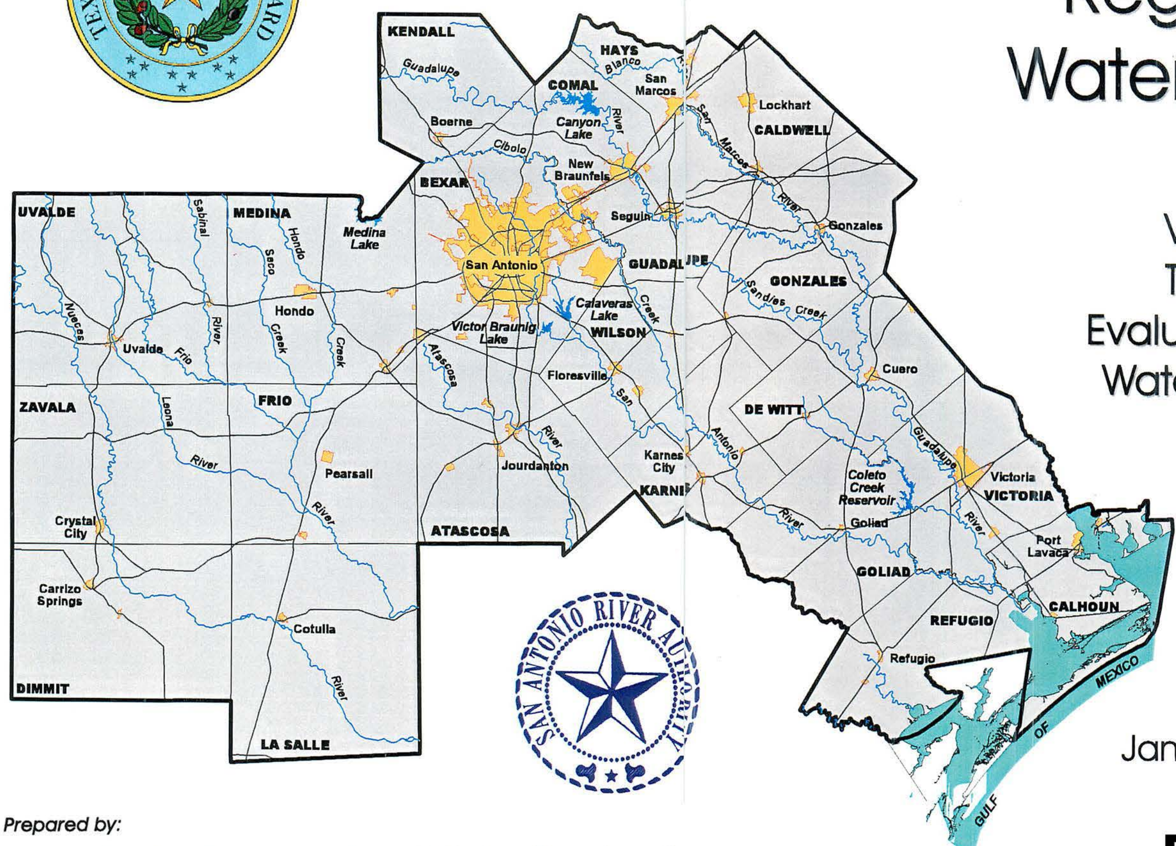
South Central Texas Regional Water Planning Area

Regional Water Plan

Volume III Technical Evaluations of Water Supply Options



January 2001

Part 2

Prepared by:

South Central Texas Regional Water Planning Group

With administration by:

San Antonio River Authority

With technical assistance by:

HDR Engineering, Inc.
Moorhouse Associates, Inc.
Open Forum

In association with:

Paul Price Associates, Inc
LBG-Guyton Associates
R.J. Brandes Company
The Wellspec Company

HDR Engineering, Inc.

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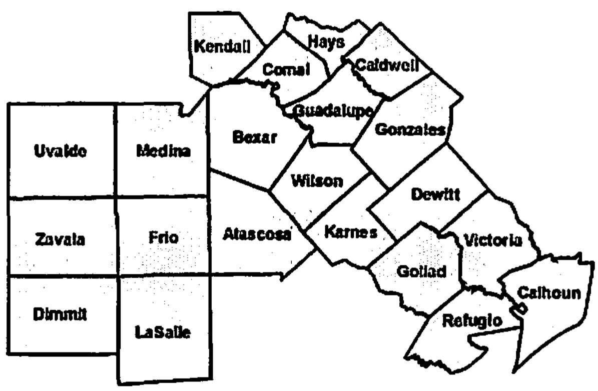

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January 2001

Volume I: Executive Summary and Regional Water Plan

Contents

Volume II: Technical Evaluations of Alternative Regional Water Plans

Contents

Volume III: Technical Evaluations of Water Supply Options

Contents

South Central Texas Regional Water Planning Area
Regional Water Plan

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As adopted by the South Central Texas
Regional Water Planning Group
on this date ______________________

South Central Texas Regional Water Planning Area

Regional Water Plan

01/04/01

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Table of Contents

Table of Contents
(continued)

Table of Contents (continued)

Table of Contents (continued)

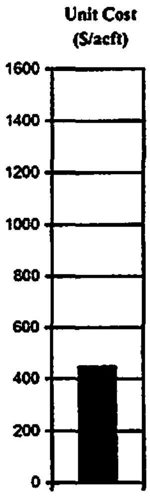
Section **Page**

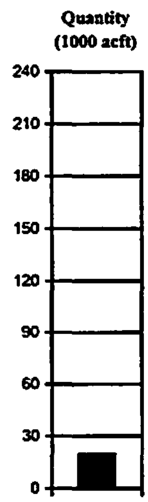
Appendices

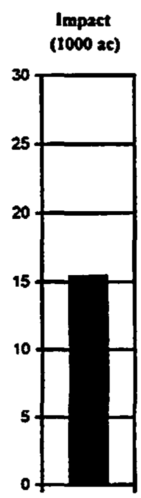
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

January 2001







OPTION NUMBER: G-22

OPTION NAME: **Dilworth Reservoir — Raw Water at the Reservoir**

OPTION DESCRIPTION: *Dilworth Reservoir site is located on Peach Creek, a tributary of the Guadalupe River, approximately 6 miles east of Gonzales in Gonzales County. At elevation 293 ft-msl, the conservation pool capacity would be 275,000 acft. Costs developed for raw water at the reservoir only.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☐ 5-15 yr. ☒ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	$446	per acft[1]	Raw Water at Reservoir
QUANTITY OF WATER:	19,705	acft/yr[2]	
LAND IMPACTED:	15,400	acres[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Embankment and spillway, outlet works, land, relocations, reservoir clearing, diversion and care of water, grout curtain, environmental studies and mitigation, and engineering and legal services. Depending upon the location(s) and type(s) of use for water supplies associated with Dilworth Reservoir, additional facilities and costs could include Guadalupe River diversion works, raw water intake at the reservoir, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

[2]**QUANTITY OF WATER:** Downstream water rights, instream flow requirements, and level of Edwards Aquifer pumpage. As the Dilworth Reservoir project is somewhat large for the Peach Creek watershed and located near the Guadalupe River, its firm yield could be enhanced with periodic diversions from the Guadalupe River, similar to that described for Sandies Creek Reservoir (Option G-17C1).

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity. This does not include land in the floodplain above the conservation pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of approximately 15,400 acres of land, including a 13-mile stretch of Peach Creek, a tributary to the Guadalupe River, and instream flow requirements. The land involved is 39 percent grass and cropland, 18 percent woodlands, 9 percent wetlands, 32 percent brush and scrublands, 1 percent riverine habitat, and 1 percent developed. The analyses were based upon consensus environmental criteria, which specifies conditions for storage and pass-through of flows to meet instream and bay and estuary needs.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and local reservoir area economic and social impacts.

ADDITIONAL FACTORS: Ability to obtain permits to develop the reservoir.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-16C1, G-17C1, and/or G-20.

5.9 Dilworth Reservoir (G-22)

5.9.1 Description of Option

The Dilworth dam and reservoir project is located at river mile 13.1 on Peach Creek, a tributary of the Guadalupe River, approximately 6 miles east of the City of Gonzales in Gonzales County. The USCE first proposed the project in 1950. The USCE report, "Report on Survey of Guadalupe and San Antonio Rivers and Tributaries, Texas for Flood Control and Allied Purposes," presented the Dilworth site as a flood control project. The site was not deemed very effective in a flood control role, however, and the dam and reservoir were not recommended for construction. The location of the dam is shown in Figure 5.9-1.

