir, Alternative S-16	Units of vertical axis of Streamflow Decile graphs changed from "Acft/Month" to "Acft/Year".
3-307	Figure 3.18-2 Changes in Streamflow, San Marcos River Diversion, Alternative G-13	Units of vertical axis of Streamflow Decile graphs changed from "Acft/Month" to "Acft/Year".
3-320	Figure 3.19-2 Changes in Streamflow, Lake Dunlap Diversion, Alternative G-14	Units of vertical axis of Streamflow Decile graphs changed from "Acft/Month" to "Acft/Year".
3-321	Figure 3.21-3 Changes in Streamflow, Cuero Reservoir, Alternative G-16	Units of vertical axis of Streamflow Decile graphs changed from "Acft/Month" to "Acft/Year".
3-372	Figure 3.22-3 Changes in Streamflow, Guadalupe River with Lindenau Reservoir, Alternative G-17	Units of vertical axis of Streamflow Decile graphs changed from "Acft/Month" to "Acft/Year".
3-373	Figure 3.22-4 Changes in Streamflow, Sandies Creek at Lindenau Reservoir, Alternative G-17	Units of vertical axis of Streamflow Decile graphs changed from "Acft/Month" to "Acft/Year".
3-399	Figure 3.23-3 Changes in Streamflow, McFaddin Reservoir, Alternative G-18	Units of vertical axis of Streamflow Decile graphs changed from "Acft/Month" to "Acft/Year".

Table 2-3
Population Projections for River Basins and Adjacent Areas--West Central Study Area
Trans-Texas Water Program

RIVER BASIN[1]	1990[2] Use	Projection[3]					
		2000	2010	2020	2030	2040	2050
NUECES							
Total In-Basin	165,139	194,657	220,567	241,683	262,746	283,247	303,748
Study Area Subtotal[4]	110,733	132,470	152,305	169,160	186,554	203,616	220,678
Remainder of Basin	54,406	62,187	68,262	72,523	76,192	79,631	83,070
SAN ANTONIO							
Total In-Basin	1,270,884	1,532,451	1,838,947	2,183,948	2,613,416	3,035,968	3,458,520
Adjacent Area[5]	450	511	562	722	665	722	779
Study Area Subtotal	1,271,334	1,532,962	1,839,509	2,184,550	2,614,081	3,036,690	3,459,299
GUADALUPE							
Total In-Basin	302,409	375,420	460,254	532,452	593,985	640,608	687,231
Adjacent Area[6]	48,250	55,424	63,504	70,154	75,650	80,430	85,210
Study Area Subtotal	350,659	430,844	523,754	602,606	669,635	721,038	772,441
LOWER COLORADO							
Total In-Basin	709,456	920,081	1,124,397	1,340,653	1,566,477	1,712,900	1,859,323
Adjacent Area[7]	73,250	83,700	91,968	98,758	106,886	114,435	121,984
Subtotal	782,706	1,003,781	1,216,365	1,439,411	1,673,363	1,827,335	1,981,317
Adjacent Inland Area[8]	153,584	236,120	320,385	409,553	558,156	654,821	751,476
Study Area Subtotal	936,290	1,239,901	1,537,190	1,848,964	2,231,519	2,482,156	2,732,793
RIVER BASIN TOTALS	2,447,888	3,022,609	3,644,165	4,298,736	5,036,624	5,672,723	6,308,822
STUDY AREA	2,669,016	3,336,177	4,052,758	4,805,280	5,701,789	6,443,500	7,185,211

[1]Study Area
[2]1990 Census, U.S. Bureau of the Census, U.S. Department of Commerce
[3]Texas Water Development Board, High Case for 1990 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April 1992, Austin, Texas.
[4]Only counties of Nueces Basin included in study area (Uvalde, Medina, Zavala, Frio, Atascosa, and parts of Bexar, Wilson and Karnes).
[5]Part of Goliad County located in adjacent San Antonio-Nueces Coastal Basin.
[6]Part of Victoria County located in adjacent Lavaca-Guadalupe Coastal Basin, plus all of Refugio and Calhoun counties.
[7]Parts of Colorado, Wharton, and Matagorda counties located in adjacent coastal basins.
[8]Parts of Fayette, Lee, Williamson, and Burnet counties located in adjacent basins.
Note: Texas population in 1990 was 16,986,510. TWDB projections of Texas population for 2000 is 20,257,960 and for 2050 is 36,308,602 (1.27% compound annual growth rate).

Table 2-18
Municipal Water Demand Projections for River Basins and Adjacent Areas
West Central Area -- Trans-Texas Water Programs

BASIN[1]	1990[2] Use	Projections in Acre-Feet[3]					
		2000	2010	2020	2030	2040	2050
NUECES							
Total In-Basin	32,450	41,412	44,834	47,205	50,815	54,241	57,667
Study Area Subtotal[4]	20,722	27,356	30,012	31,995	34,995	37,886	40,777
Remainder of Basin	11,728	14,056	14,822	15,210	15,820	16,355	16,890
SAN ANTONIO							
Total In-Basin	239,393	352,963	404,974	460,729	545,243	626,733	708,223
Adjacent Area[5]	59	80	83	84	90	96	102
Study Area Subtotal	239,452	353,043	405,057	460,813	545,333	626,829	708,325
GUADALUPE							
Total In-Basin	52,958	76,247	88,135	97,199	106,717	113,468	120,219
Adjacent Area[6]	8,165	9,458	10,342	10,922	11,590	12,126	12,662
Study Area Subtotal	61,123	85,705	98,477	108,121	118,307	125,594	132,881
LOWER COLORADO							
Total In-Basin	138,203	206,215	241,246	278,171	322,217	348,944	375,671
Adjacent Coastal Area[7]	10,904	14,231	14,842	15,190	16,091	16,866	17,641
Study Area Subtotal	149,107	220,446	256,088	293,361	338,308	365,810	393,312
Adjacent Inland Area[8]	27,724	51,358	66,612	81,708	109,000	126,958	144,916
Study Area Subtotal	176,831	271,804	322,700	375,069	447,308	492,768	538,228
RIVER BASIN TOTALS[9]	463,004	676,837	779,189	883,304	1,024,992	1,143,386	1,261,780
STUDY AREA TOTALS[10]	498,128	737,908	856,246	975,998	1,145,943	1,283,077	1,420,211

[1]Study Area
[2]As reported to and/or estimated by the Texas Water Development Board.
[3]Texas Water Development Board, High Case for 1990 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April 1992, Austin, Texas.
[4]Counties of Nueces Basin included in study area are: Uvalde, Medina, Zavala, Frio, Atascosa, and parts of Bexar, Wilson and Karnes.
[5]Part of Goliad County located in adjacent San Antonio-Nueces Coastal Basin.
[6]Part of Victoria County located in adjacent Lavaca-Guadalupe Coastal Basin, plus all of Refugio and Calhoun counties.
[7]Parts of Colorado, Wharton, and Matagorda counties located in adjacent coastal basins.
[8]Parts of Fayette, Lee, Williamson, and Burnet counties located in adjacent basins.
[9]Total for counties and parts of counties located within basin boundaries.
[10]Total for 33-county study area.