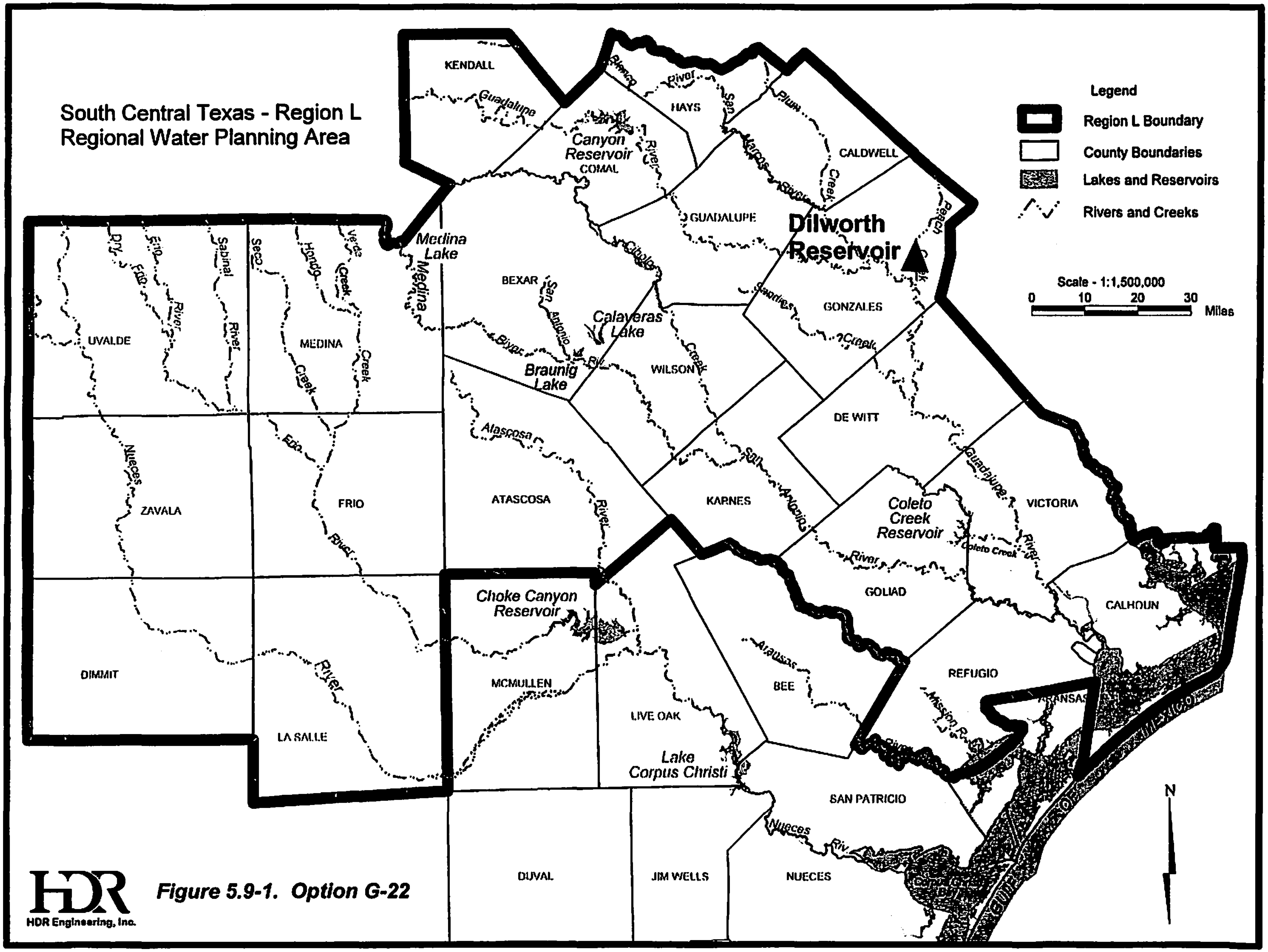
The dam would consist of a 15,700-foot earthen embankment with a top-of-dam crest elevation of 307 ft-msl (maximum dam height of 67 feet), to impound runoff from the 438 square mile watershed. The spillway system would consist of a 700-foot controlled concrete weir section with radial gates at a crest elevation of 280 ft-msl. The spillway design flood elevation would be 300 ft-msl, inundating approximately 20,700 acres. The reservoir would have a conservation pool capacity of 275,000 acft at elevation 293 ft-msl, permanently inundating 15,400 acres along a 13-mile segment of Peach Creek.

5.9.2 Water Availability

The firm yield of the proposed Dilworth Reservoir was computed utilizing the Environmental Water Needs of the Consensus Planning Process (Consensus Criteria, Appendix B and F). The GSA Model[1] was used to estimate daily total streamflow and unappropriated streamflow available at the reservoir site. General assumptions for this application of the GSA Model are as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

For modeling purposes, streamflows for Peach Creek below Dilworth (USGS# 08174600) were assumed representative of inflows to the proposed reservoir. These inflows are the naturalized flows at the reservoir, adjusted for upstream water rights and return flows. The GSA Model computes streamflow available for impoundment without causing increased shortages to downstream rights.

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



HDR Engineering, Inc.

Figure 5.9-1. Option G-22

The firm yield of the Dilworth Reservoir was computed using the inflows and pass-through flows computed by the GSA Model, and a modified version of the SIMDLY reservoir operation model (originally written by the Texas Water Development Board). The streamflow statistics used to determine the Consensus Criteria pass-through requirements are presented in Table 5.9-1. Subject to a uniform seasonal demand pattern, the firm yield of the project is 19,705 acft/yr (which represents a reliable water supply based on the 1934 to 1989 historical period of hydrologic record). In order to calculate an accurate firm yield estimate, the reservoir was assumed full at the start of the SYMDLY simulation, due to extremely low naturalized flows in 1934. Available flows for 1935 and 1936 are sufficient to fill the reservoir, accounting for evaporation and the estimated firm yield.

Table 5.9-1.
Daily Natural Streamflow Statistics
for the Dilworth Reservoir Site

Month	*Median Flows – Zone 1 Pass-Through Requirement (acft/day)*	*25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)*
January	20	1
February	24	4
March	20	1
April	10	1
May	26	2
June	16	1
July	2	1
August	1	1
September	1	1
October	1	1
November	7	1
December	10	1
Zone 3 Pass-Through Requirement[1] (acft/day)		1

[1] HDR natural 7Q2 (1934 to 1989).

Figure 5.9-2 illustrates the simulated Dilworth Reservoir storage fluctuations for the 1934 to 1989 historical period, subject to the firm yield of 19,705 acft/yr. Simulated reservoir storages remain above the Zone 2 trigger level (80 percent capacity) about 49 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 88 percent of the time over the 1934 to 1989 historical period. As the Dilworth Reservoir project is somewhat large for the Peach Creek watershed and located near the Guadalupe River, its firm yield could be enhanced with periodic diversions from the Guadalupe River. Such operation as a large-scale off-channel storage facility would be similar to that described for Sandies Creek Reservoir (Option G-17C1, Section 5.11). Figure 5.9-3 illustrates the changes in streamflow medians and frequencies caused by the reservoir at the project location and for the Guadalupe River at the Saltwater Barrier. Monthly median streamflows in Peach Creek would be reduced by about 90 percent at the project site. Monthly median freshwater inflows to the Guadalupe Estuary, as measured at the Saltwater Barrier, would be reduced by about 2 percent.

5.9.3 Environmental Issues

The Dilworth Reservoir project involves dam construction and inundation of approximately 15,400 acres along a 13-mile reach of Peach Creek, a tributary of the Guadalupe River. The proposed reservoir is located in northeastern Gonzales County on the boundary between the Texas Blackland Prairies and the East Central Texas Plains ecoregions,[2] in the Post Oak Savannah region of Texas,[3] and in the Texas biotic province.[4]

Vegetation types within the proposed Dilworth Reservoir project area include bottomland and upland woodlands, shrubland, grassland, cropland, and wetlands. Streamside vegetation within the proposed reservoir is typical of pecan-elm forests. These forests are found in bottomlands along the Brazos, Colorado, Guadalupe, San Antonio and Frio Rivers. They contain, among other species, American elm, cedar elm, pecan, cottonwood, sycamore, black willow, yaupon, greenbriar, Johnsongrass, frostweek and western ragweed.[5]

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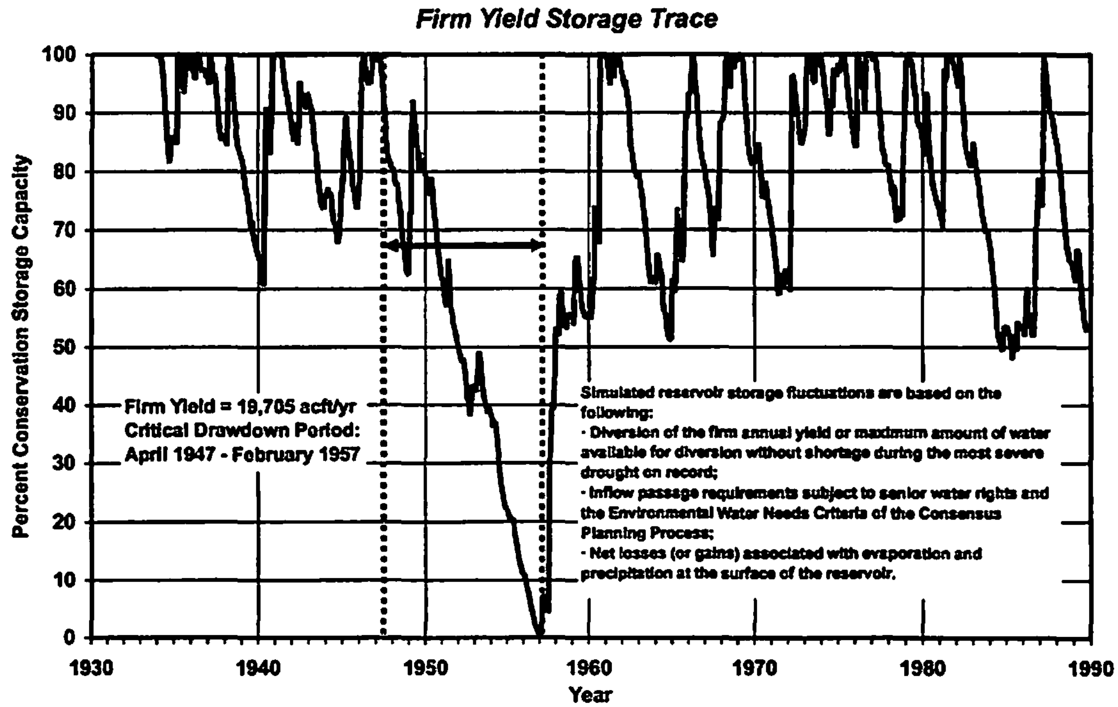
[2] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1), pp. 118-125, 1986.
[3] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1975.
[4] Blair, W.F., "The Biotic Provinces of Texas," Tex. J. Sci. 2:93-117, 1950.
[5] McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas, Including Cropland," Texas Parks and Wildlife Department, Austin, Texas, 1984.



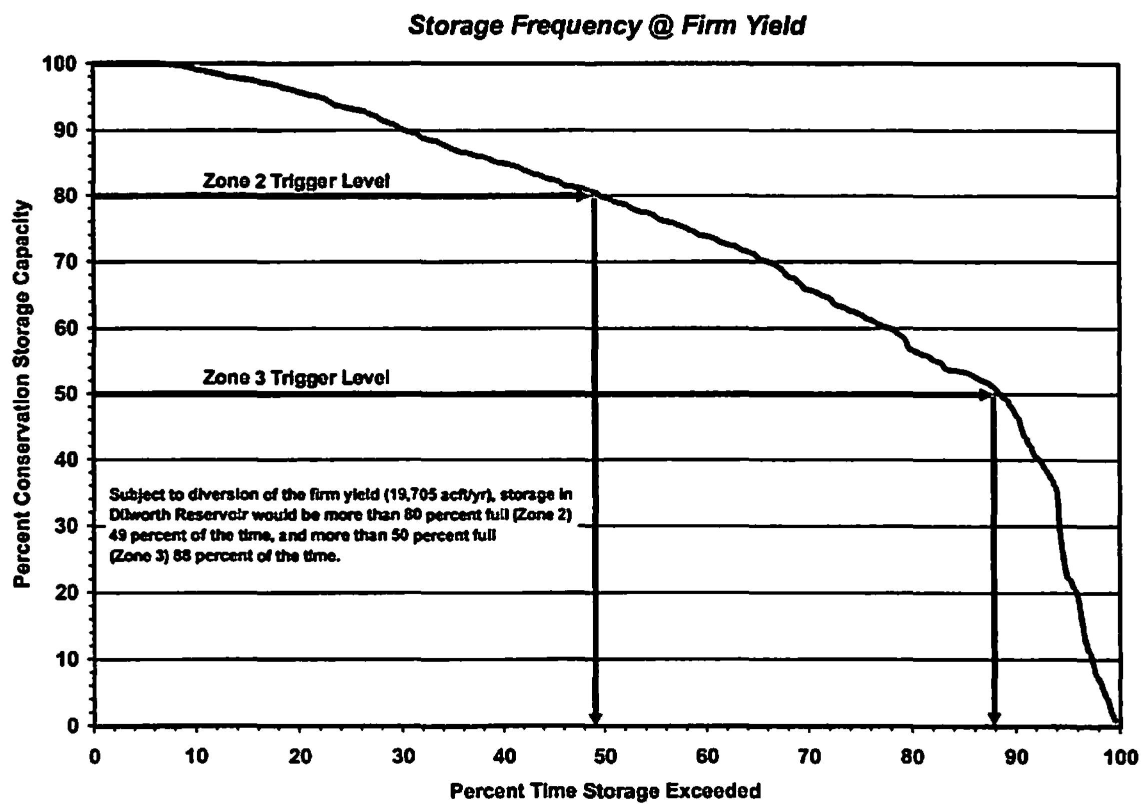


Figure 5.9-2. Dilworth Reservoir Storage Considerations

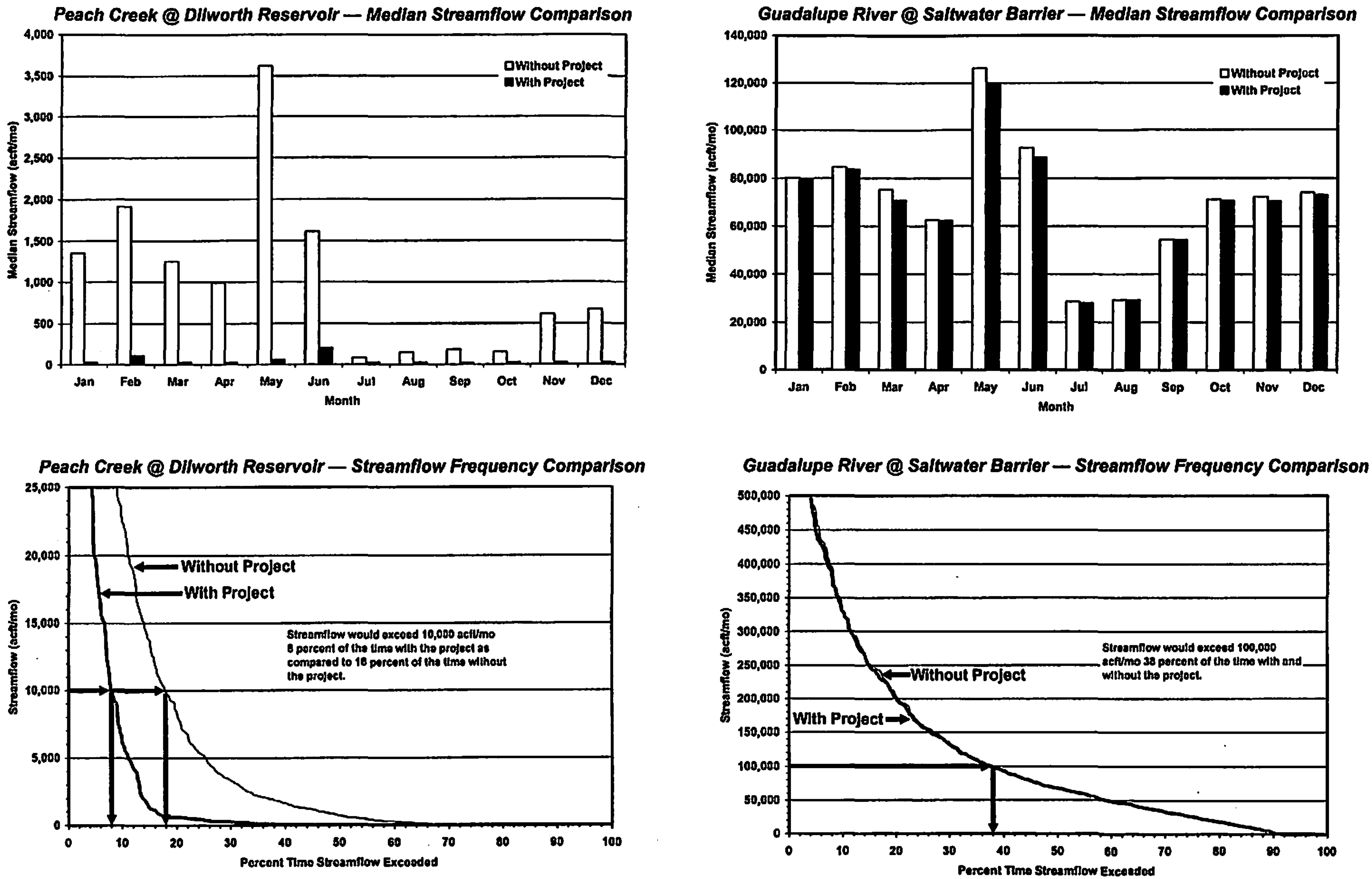


Figure 5.9-3. Dilworth Reservoir Streamflow Comparisons

Upland areas are dominated by post oak woods, forest and grassland mosaics. These areas are typically found on sandy soils. Common species include blackjack oak, eastern redcedar, mesquite, black hickory, live oak, hackberry, yaupon, American beautyberry, hawthorn, little bluestem, beaked panicum, three-awn and tickclover.[6]

Within the floodplains, soils are a calcareous black clay classified as Tinn clay and Bosque clay loam. These soils have the highest fertility in the county, thus making excellent cropland. Gholson and Sunev soils are a fine loamy sand found in uplands with slopes of 1 to 5 percent and 3 to 8 percent, respectively.[7]

Wetlands within the reservoir site include approximately 1,530 acres of palustrine forested, scrub/shrub, emergent and intermittent riverine wetlands.

The primary impacts that would result from construction and operation of the Dilworth Reservoir include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. The Dilworth Reservoir site would be permanently inundated to 293 ft-msl with a surface area of 15,400 acres. Approximately 5,049 acres of brushlands, 5,967 acres of grasslands and croplands, 2,754 acres of woodlands, 68 acres of riverine habitat, 1,462 acres of wetlands, and 100 acres of developed land would be converted to open water. Several lakes would be inundated by the reservoir, including Post Oak, Laws, Jones, Wood, Mooney, Pogue, Bailey, Lee, Rinehart, and Long. The town of Little New York and St. James Cemetery would also be inundated by the proposed reservoir. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Potential downstream impacts would include substantial reductions in monthly median streamflows below the dam, but minimal reductions of freshwater inflows to the Guadalupe Estuary. At the project site, monthly median flows would be reduced by a maximum of 98 percent in January, March, and May, with the reduction for other months ranging from 61 to 95 percent. Reductions in monthly streamflow would result primarily from the reservoir impounding flood flows, which constitute the majority of the monthly flows at the reservoir location. Low flows (those exceeded about 85 percent of the time) would be

[6] Ibid.
[7] U.S. Department of Agriculture, Soil Conservation Service (SCS), Personal communication with Gonzales County Soil Survey Staff, March 1994.

unchanged at the project site, largely due to the requirements of the Consensus Criteria. Such an operating regine can be expected to have substantial effects on the downstream biological community in Peach Creek. As a new reservoir without a current operating permit, the Dilworth Reservoir would likely be required to meet environmental flow requirements determined by site-specific studies. Guadalupe River flows at the Saltwater Barrier are relatively unaffected by the project, with an expected reduction in the mean annual flows of about 2.5 percent

Plant and animal species listed by USFWS, TPWD, and/or TOES as endangered or threatened, and those with candidate status for listing with potential habitat in Gonzales County are listed in Table 5.9-2. No protected species have been recorded on the site, but the area may provide potential habitat for ten threatened, endangered or candidate species that occur in Gonzales County. Other protected species may use habitats in the area during migration. A survey of the reservoir site may be required prior to dam construction to determine whether populations of or potential habitat for species of concern occur in the area to be impacted.