Table 2-19
Industrial Water Demand Projections for River Basins and Adjacent Areas
West Central Area -- Trans-Texas Water Programs

BASIN[1]	1990[2] Use	Projections in Acre-Feet[3]					
		2000	2010	2020	2030	2040	2050
NUECES							
Total In-Basin[9]	4,306	4,263	4,980	5,875	6,911	8,027	9,143
Study Area Subtotal[4]	2,149	1,768	2,170	2,652	3,229	3,926	4,623
Remainder of Basin	2,157	2,495	2,810	3,223	3,682	4,101	4,520
SAN ANTONIO							
Total In-Basin[9]	14,323	19,794	24,695	30,405	36,904	43,149	49,394
Adjacent Area[5]	0	0	0	0	0	0	0
Study Area Subtotal	14,323	19,794	24,695	30,405	36,904	43,149	49,394
GUADALUPE							
Total In-Basin[9]	26,263	46,352	59,038	73,113	85,326	98,987	112,648
Adjacent Area[6]	24,539	73,297	83,156	94,154	103,934	114,509	125,084
Study Area Subtotal	50,802	119,649	142,194	167,267	189,260	213,496	237,732
LOWER COLORADO							
Total In-Basin[9]	13,575	25,526	33,454	41,841	51,400	62,715	74,030
Adjacent Coastal Area[7]	2,082	5,022	11,666	22,137	27,651	38,052	48,453
Subtotal	15,657	30,548	45,120	63,978	79,051	100,767	122,483
Adjacent Inland Area[8]	376	638	836	1,044	1,297	1,509	1,721
Study Area Subtotal	16,033	31,186	45,956	65,022	80,348	102,276	124,204
RIVER BASIN TOTALS[9]	58,467	95,935	122,167	151,234	180,541	212,878	245,215
STUDY AREA TOTALS[10]	83,307	172,397	215,015	265,346	309,741	362,847	415,953

[1]Study Area
[2]As reported to and/or estimated by the Texas Water Development Board.
[3]Texas Water Development Board, High Case for 1990 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April 1992, Austin, Texas.
[4]Counties of Nueces Basin included in study area are: Uvalde, Medina, Zavala, Frio, Atascosa, and parts of Bexar, Wilson and Karnes.
[5]Part of Goliad County located in adjacent San Antonio-Nueces Coastal Basin.
[6]Part of Victoria County located in adjacent Lavaca-Guadalupe Coastal Basin, plus all of Refugio and Calhoun counties.
[7]Parts of Colorado, Wharton, and Matagorda counties located in adjacent coastal basins.
[8]Parts of Fayette, Lee, Williamson, and Burnet counties located in adjacent basins.
[9]Total for counties and parts of counties located within basin boundaries.
[10]Total for 33-county study area.

Table 2-24
Total Water Demand Projections for River Basins and Adjacent Areas
West Central Area -- Trans-Texas Water Program

BASIN[1]	1990[2] Use	Projections in Acre-Feet[3]					
		2000	2010	2020	2030	2040	2050
NUECES							
Total In-Basin[9]	612,217	557,543	517,960	513,897	519,186	524,462	529,747
Study Area Subtotal[4]	555,503	501,826	461,468	457,295	461,551	465,860	470,173
Remainder of Basin	56,714	55,717	56,492	56,602	57,635	58,602	59,574
SAN ANTONIO							
Total In-Basin[9]	357,901	469,604	526,084	592,302	693,100	780,706	868,325
Adjacent Area[5]	403	586	587	586	592	597	603
Study Area Subtotal	358,304	470,190	526,671	592,888	693,692	781,303	868,928
GUADALUPE							
Total In-Basin[9]	116,519	196,476	220,105	247,655	268,945	288,998	309,066
Adjacent Area[6]	81,440	124,965	134,594	145,127	153,409	164,352	175,300
Study Area Subtotal	197,959	321,441	354,699	392,782	422,354	453,350	484,366
LOWER COLORADO							
Total In-Basin[9]	374,659	392,382	440,891	488,667	545,687	587,499	629,321
Adjacent Coastal Area[7]	655,943	518,384	509,061	497,277	484,558	478,784	469,006
Subtotal	1,030,602	910,766	949,952	985,944	1,030,245	1,066,283	1,098,327
Adjacent Inland Area[8]	34,637	73,854	88,387	103,918	131,385	149,414	167,958
Study Area Subtotal	1,065,239	984,620	1,038,339	1,089,863	1,161,630	1,215,697	1,266,242
RIVER BASIN TOTALS[9]	1,461,296	1,616,005	1,705,040	1,842,521	2,026,918	2,181,665	2,336,459
STUDY AREA TOTALS[10]	2,177,005	2,278,077	2,381,177	2,532,828	2,739,262	2,916,210	3,089,709

[1]Study Area
[2]As reported to and/or estimated by the Texas Water Development Board.
[3]Texas Water Development Board, High Case for 1990 through 2040, with extrapolation to 2050 at same rate as projected for 2030-2040, April 1992, Austin, Texas.
[4]Counties of Nueces Basin included in study area are: Uvalde, Medina, Zavala, Frio, Atascosa, and parts of Bexar, Wilson and Karnes.
[5]Part of Goliad County located in adjacent San Antonio-Nueces Coastal Basin.
[6]Part of Victoria County located in adjacent Lavaca-Guadalupe Coastal Basin, plus all of Refugio and Calhoun counties.
[7]Parts of Colorado, Wharton, and Matagorda counties located in adjacent coastal basins.
[8]Parts of Fayette, Lee, Williamson, and Burnet counties located in adjacent basins.
[9]Total for counties and parts of counties located within basin boundaries.
[10]Total for 33-county study area.

Table 2-25
1990 Groundwater Use -- 33-County West Central Area
Trans-Texas Water Program