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). Implementation of this option is expected to require field surveys by qualified professionals to document vegetation/habitat types and cultural resources that may be impacted by the proposed reservoir. Where impacts to potential protected species habitat or significant cultural resources could not be avoided, additional studies would be necessary to evaluate habitat use and/or value, or eligibility for inclusion in the National Register of Historic Places, respectively. Compensation would be required for unavoidable adverse impacts involving net losses of wetlands.

5.9.4 Engineering and Costing

The cost estimate for this option is shown in Table 5.9-3. The portion of the estimate pertaining to the dam and reservoir is based on a previous cost estimate performed by the United States Study Commission in 1960,[8] subsequent to the USCE study. Inundated land and mitigation land acquisition, and operation and maintenance costs were developed in accordance with the standard cost estimating procedures summarized in Appendix A. Costs include land

[8] United States Study Commission – Texas, "Capacity Cost Curve for Dilworth Reservoir Site," May 1960.

Table 5.9-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Dilworth Reservoir (G-22)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C			Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/ Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes. Barrier islands and sandy areas				Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

purchased within the spillway design flood pool (elevation 300 ft-msl; 20,700 acres). Financing the project under the Senate Bill 1 assumptions (40 years at 6 percent annual interest) results in an annual expense of $8,269,406. Annual operation and maintenance costs total $528,000. The annual cost, including debt service and operation and maintenance, totals $8,797,406. For an annual firm yield of 19,705 acft, the resulting cost of raw water at the reservoir is $446/acft (Table 5.9-3). Depending upon the location(s) and type(s) of use for water supplies associated with Dilworth Reservoir, additional facilities and costs could include Guadalupe River diversion works, raw water intake at the reservoir, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

Table 5.9-3.
Cost Estimate Summary for
Dilworth Reservoir (G-22)
Second Quarter 1999 Prices

Item	Estimated Costs for Facilities
Capital Costs	
Dam and Reservoir (Conservation Pool: 275,000 acft; 15,400 acres; 293 ft-msl)	
Relocations	$205,000
Diversion and Care of Water	183,000
Reservoir Clearing	4,207,000
Embankment	12,836,000
Spillway	16,158,000
Outlet Works	1,613,000
Total Capital Cost	**$35,202,000**
Engineering, Legal Costs and Contingencies	$12,320,000
Environmental & Archaeology Studies and Mitigation	29,353,000
Land Acquisition and Surveying (20,700 acres)	30,388,000
Interest During Construction (4 years)	17,162,000
Total Project Cost	**$124,425,000**
Annual Costs	
Debt Service (6 percent, 40 years)	$8,269,406
Operation and Maintenance	528,000
Total Annual Cost	**$8,797,406**
Available Project Yield (acft/yr)	19,705
Annual Cost of Water ($ per acft) Raw Water at Reservoir	$446
Annual Cost of Water ($ per 1,000 gallons) Raw Water at Reservoir	$1.37

5.9.5 Implementation Issues

Implementation of Dilworth Reservoir could directly affect the feasibility of other water supply options under consideration, including G-16C1, G-17C1, and/or G-20.

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

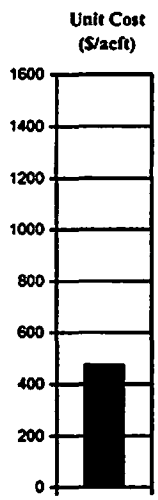
1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer approval depending upon location(s) of use.
   c. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. GLO Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. TPWD Sand, Gravel, and Marl permit.

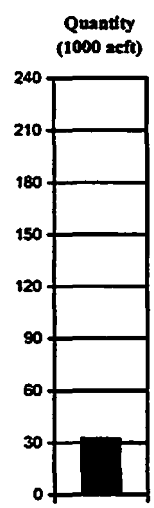
2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

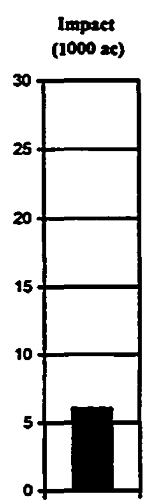
3. Land will need to be acquired through either negotiations or condemnation.

4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Other utilities.
   c. Structures of historical significance.
   d. Cemeteries.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: G-40

OPTION NAME: Cloptin Crossing Reservoir — Raw Water at the Reservoir

OPTION DESCRIPTION: *The Cloptin Crossing Reservoir site is located in Hays and Comal Counties, on the Blanco River, about 2 miles southwest of Wimberley. At elevation 980.5 ft-msl, the conservation pool capacity would be 275,000 acft. Costs developed for raw water at the reservoir only.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☐ 5-15 yr. ☒ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	$473	per acft[1]	Raw Water at Reservoir
QUANTITY OF WATER:	32,458	acft/yr[2]	
LAND IMPACTED:	6,060	acres[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Embankment and spillway, outlet works, land, relocations, reservoir clearing, diversion and care of water, grout curtain, environmental studies and mitigation, and engineering and legal services. Depending upon the location(s) and type(s) of use for water supplies associated with Cloptin Crossing Reservoir, additional facilities and costs include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

[2]**QUANTITY OF WATER:** Level of Edwards Aquifer pumpage, downstream water rights, and instream flow requirements.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity. This does not include land in the floodplain above the conservation pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of approximately 6,060 acres of land within the conservation pool, including a 13-mile reach of the Blanco River, and instream flow requirements. The land involved is 24 percent grassland, 14 percent brushland, 20 percent woodland, 38 percent developed land, 1 percent wetlands, and 3 percent riverine habitat. The analyses were based upon consensus environmental criteria, which specifies conditions for storage and passthrough of flows to meet instream and bay and estuary needs. Reservoir site in segment of Blanco River recommended for designation as Ecologically Unique by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and local reservoir area economic and social impacts.

ADDITIONAL FACTORS: Ability to obtain permits to develop the reservoir.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-16C1, G-17C1, G-20, G-38C, S-15Db, S-15Dc, S-15E, SCTN-16b, and/or SCTN-16c.

5.10 Cloptin Crossing Reservoir (G-40)

5.10.1 Description of Alternative

The Cloptin Crossing dam and reservoir project is a proposed reservoir located at river mile 32.5 on the Blanco River in Hays and Comal Counties, about 2 miles southwest of the town of Wimberley. The proposed project was described in detail by USCE in 1980 as a flood control and water supply project. The USCE report, "Cloptin Crossing Lake, Phase I General Design Memorandum," presented detailed siting information and found the project to be economically unfeasible.[1] The 1978 U.S. Bureau of Reclamation report, "Summary of Special Report, San Antonio-Guadalupe River Basins Study, Texas Basins Project," presents a summary of the project and a cost estimate. The location of the project is shown in Figure 5.10-1.

The dam would be a 7,520-foot earthen embankment with a top-of-dam crest elevation of 1,023 ft-msl (maximum dam height of 200 feet), to impound runoff from the 307 square mile watershed. The spillway system would consist of a 760-foot concrete weir section at a crest elevation of 998 ft-msl. The spillway design flood would inundate approximately 7,730 acres. The reservoir would have a conservation pool capacity of 274,900 acft at elevation 980.5 ft-msl, permanently inundating approximately 6,060 acres along a 13-mile segment of the Blanco River.

5.10.2 Water Availability

The firm yield of the proposed Cloptin Crossing Reservoir was computed utilizing the Environmental Water Needs of the Consensus Planning Process (Consensus Criteria, Appendices B and F). The GSA Model[2] was used to estimate daily total streamflow and unappropriated streamflow available at the reservoir site. General assumptions for this application of the GSA Model are as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

For modeling purposes, streamflows for the Blanco River at Wimberley (USGS# 08171000) were assumed representative of inflows to the proposed reservoir. These inflows are the naturalized flows from above the reservoir, adjusted for upstream water rights and return

[1] The benefit-cost ratio for the flood protection element was less than 1.0, thus, the project was declared to be unfeasible.
[2] HDR Engineering, Inc., "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.

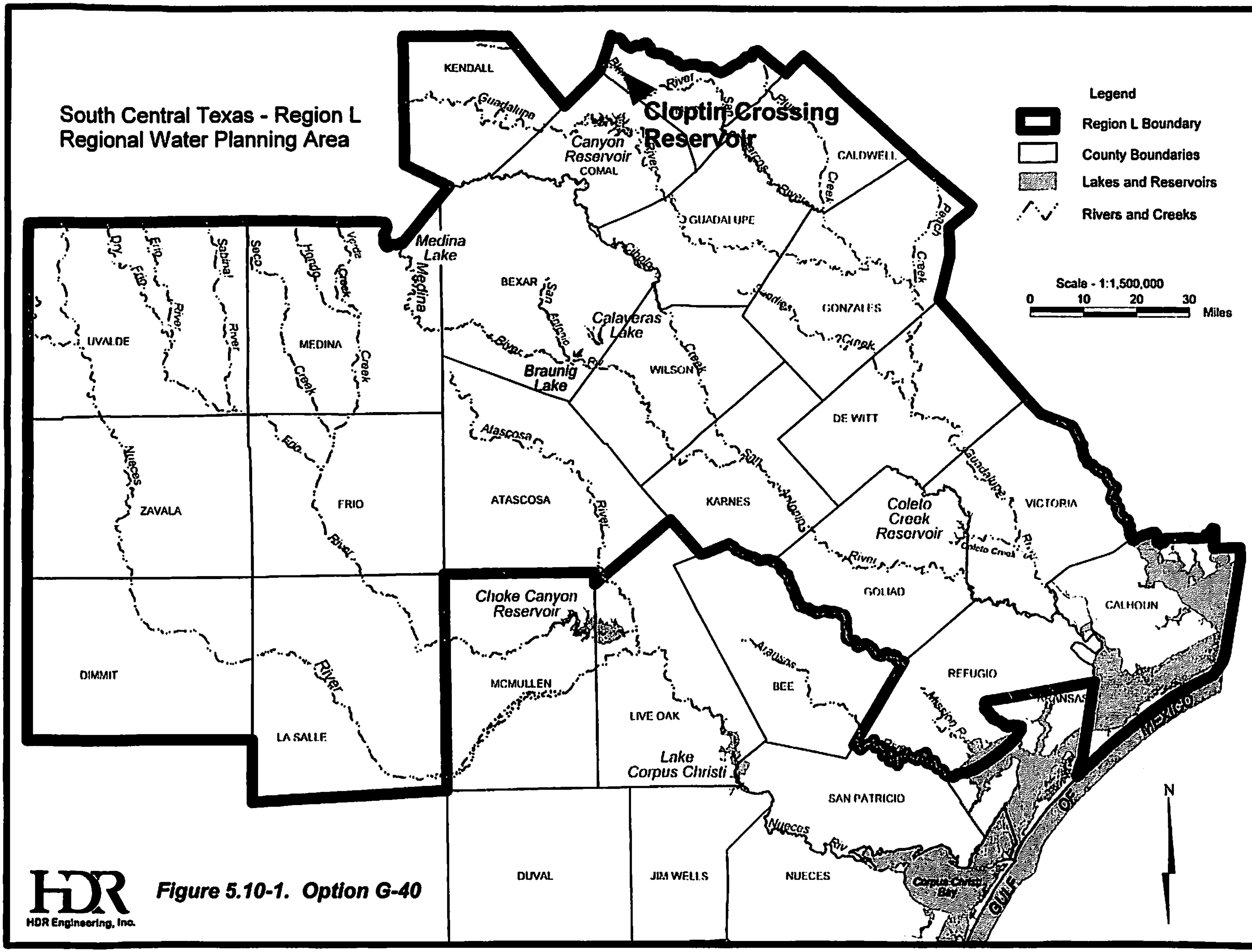


Figure 5.10-1. Option G-40

flows. The GSA Model computed the streamflow available for impoundment without causing increased shortages to downstream rights.

The firm yield of the Cloptin Crossing Reservoir was computed using the inflows and pass-through flows computed by the GSA Model, and a modified version of the SIMDLY reservoir operation model (originally written by the TWDB). The streamflow statistics used to determine the Consensus Criteria pass-through requirements are presented in Table 5.10-1. Subject to a uniform seasonal demand pattern, the firm yield of the project is 32,458 acft/yr, which represents a reliable supply based on the 1934 to 1989 historical period of hydrologic record. In order to calculate an accurate firm yield estimate, the reservoir was assumed full at the start of the SYMDLY simulation, due to extremely low naturalized flows in 1934. Available flows in the 1930s are sufficient to fill the reservoir prior to the critical drawdown period, accounting for evaporation and the estimated firm yield.

Table 5.10-1. Daily Natural Streamflow Statistics for the Cloptin Crossing Reservoir Site

Month	*Median Flows – Zone 1 Pass-Through Requirement (acft/day)*	*25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)*
January	105	52[1]
February	121	59[1]
March	137	58[1]
April	161	63
May	167	74
June	161	77
July	107	44[1]
August	65	34[1]
September	81	37[1]
October	96	40[1]
November	93	43[1]
December	105	44[1]
Zone 3 Pass-Through Requirement[2] (acft/day)		63

1 When the Zone 3 pass-through requirement is greater than the 25th percentile flow, the 25th percentile flow is superceded by the Zone 3 pass-through requirement.
2 Water Quality Standard (TNRCC 7Q2).

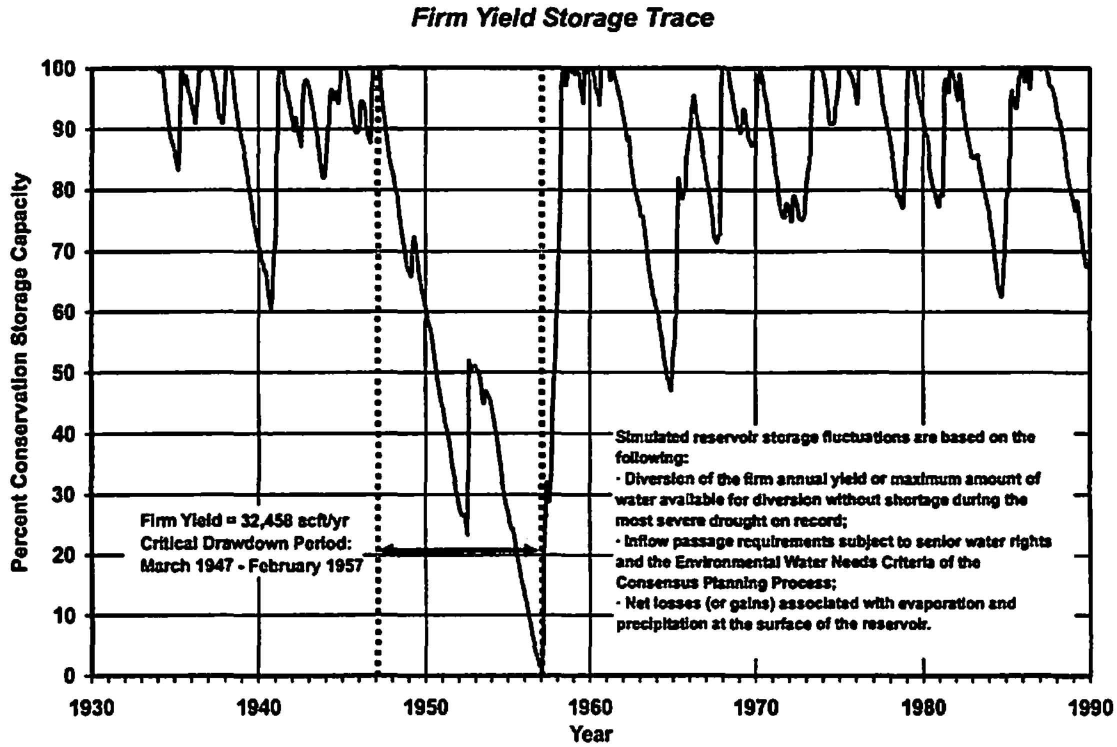
Figure 5.10-2 illustrates the simulated Cloptin Crossing Reservoir storage fluctuations for the 1934 to1989 historical period, subject to the firm yield of 32,458 acft/yr. Simulated reservoir storages remain above the Zone 2 trigger level (80 percent capacity) about 63 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 88 percent of the time over the 1934 to 1989 historical period. Figure 5.10-3 illustrates the changes in streamflow medians and frequencies caused by the reservoir at the project location and for the Guadalupe River at the Saltwater Barrier. Monthly median streamflows in the Blanco River would be reduced about 38 percent at the project site. Monthly median freshwater inflows to the Guadalupe Estuary, as measured at the Saltwater Barrier, would be reduced by about 3 percent.

5.10.3 Environmental Issues

The Cloptin Crossing Reservoir project involves dam construction and inundation of approximately 6,060 acres along a 13-mile reach of the Blanco River approximately 2 miles from Wimberley in Hays County. The dam centerline would be located approximately one-half mile upstream from Cloptin Crossing.

The proposed reservoir is located on the Edwards Plateau,[3] upstream of the Balcones Fault Zone and Blackland Prairie, and in the Texan biotic province.[4] Vegetation types within the project area on the Blanco River include riparian and upland woodland, park, brush, grassland, and wetland. Edwards Plateau vegetation has historically been grassland or open savannah-type plains with tree and understory species distributed primarily on rocky slopes and in stream bottoms. Throughout the more savannah-type level to rolling uplands of the Edwards Plateau, brush species (particularly Ashe juniper and mesquite) are common invaders, while the steeper canyon slopes have historically supported a dense oak-Ashe juniper thicket. The most important climax grasses of the Plateau include switchgrass (*Panicum virgatum*), several species of bluestems and gramas, Indian grass (*Sorghastrum nutans*), Canada wild-rye (*Elymus canadensis*), curly mesquite (*Hilaria berlangeri*), and buffalograss (*Buchloe dactyloides*). The rough, rocky areas typically support a tall or mid-grass understory and a brush overstory complex consisting primarily of live oak (*Quercus virginiana*), Texas oak (*Q. buckleyi*), shinnery oak (*Q. havardii*), Ashe juniper (*Juniperus ashei*), and mesquite (*Prosopis glandulosa*).

[3] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1962.
[4] Blair, W.F, "The Biotic Provinces of Texas," Texas Journal of Science 2:93-117, 1950.