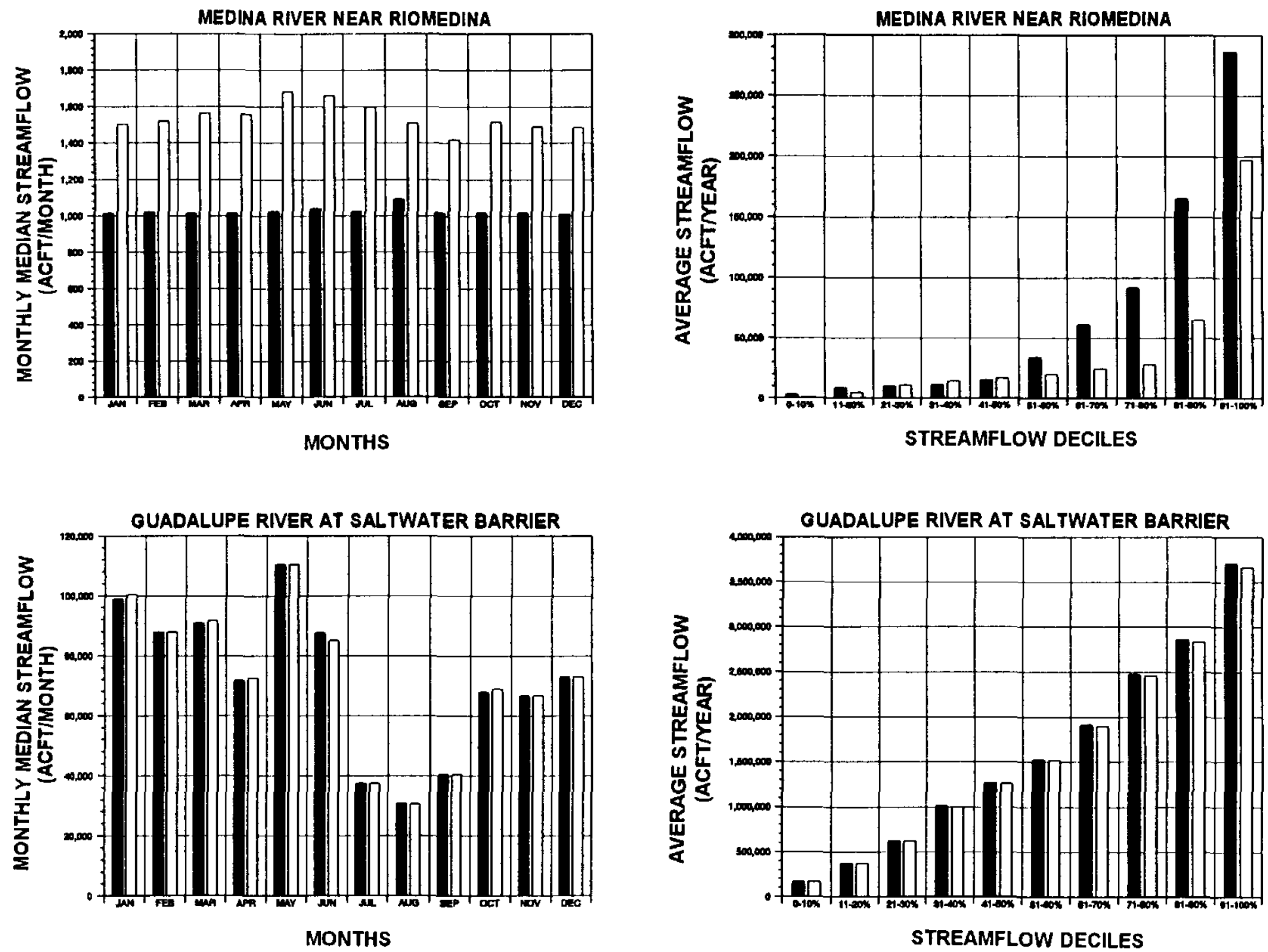
COUNTIES[1]	1990 Use[2] (Acre-Feet)						
	Municipal	Industrial	Steam-Electric	Irrigation	Mining	Livestock	Total
Atascosa	5,670	0	3,622	47,208	664	160	57,324
Bandera	1,417	0	0	151	20	260	1,848
Bastrop	6,234	26	0	323	10	572	7,165
Bexar	224,762	13,911	1,408	27,399	1,319	137	268,936
Blanco	646	0	0	425	0	443	1,514
Burnet	1,240	8	0	114	174	410	1,946
Caldwell	3,589	0	0	674	27	81	4,371
Calhoun	515	1,812	62	1,984	1	175	4,549
Colorado	2,927	96	0	44,280	993	837	49,133
Comal	10,338	1,237	0	469	946	253	13,243
DeWitt	3,494	91	0	274	129	182	4,170
Fayette	3,397	32	0	80	7	203	3,719
Frio	3,045	0	38	81,568	313	109	85,073
Goliad	916	0	136	205	0	87	1,344
Gonzales	1,487	618	0	2,124	21	410	4,660
Guadalupe	4,949	131	0	1,376	8	102	6,566
Hays	11,635	293	0	0	0	66	11,994
Karnes	2,187	270	0	1,831	187	135	4,610
Kendall	1,734	2	0	274	0	312	2,322
Kerr	2,607	2	0	187	73	307	3,176
Lee	2,991	5	0	164	0	559	3,719
Llano	151	0	0	1,043	65	863	2,122
Matagorda	5,225	3,514	1,158	26,717	250	673	37,537
Medina	5,254	286	0	77,694	120	155	83,509
Refugio	1,227	0	0	0	77	56	1,360
San Saba	363	0	0	573	86	897	1,919
Travis	8,139	412	21	448	0	471	9,491
Uvalde	5,213	557	0	137,856	399	497	144,522
Victoria	11,545	489	865	13,151	2,409	763	29,222
Wharton	6,218	396	0	155,474	4	728	162,820
Williamson	14,787	233	0	18	1,654	150	16,842
Wilson	3,745	50	0	11,642	281	180	15,898
Zavala	2,349	1,306	0	76,296	116	71	80,138
Total	359,996	25,777	7,310	712,022	10,353	11,304	1,126,762

[1]Study Area.
[2]As reported to and/or estimated by the Texas Water Development Board.
Note: Source in unpublished planning data, Texas Water Development Board, 1992.

Table 2-26
1990 Surface Water Use -- 33-County West Central Area
Trans-Texas Water Program

COUNTIES[1]	1990 Use[2] (Acre-Feet)						
	Municipal	Industrial	Steam-Electric	Irrigation	Mining	Livestock	Total
Atascosa	0	0	0	0	0	1,453	1,453
Bandera	28	0	0	139	0	65	232
Bastrop	0	1	2,967	322	6	859	4,155
Bexar	295	138	22,855	9,613	272	1,239	34,412
Blanco	258	0	0	58	0	110	426
Burnet	2,286	1,108	0	186	762	410	4,752
Caldwell	1,342	0	0	701	0	735	2,778
Calhoun	3,401	22,727	0	33,437	0	116	59,681
Colorado	0	982	0	172,200	30,974	558	204,714
Comal	77	2,011	0	10	0	63	2,161
DeWitt	62	0	0	11	0	1,658	1,731
Fayette	0	0	11,701	320	0	1,834	13,855
Frio	0	0	0	1,665	0	988	2,653
Goliad	0	0	12,029	480	0	797	13,306
Gonzales	2,345	247	0	1,416	0	3,698	7,706
Guadalupe	4,678	1,530	0	1,270	0	929	8,407
Hays	74	0	0	320	0	610	1,004
Karnes	0	0	0	203	0	1,236	1,439
Kendall	396	0	0	106	0	77	579
Kerr	3,214	26	0	663	0	75	3,978
Lee	0	0	0	119	0	839	958
Llano	2,337	0	937	79	0	45	3,398
Matagorda	0	3,293	34,757	178,110	0	447	216,607
Medina	0	0	0	79,686	0	1,405	81,091
Refugio	0	0	0	0	0	507	507
San Saba	909	0	0	5,161	0	224	6,294
Travis	106,670	5,831	6,177	352	2,288	471	121,789
Uvalde	65	0	0	2,813	0	497	3,375
Victoria	0	19,543	22	548	0	508	20,621
Wharton	0	0	0	172,746	2,646	485	175,877
Williamson	9,695	93	0	142	59	1,358	11,347
Wilson	0	0	0	2,055	0	1,633	3,688
Zavala	0	0	0	34,626	0	643	35,269
Total	138,132	57,530	91,445	699,557	37,007	26,572	1,050,243

[1]Study Area
[2]As reported to and/or estimated by the Texas Water Development Board.
Note: Source in unpublished planning data, Texas Water Development Board, 1992.



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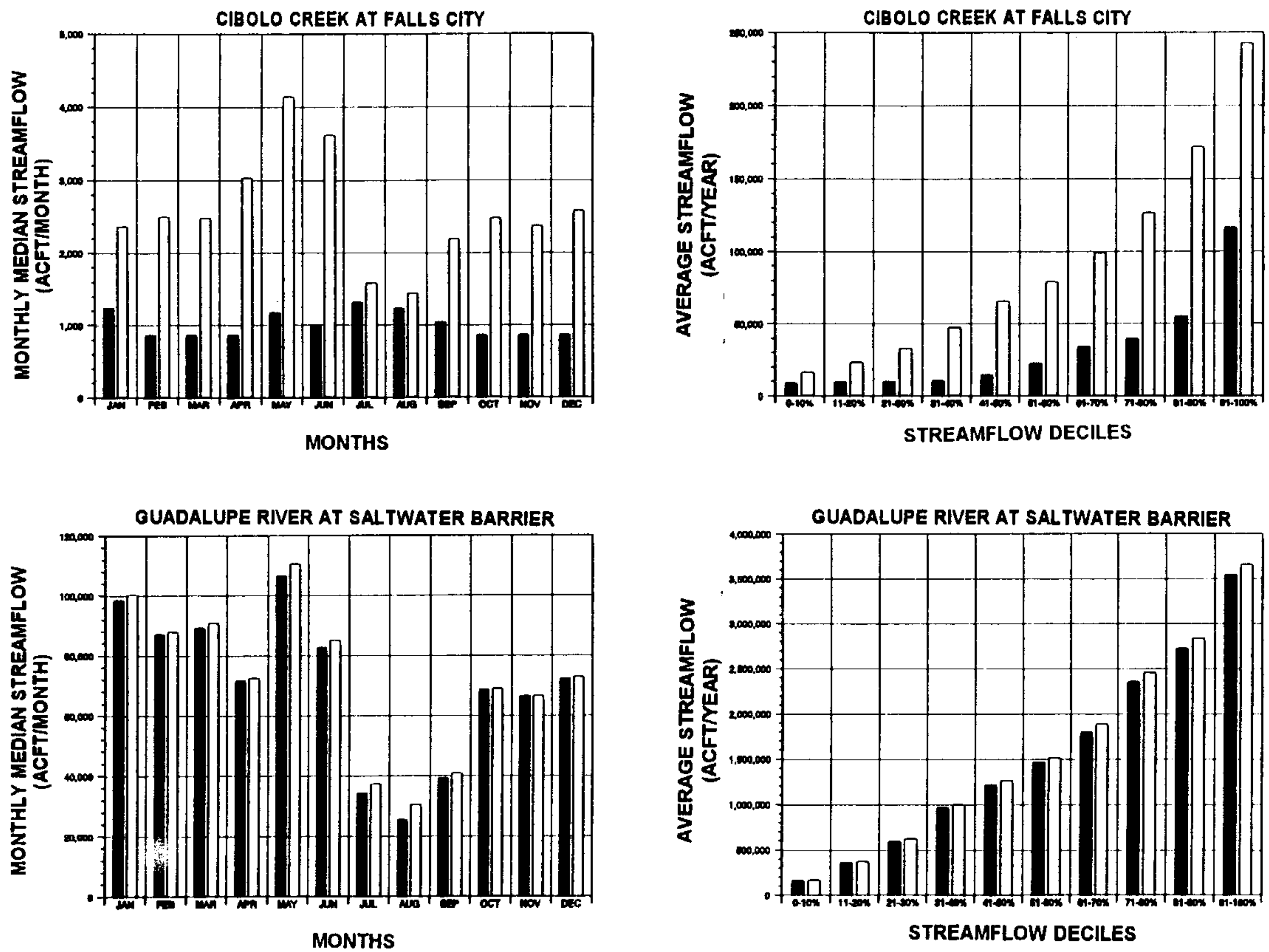
TRANS TEXAS WATER PROGRAM /
WEST CENTRAL STUDY AREA

CHANGES IN STREAMFLOW
MEDINA LAKE
ALTERNATIVE S-13

FIGURE 3.13-3



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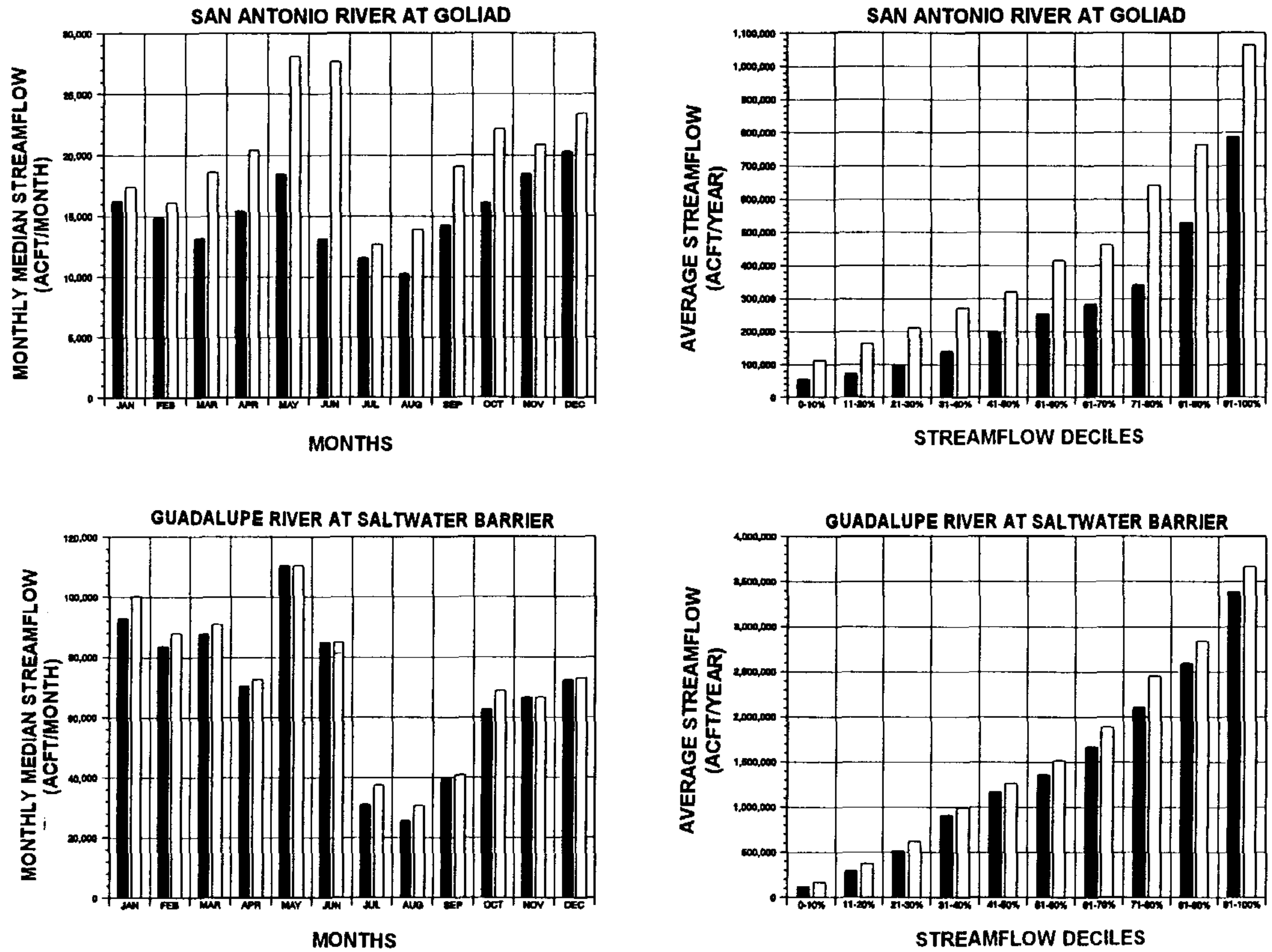
CHANGES IN STREAMFLOW CIBOLO RESERVOIR ALTERNATIVE -15