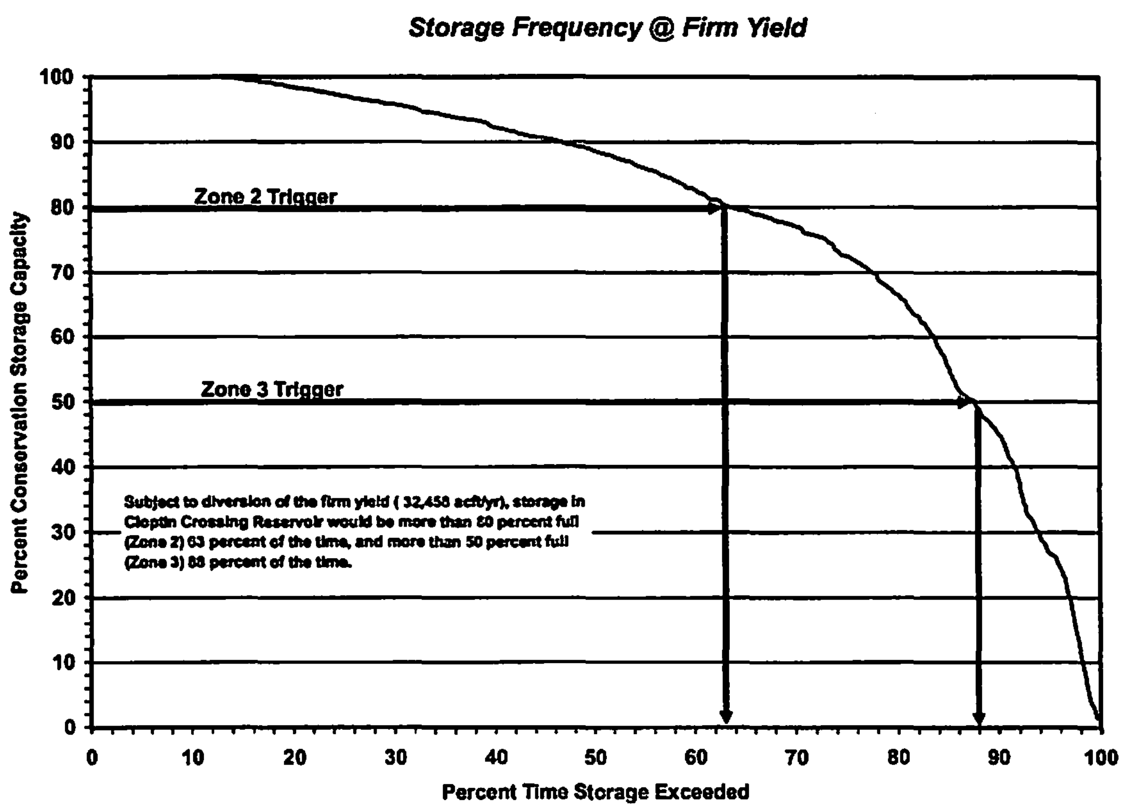


Figure 5.10-2. Cloptin Crossing Reservoir Storage Considerations

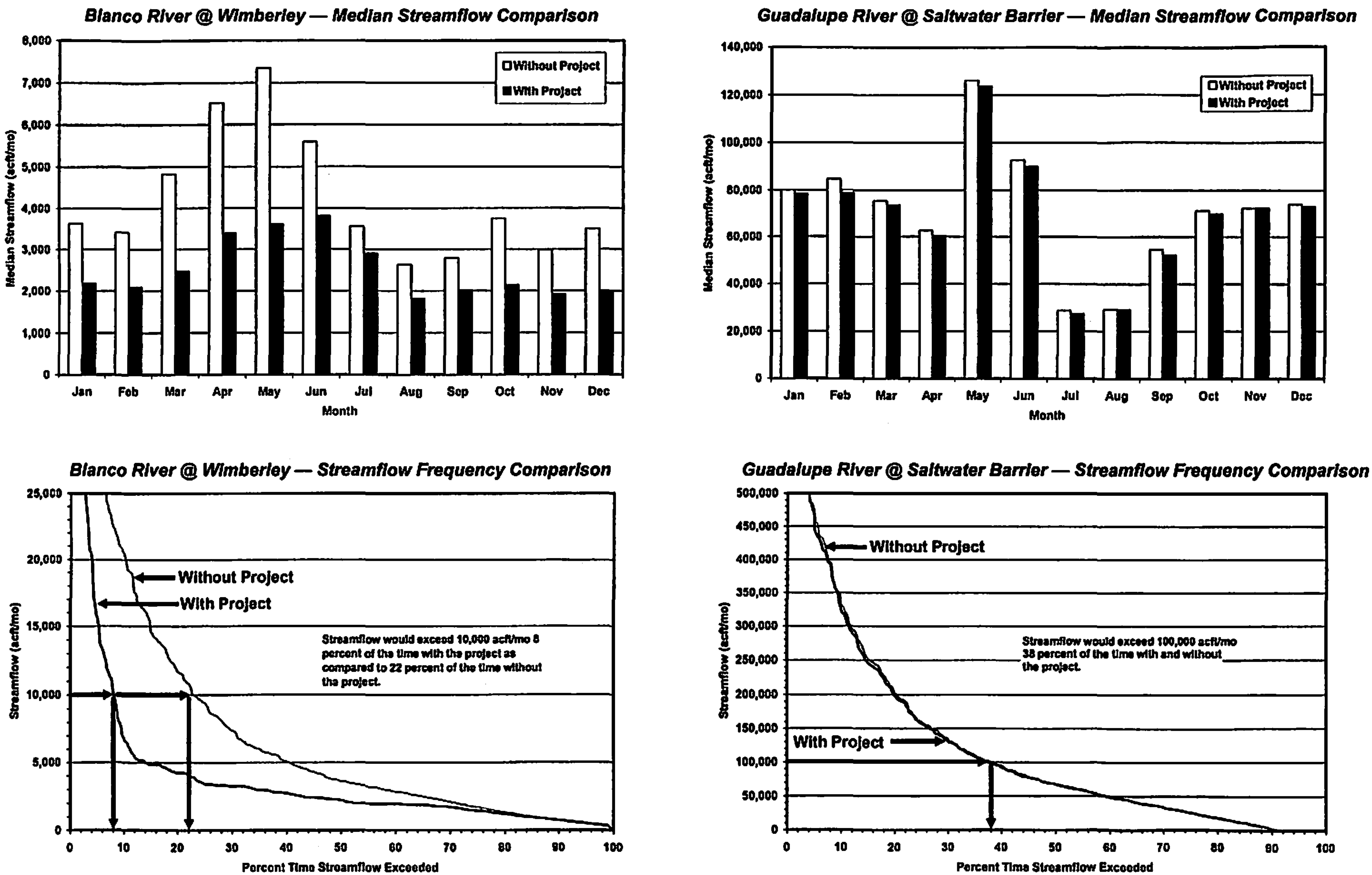


Figure 5.10-3. Cloptin Crossing Reservoir Streamflow Comparisons

Mesic stream bottom habitats were created as rivers and tributary streams, fed by numerous springs that occur at the base of the Edwards limestone, cut canyons through the plateau and formed isolated, mesic habitats that harbor a variety of plant species exhibiting disjunct distributions or endemism. Because of the many large canyons and rugged terrain, this area is of much botanical interest, and consequently has been visited by many collectors. The ferns, and many of the flowering plants which are common to the area are primarily lithophilous ("rock-loving"), and are represented primarily by various species of lipferns (*Cheilanthes* spp.), cloak-ferns (*Notholaena* spp.), and cliff brakes (*Pellaea* spp.). Columbine (*Aquilegia canadensis*) and endemic species such as anemone *(Anemone edwardsianas)* and wand butterfly-bush (*Buddlega racemosa*) also are present. These plants are sometimes found together with species such as mockorange (*Philadelphus* spp.), American smoke-tree (*Cotinus americana*), spicebush (*Benzoin aestivale*), and the endemic silver bells (*Styrax platanifolia* and *S. texana*) on large boulders and in shaded ravines.

The surface geology of the Cloptin Crossing Reservoir site is Cretaceous Glen Rose Limestone.[5] The soil units that have formed over these limestones are predominantly thin soils from the Brackett-Rock Outcrop-Comfort Complex (undulating), Brackett-Rock-Real Outcrop Complex (steep), Boerne Fine Sandy Loam (1 to 3 percent slopes), Lewisville Silty Clay (0 to 1 percent slopes), Lewisville Silty Clay (1 to 3 percent slopes), Purves Clay, and Oakalla Silty Clay Loam (rarely flooded).[6] The soils within the floodplain range from shallow to deep and are used typically for pastureland, cropland, and wildlife habitat.

Wetlands within the conservation pool include approximately 255 acres of riverine and palustrine habitats. Associated with the channel and banks of the Blanco River, the aquatic habitats are predominantly lower perennial riverine and palustrine that have substrates composed of both bedrock and unconsolidated bottom that are permanently flooded. The smaller drainages feeding the Blanco River are described as intermittent riverine habitats with streambeds that are temporarily flooded. A few small stock ponds are found within the upland area surrounding the project site.

[5] Fisher, W.L, "Geologic Atlas of Texas: San Antonio Sheet," Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas, 1983.
[6] Batte, C.D, "Soil Survey of Comal and Hays Counties, Texas," United States Department of Agriculture Natural Resource Conservation Service, 1984.