FIGURE 3.15-3



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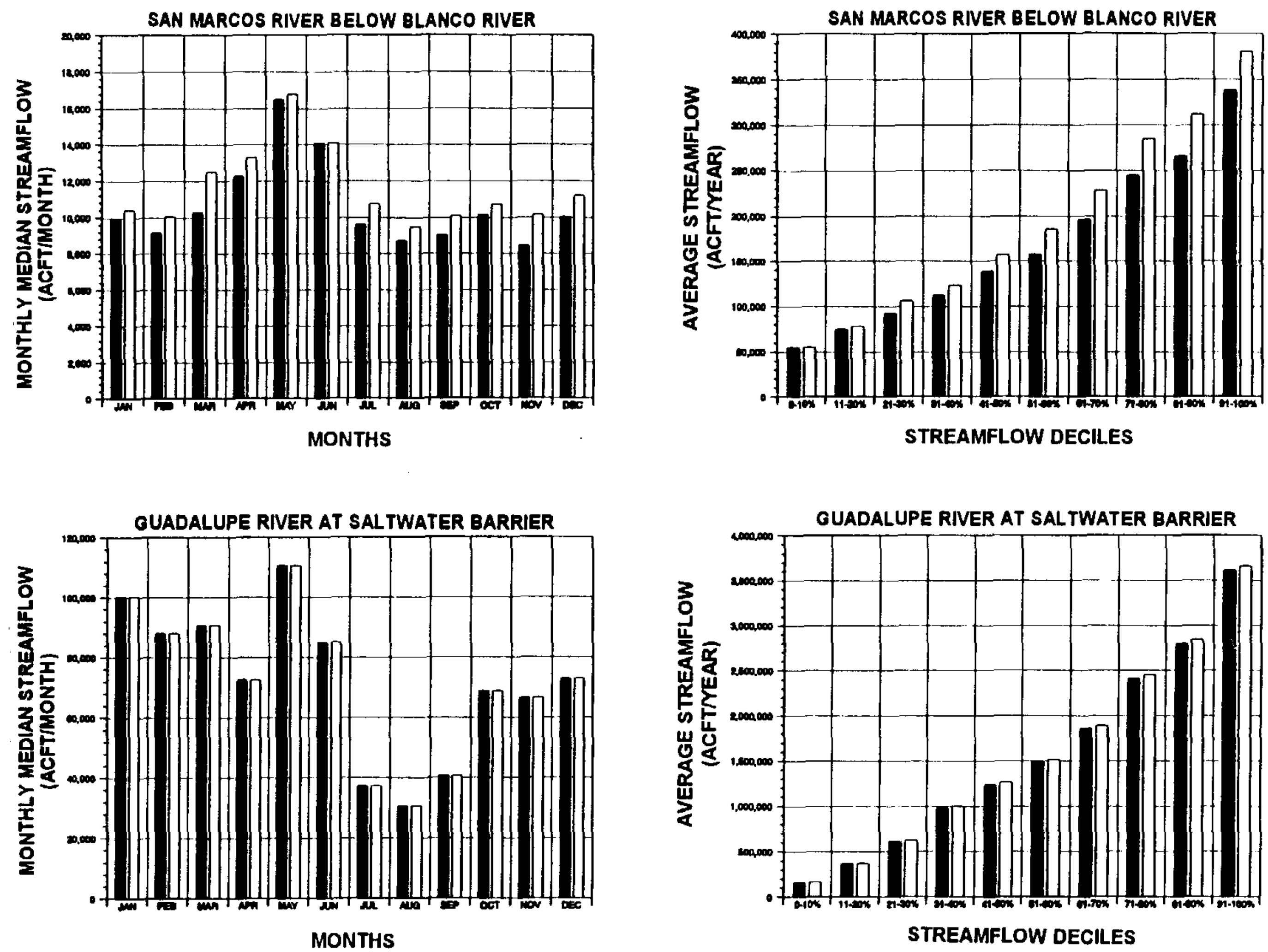
CHANGES IN STREAMFLOW GOLIAD RESERVOIR ALTERNATIVE S-16

FIGURE 3.16-3



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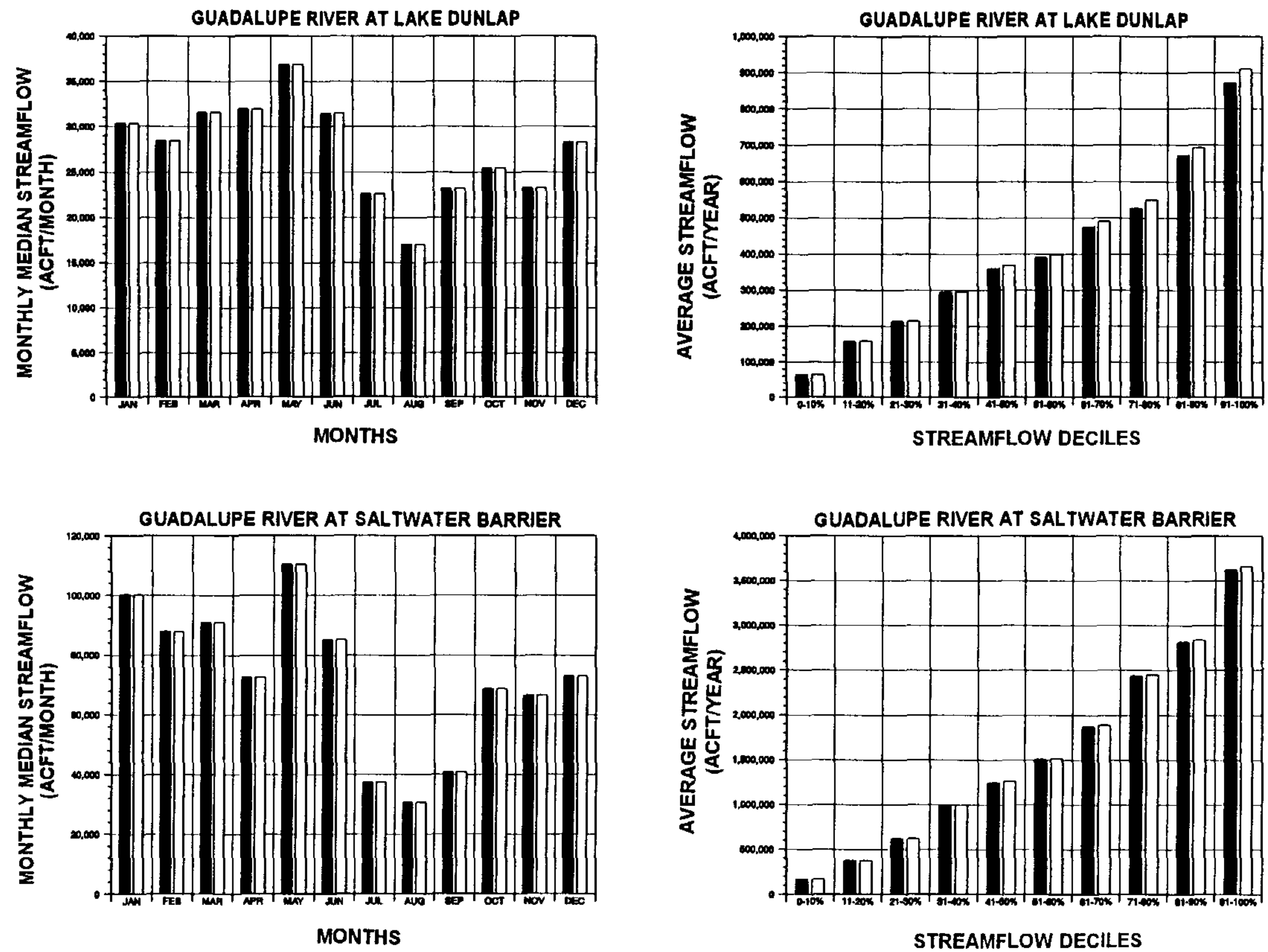
CHANGES IN STREAMFLOW
SAN MARCOS RIVER DIVERSION
ALTERNATIVE G-13

FIGURE 3.18 - 2



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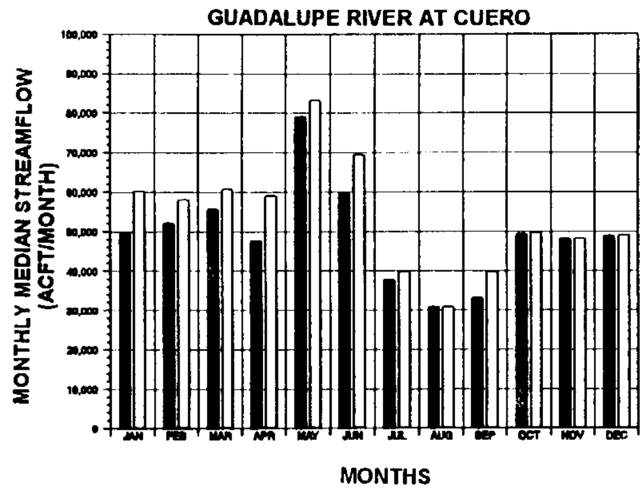
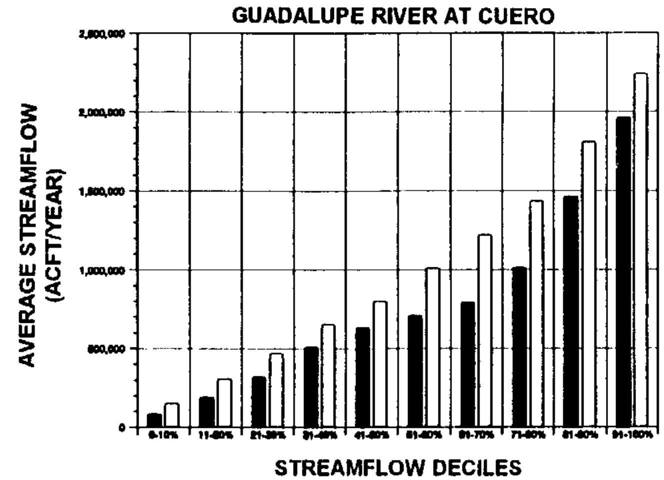
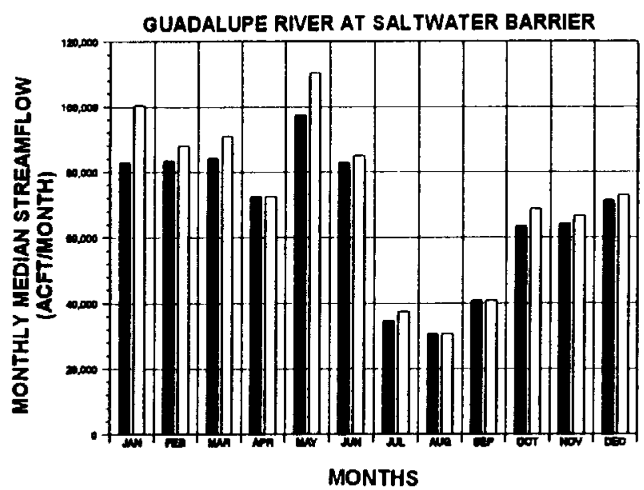
WEST CENTRAL STUDY AREA