The primary impacts that would result from construction and operation of the Cloptin Crossing Reservoir include conversion of existing habitats, including existing stream habitats, and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing temperature, water quality, and flow regimes. Permanent inundation of the Cloptin Crossing Reservoir site would create a conservation pool with a surface area of 6,060 acres. Approximately 1,448 acres of grassland, 848 acres of brushland, 1,236 acres of woodland, 81 acres of wetlands, 174 acres of riverine habitat, and 2,273 acres of developed land would be converted to open water. In addition to long-term impacts within the conservation pool, minor changes to existing resources situated between the conservation pool elevation and maximum flood pool elevation are anticipated due to temporary inundation during flood events. Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Potential downstream impacts would include modification of the stream flow regime below the dam, and a minimal reduction of inflows to the Guadalupe Estuary. At the project site, monthly median flows would be reduced by a maximum of 51 percent in May, with the reduction for other months ranging from 18 to 49 percent. Low flows (those exceeded about 85 percent of the time) will be unchanged at the project site, largely due to the requirements of the Consensus Criteria. As a large new reservoir without a current water rights permit, the Cloptin Crossing Reservoir would likely be required to meet environmental flow requirements determined by site-specific studies. Guadalupe River flows at the Saltwater Barrier are relatively unaffected by the project, with an expected reduction in the mean annual flow of about 2 percent

Plant and animal species listed by USFWS, TPWD, and TOES as endangered or threatened, and those with candidate status for listing with potential habitat in Hays and Comal Counties are listed in Table 5.10-2. Although the most current TPWD data files show no reports of any federally or state listed endangered or threatened species, or TOES species of concern within the footprint of the proposed project, few surveys in the area have been conducted and an intensive survey of the project area would be required to assess the habitats within the project area accurately and determine the possibility of any associated threatened or endangered species occurrence. The species listed in Table 5.10-2 may not necessarily be encountered within the

Table 5.10-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Cloptin Crossing Reservoir (G-40)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Blanco Blind Salamander	*Eurycea robusta*	Troglobitic; Stream bed of the Blanco River		T	T	Resident
Blanco River Springs Salamander	*Eurycea pterophila*	Subaquatic; Springs and caves of the Blanco River				Resident
Blue Sucker	*Cycleptus elongatus*	Channels and flowing pools with exposed bedrock		T	WL	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C		C	Resident
Canyon Mock-Orange	*Philadelphus ernestii*	Edwards Plateau			WL	Resident
Cascade Caverns Salamander	*Eurycea latitans*	Endemic; Subaquatic; Springs and caves		T	T	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau				Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Cling to objects in streams; adults fly especially at night	E			Resident
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Comal and San Marcos Springs	E			Resident
Comal Springs Salamander	*Eurycea sp. 8*	Endemic; Comal Springs				Resident
Dark Noseburn	*Tragia nigricans*	Deciduous woodlands, clay or clay loams, mesic canyons			WL	Resident
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Habitat poorly known; known from artesian well				Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau				Resident
Flint's Net-Spinning Caddisfly	*Cheumatopsyche flinti*	"a spring"				Resident
Fountain Darter	*Etheostoma fonticola*	San Marcos and Comal rivers; springs and spring-fed streams	E	E	E	Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant
Hill Country Wild-Mercury	*Argythamnia aphoroides*	Shallow to moderately deep clays; live oak woodlands			WL	Resident
Horseshoe Liptooth	*Polygyra hippocrepis*	Steep, wooded hillsides of Land Park in New Braunfels				Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident
Lindheimer's Tickseed	*Desmodium lindheimeri*	Presumably flowers in mid-summer			WL	Resident

Table 5.10-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Peck's Cave Amphipod	*Stygobromus pecki*	Underground in Edwards aquifer	E			Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies				Resident
San Marcos Gambusia (extirpated)	*Gambusia georgei*	Endemic; upper San Marcos River	E	E	E	Resident
San Marcos Saddle-case Caddisfly	*Protoptila arca*	Swift; well-oxygenated warm water 1-2 m deep				Resident
San Marcos Salamander	*Eurycea nana*	Headwaters of the San Marcos River	T	T	T	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear				Resident
Texas Amorpha	*Amorpha roemeriana*					Resident
Texas Blind Salamander	*Eurycea rathbuni*	Troglobitic; Caverns along 6 mile stretch of San Marcos Springs Fault	E	E	T	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures				Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	*Philadelphus texensis*	Endemic; Limestone cliffs and boulders in mesic stream bottoms and canyons			WL	Resident
Texas Salamander	*Eurycea neotenes*	Edwards Aquifer creek gravel bottoms, emergent vegetation; underground & rock ledges				Resident
Texas Wild-Rice	*Zizania texana*	Upper 2.5 km of the San Marcos River	E	E	E	Resident
Warnock's Coral Root	*Hexalectris warnockii*	Oak-juniper woodlands in mountain canyons; terraces along creekbeds				Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division. Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

project area. The TPWD data files show a number of important species within 2 miles of the proposed project site, including Golden-cheeked warbler (*Dendroica chrysoparia*), glass mountains coral-root (*Hexalectris nitida*), Texas amorpha (*Amorpha roemeriana*), Texas Mock-Orange (*Philadelphus texensis*), Dark Noseburn (*Tragia nigricans*), and Texas Salamander (*Eurycea neotenes*). Also found within two miles of the proposed project site is the Ashe juniper-Oak series which is considered important nesting and foraging habitat for the federally and state endangered Golden-cheeked warbler and Black-capped vireo (*Vireo atricapillus*).

There are several species that may inhabit locations within the vicinity of the reservoir. The Blanco River Springs Salamander (*Eurycea pterophila*) resides within the springs and caves of the Blanco River, while the threatened Blanco Blind Salamander (*Eurycea robusta*) hold habitat in the streambed. The threatened Texas Garter Snake (*Thamnophis sirtalis annectens*) is found in bottomlands and pastures, but especially in wet areas. The Texas horned lizard (*Phrynosoma cornutum*) may be present in grassland areas, while the Plains Spotted Skunk (*Spilogale putorius interrupta*) occupies tall grass prairies and wooded, brushy areas. The Spot-tailed Earless Lizard (*Holbrookia lacerata*) may be found in oak-juniper woodlands and locations characterized by mesquite and prickly pear.

A search of the database at the Texas Archeological Research Laboratory (TARL) revealed 27 archeological sites recorded from within the general area of the proposed conservation pool. Prior to inundation, it must be determined if any cultural properties are located within the conservation pool by an on-site survey. Once all cultural properties within the conservation pool are identified, they will undergo preliminary assessment to determine the significance and potential for eligibility in the Register of Historic Places. Because the assessment methods used during the survey are limited in their ability to determine significance potential, some sites may have to undergo more extensive test-level investigations before their eligibility can be adequately determined. If cultural resource properties are determined to be eligible, additional work may be required by the State Historic Preservation Officer to protect the site, or to mitigate for unavoidable impacts. 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 Archeological and Historic Preservation Act (PL93-291).

5.10.4 Engineering and Costing

The cost estimate for this option is shown in Table 5.10-3. The portion of the estimate pertaining to the dam and reservoir is based on a previous cost estimate performed by the U.S. Bureau of Reclamation. Inundated land and mitigation land acquisition, and operation and maintenance costs were developed in accordance with the standard costing methodology presented in Appendix A. Costs include land purchased within the spillway design flood pool (elevation 998 ft-msl; 7,730 acres). Financing the project under the Senate Bill 1 assumptions

Table 5.10-3.
Cost Estimate Summary for
Cloptin Crossing Reservoir (G-40)
(Second Quarter 1999 Prices)

Item	Estimated Cost
Capital Costs	
Dam and Reservoir[1] (Conservation Pool: 275,000 acft; 6,060 acres; 980.5 ft-msl)	$47,757,000
Total Capital Cost	**$47,757,000**
Engineering, Contingencies and Legal Costs	$16,715,000
Environmental & Archaeology Studies, Mitigation, and Permitting	62,530,000
Land Acquisition and Surveying (7,730 acres)	62,917,000
Interest During Construction (4 years)	30,388,000
Total Project Cost	**$220,307,000**
Annual Costs	
Debt Service (6 percent for 40 years)	$14,641,996
Operation and Maintenance	716,000
Total Annual Cost	**$15,357,996**
Available Project Yield (acft/yr)	**32,458**
Annual Cost of Water ($ per acft) Raw Water at Reservoir	**$473**
Annual Cost of Water ($ per 1,000 gallons) Raw Water at Reservoir	**$1.45**

[1] Based on previous cost estimate developed by the U.S. Bureau of Reclamation (USBR), no detailed breakdown of construction costs from the USBR estimate was located. The cost shown here is the USBR estimate (1978) updated to 2nd Quarter 1999 prices.

(40 years at 6 percent annual interest) results in an annual expense of $15,094,000. Annual operation and maintenance costs total $716,000. The annual cost, including debt service and operation and maintenance, totals $15,810,000. For an annual firm yield of 32,458 acft, the resulting cost of raw water at the reservoir is $487 per acft (Table 5.10-3). Depending upon the location(s) and type(s) of use for water supplies associated with Cloptin Crossing Reservoir, additional facilities and costs could include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems and/or the Edwards Aquifer recharge zone.

5.10.5 Implementation Issues

Implementation of Cloptin Crossing Reservoir could directly affect the feasibility of other water supply options under consideration, including G-16C1, G-17C1, G-20, G-38C, S-15Db, S-15Dc, S-15E, SCTN-16b, and/or SCTN-16c.

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

Reservoir Alternative

1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer approval depending upon location(s) of use.
   c. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. GLO Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. TPWD Sand, Gravel, and Marl permit.

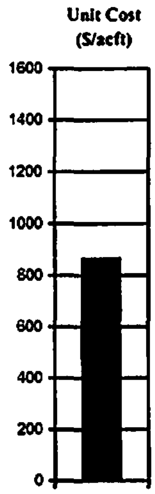
2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

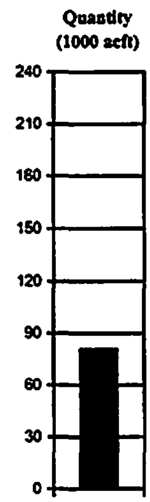
3. Land will need to be acquired through either negotiations or condemnation.

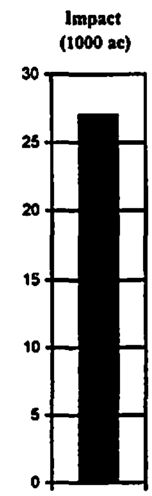
4. Relocations for the reservoir include:
   a. Highways and railroads.
   b. Other utilities.
   c. Structures of historical significance.
   d. Cemeteries.