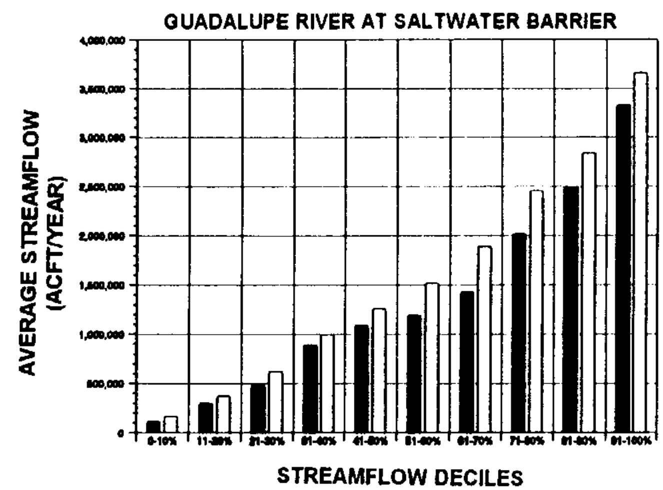
**CHANGES IN STREAMFLOW
LAKE DUNLAP DIVERSION
ALTERNATIVE G-14**

FIGURE 3.19 - 2









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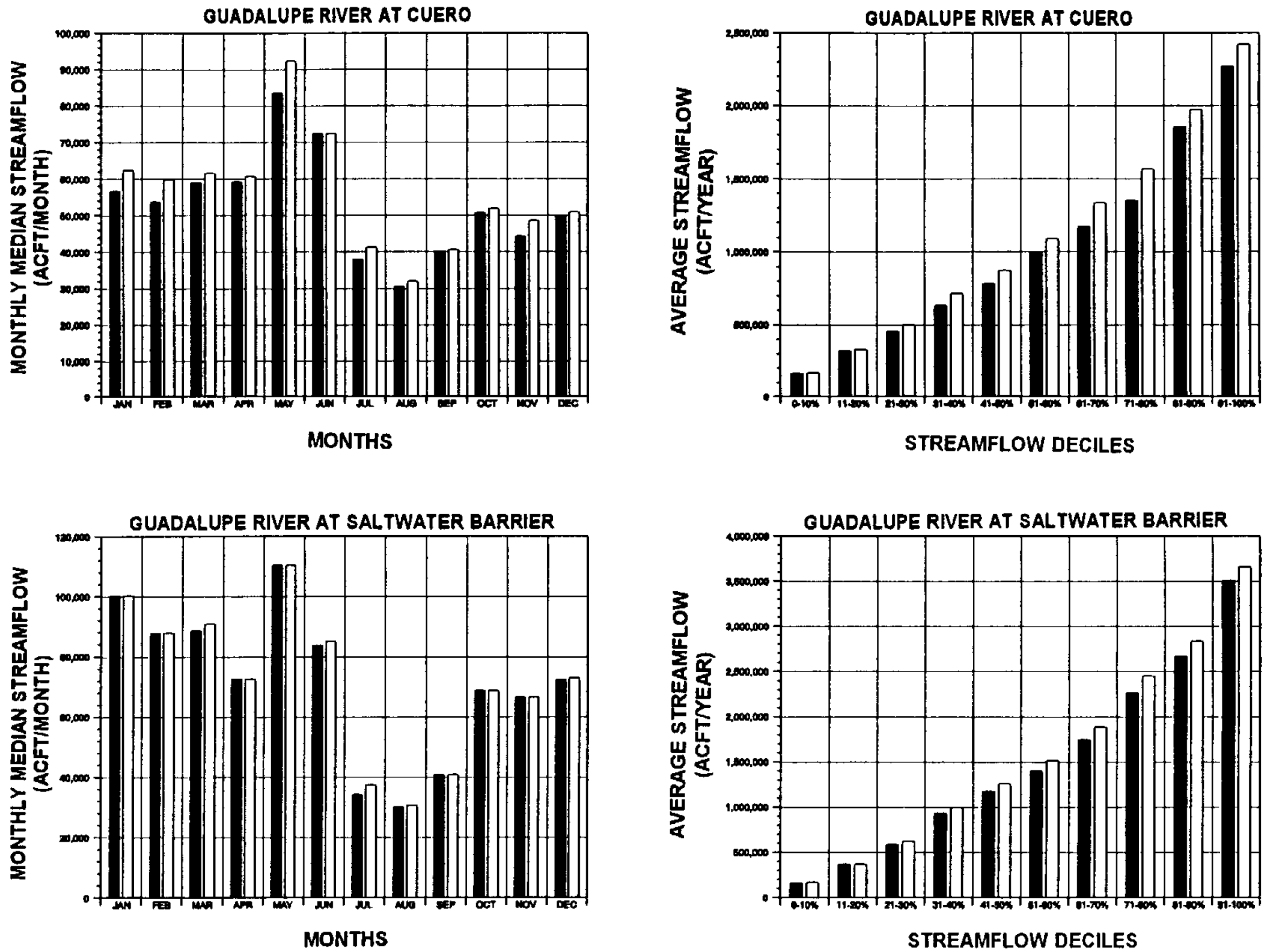
CHANGES IN STREAMFLOW CUERO RESERVOIR ALTERNATIVE G-16

FIGURE 3.21-3



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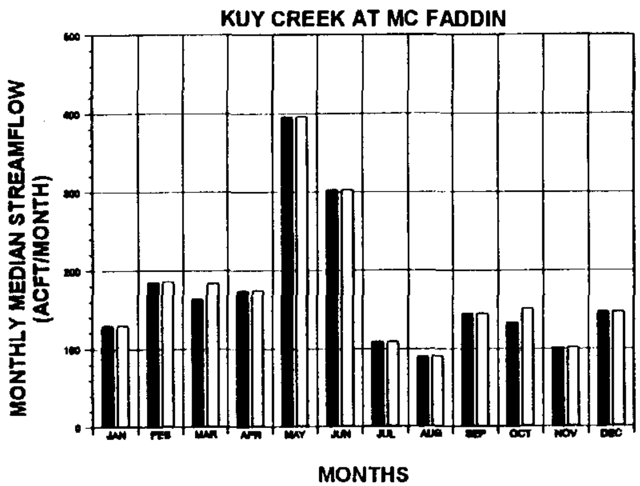
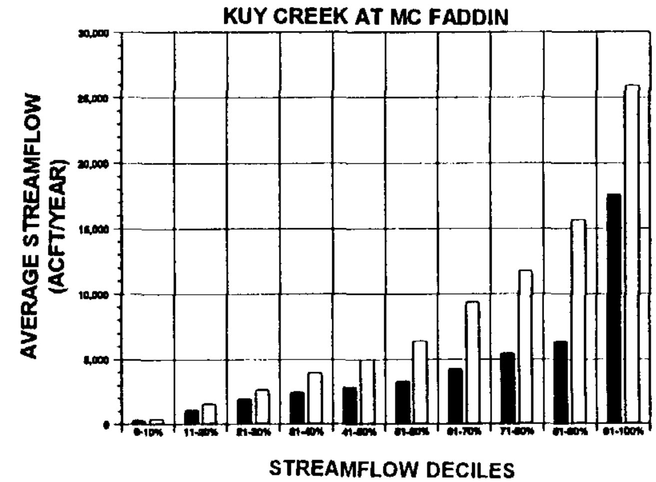
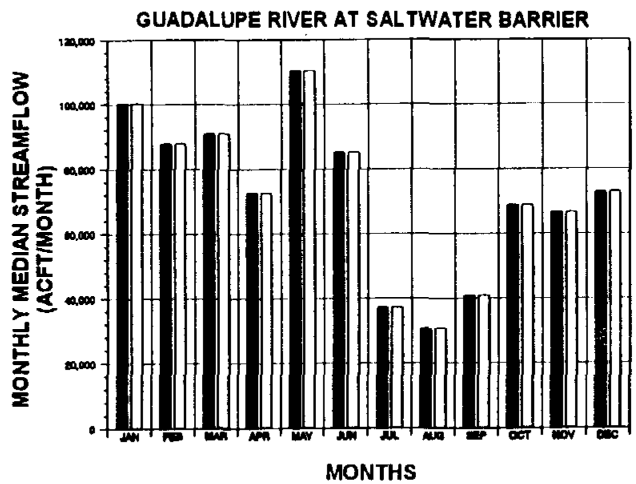
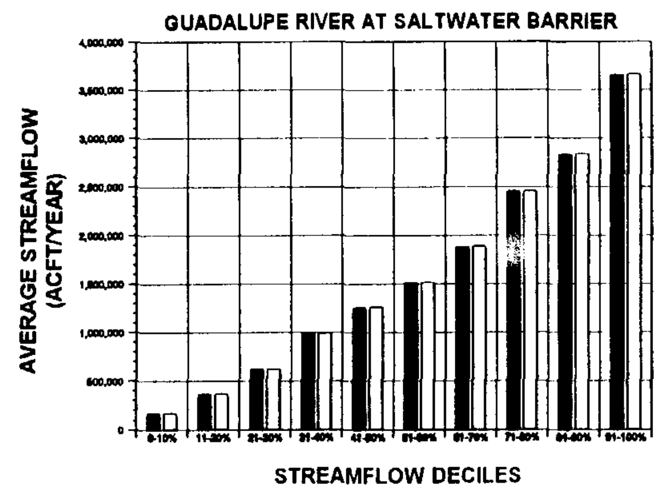
CHANGES IN STREAMFLOW - GUADALUPE RIVER WITH LINDENAU RESERVOIR - ALTERNATIVE G-17

FIGURE 3.22-3









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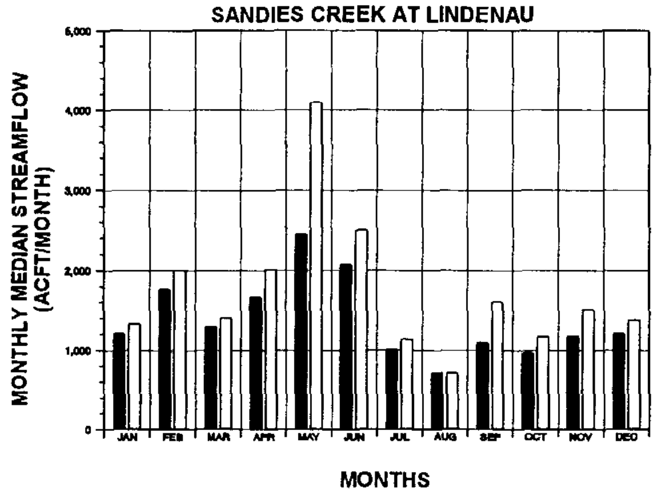
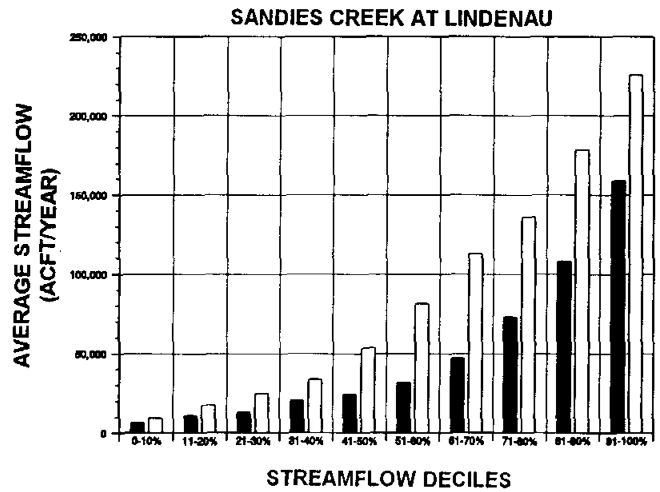
CHANGES IN STREAMFLOW MC FADDIN RESERVOIR ALTERNATIVE G-18

FIGURE 3.23-3





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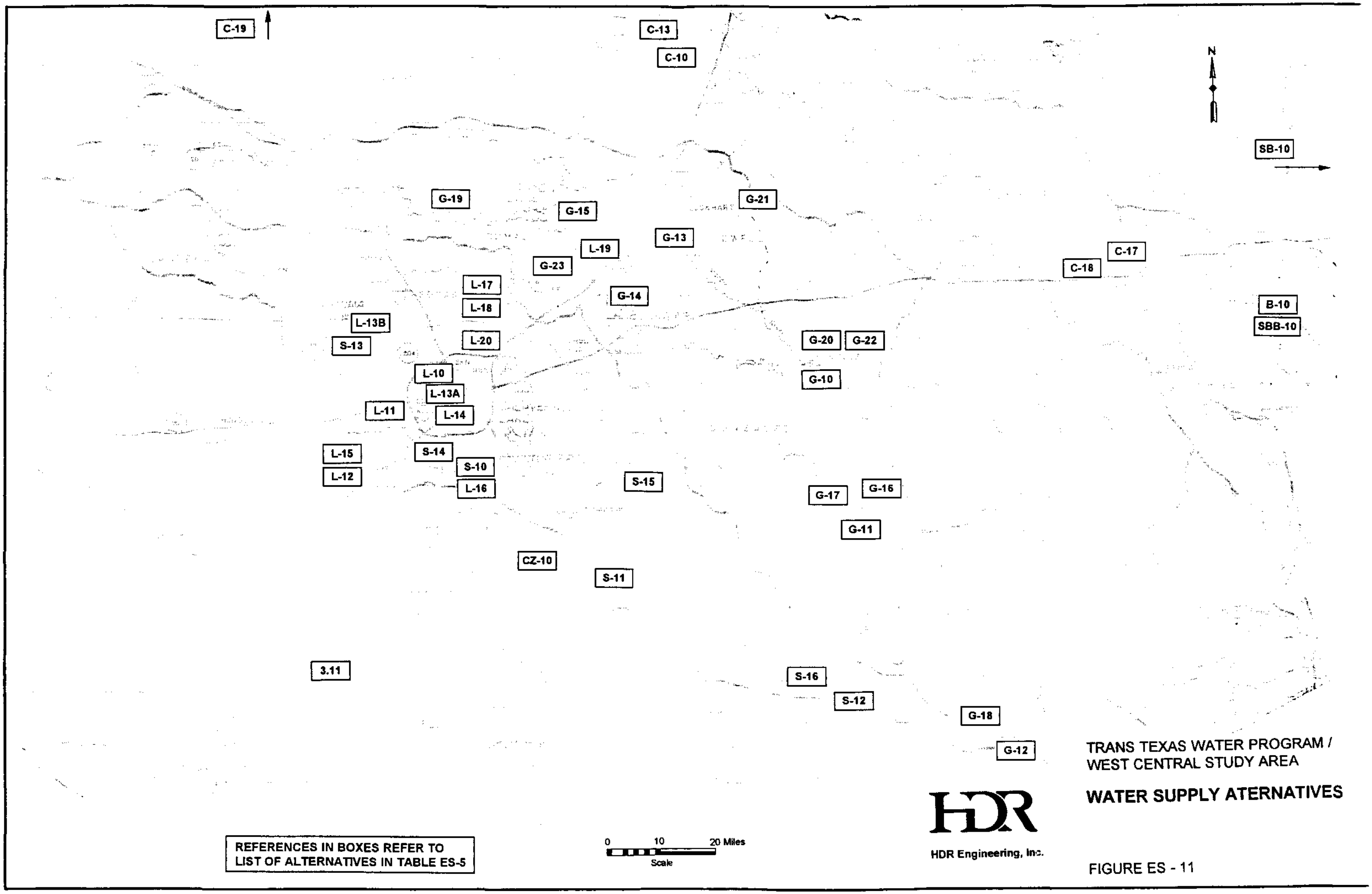
CHANGES IN STREAMFLOW - SANDIES CREEK AT LINDENAU RESERVOIR - ALTERNATIVE G-17

FIGURE 3.22 - 4



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WEST CENTRAL STUDY AREA

WATER SUPPLY ATERNATIVES

FIGURE ES - 11