5. Other Coordination:
   a. Implementation of this option would require substantial coordination with groups having specific local or regional interests.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: G-17C1
OPTION NAME: Sandies Creek Reservoir — Firm Yield

OPTION DESCRIPTION: *Firm yield of proposed Sandies Creek Reservoir on Sandies Creek, a tributary of the Guadalupe River in DeWitt and Gonzales Counties, would be diverted and transmitted to a water treatment plant at the major municipal demand center of the South Central Texas Region, via a 64-inch diameter, 73.7-mile long pipeline.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☐ 5-15 yr. ☒ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	$865	per acft[1]	Treated Water Distributed
QUANTITY OF WATER:	80,836	acft/yr[2]	
LAND IMPACTED:	27,240	acres[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Dam and reservoir, Guadalupe River diversion, pump station and pipeline, reservoir intake and pump station, raw water pipeline and pump station, water treatment plant, finished water pipeline and pump station to municipal distribution system, and mitigation. Unit cost for raw water at the reservoir is $325 per acft.

[2]**QUANTITY OF WATER:** Level of Edwards Aquifer pumpage, instream flow requirements, and level of hydropower subordination.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, transmission facilities right-of-way, and water treatment plant site. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of about 30 miles of Sandies Creek streambed, about 5,383 acres of wooded bottomland, 8,409 acres of brushland in the upland portion of the reservoir site, 904 acres of cropland, 2,600 acres of wetlands, and 9,390 acres of pastureland. Habitat for candidate species for protection, and three cemeteries. Archeological and cultural resource surveys have not been conducted. Streamflow below the dam would be modified, but sufficient flow to maintain bay and estuary sustenance would remain.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and local reservoir area economic and social impacts.

ADDITIONAL FACTORS: Ability to obtain permits to use surface water from Sandies Creek Reservoir.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17, L-18, G-16C1, G-19, G-20, G-21, G-22, G-30, G-32, G-38C, G-40, S-15Db, S-15Dc, S-15E, S-16C, SCTN-6, SCTN-16b, and/or SCTN-16c.

5.11 Sandies Creek Reservoir — Firm Yield (G-17C1)

5.11.1 Description of Option

Sandies Creek Reservoir is a proposed reservoir located on Sandies Creek, a tributary of the Guadalupe River in DeWitt and Gonzales Counties. The project would impound water from the Sandies Creek watershed as well as water diverted from the Guadalupe River during periods of flow in excess of downstream needs. This reservoir was proposed as a water supply for in-basin needs as part of the Texas Basins Project[1] in the mid-1960s. Subsequent studies of the reservoir were performed,[2] the latest of which is by Espey, Huston & Associates, Inc.[3] in 1986, which provided the siting and basic data used herein. The location of the dam is shown in Figure 5.11-1.

The dam would be an earthfill embankment with a roller-compacted concrete spillway to impound runoff from the 678 square mile watershed. The dam embankment would extend about 2 miles across the Sandies Creek valley, and provide a conservation storage capacity of 606,280 acft at elevation 232 ft-msl; at full conservation pool the surface area would be 26,875 acres; the spillway design flood elevation would be 240.5 ft-msl, inundating approximately 39,879 acres; and approximately 30 miles of Sandies Creek channel would be permanently inundated by the reservoir. Water supply developed by this project would be transported by a 64-inch diameter, 73.7-mile-long pipeline to the major municipal demand center of the South Central Texas Region.

5.11.2 Water Availability

The firm yield of the proposed Sandies Creek Reservoir was computed utilizing the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendices B and F). The GSA Model[4] was used to estimate daily total streamflow and unappropriated streamflow available at the reservoir site. The GSA Model was also used to

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[1] United States Bureau of Reclamation, "Texas Basins Project," February 1965.
[2] Texas Water Development Board, "A Summary of the Preliminary Plan for Proposed Water Resources Development in the Guadalupe River Basin," July 1966.
[3] Espey, Huston & Associates, Inc. (EH&A), "Water Availability Study for the Guadalupe and San Antonio River Basins," prepared for San Antonio River Authority, Guadalupe-Blanco River Authority, and City of San Antonio, Volumes I and II, EH&A Document No. 85580, February 1986
[4] HDR Engineering, Inc. (HDR), "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.

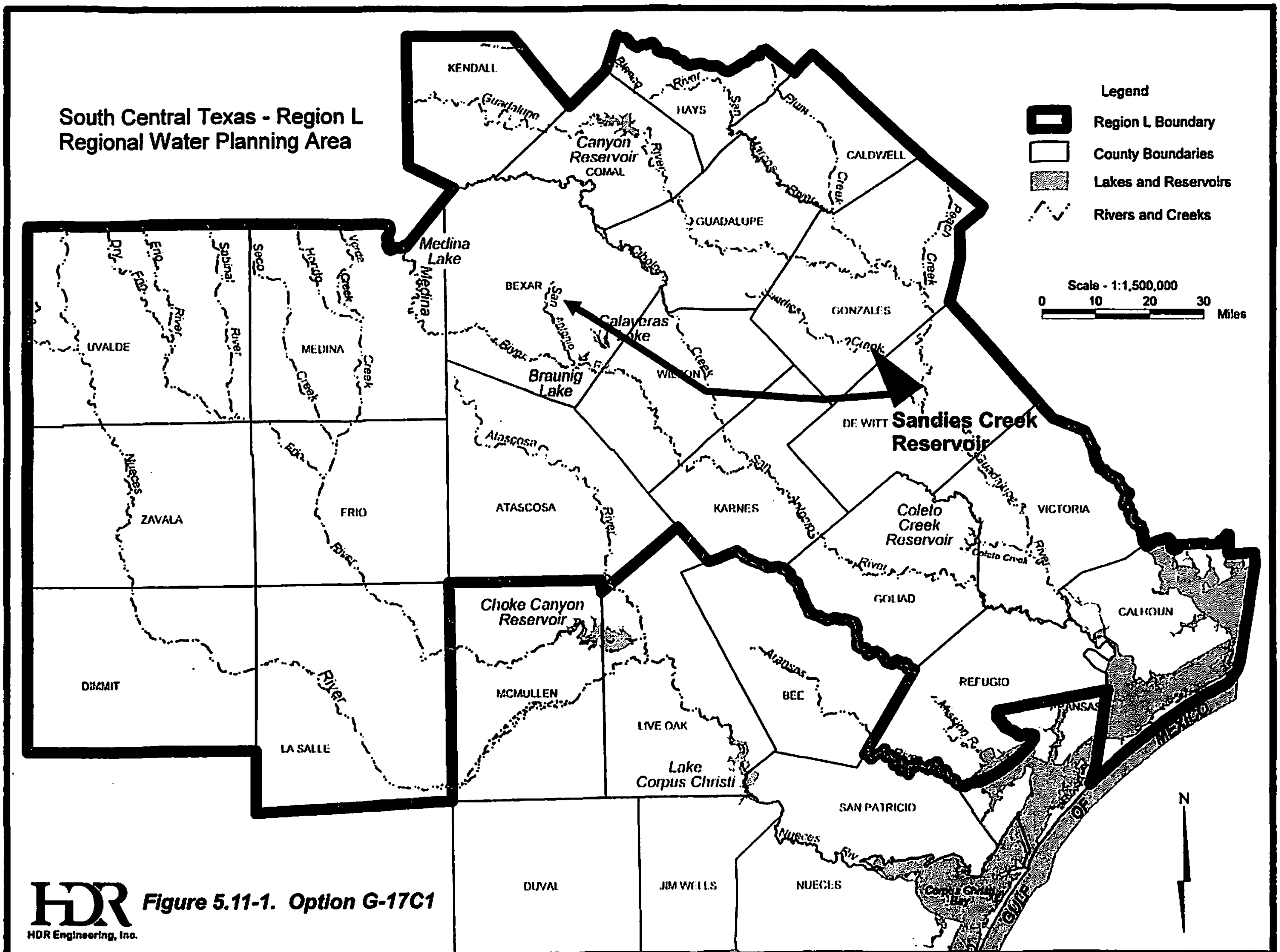


Figure 5.11-1. Option G-17C1

obtain daily estimates of unappropriated streamflow potentially available for diversion from the Guadalupe River upstream of the Sandies Creek confluence into Sandies Creek Reservoir, assuming full control of the Sandies Creek watershed above the proposed reservoir. General assumptions for this application of the GSA Model are as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

For modeling purposes, streamflows for Sandies Creek near Westhoff (USGS# 08175000) were assumed representative of inflows to Sandies Creek Reservoir. Streamflows for the Guadalupe River at Cuero (USGS# 08175800), less those for Sandies Creek near Westhoff, were assumed representative of flows at the diversion site. These inflows are the naturalized flows from above the reservoir and diversion sites, adjusted for upstream water rights and return flows.

The GSA Model computed the streamflow available for diversion from the Guadalupe River into Sandies Creek Reservoir without causing increased shortages to downstream rights and subject to the Consensus Criteria for direct diversion. In addition, various maximum transmission capacities associated with potential diversion pipeline sizes (48-inch, 72-inch, 96-inch, 120-inch, and parallel 120-inch pipelines) were considered. Figure 5.11-2 presents the mean annual water available from the Guadalupe River for diversion into Sandies Creek Reservoir for each of the maximum diversion rates investigated. The mean annual water availability is constrained substantially by downstream water rights and environmental requirements, particularly as the pipeline diversion capacity increases.

The firm yield of Sandies Creek Reservoir was computed with a modified version of the SIMDLY reservoir operation model (originally written by TWDB), using the Sandies Creek inflows and the flows available for diversion from the Guadalupe River. Only inflows from the Sandies Creek watershed were subject to the Consensus Criteria pass-through requirements for Sandies Creek. The streamflow statistics used to determine the Consensus Criteria pass-through requirements for Sandies Creek Reservoir and the Guadalupe River diversion are presented in Tables 5.11-1 and 5.11-2. Subject to a uniform seasonal demand pattern, the firm yield of the project is 80,836 acft/yr. The estimate of the firm yield is considered a reliable water supply based on the 56-year period of historical hydrologic record. In order to calculate an accurate firm yield estimate, the reservoir was assumed full at the start of the SYMDLY simulation, due

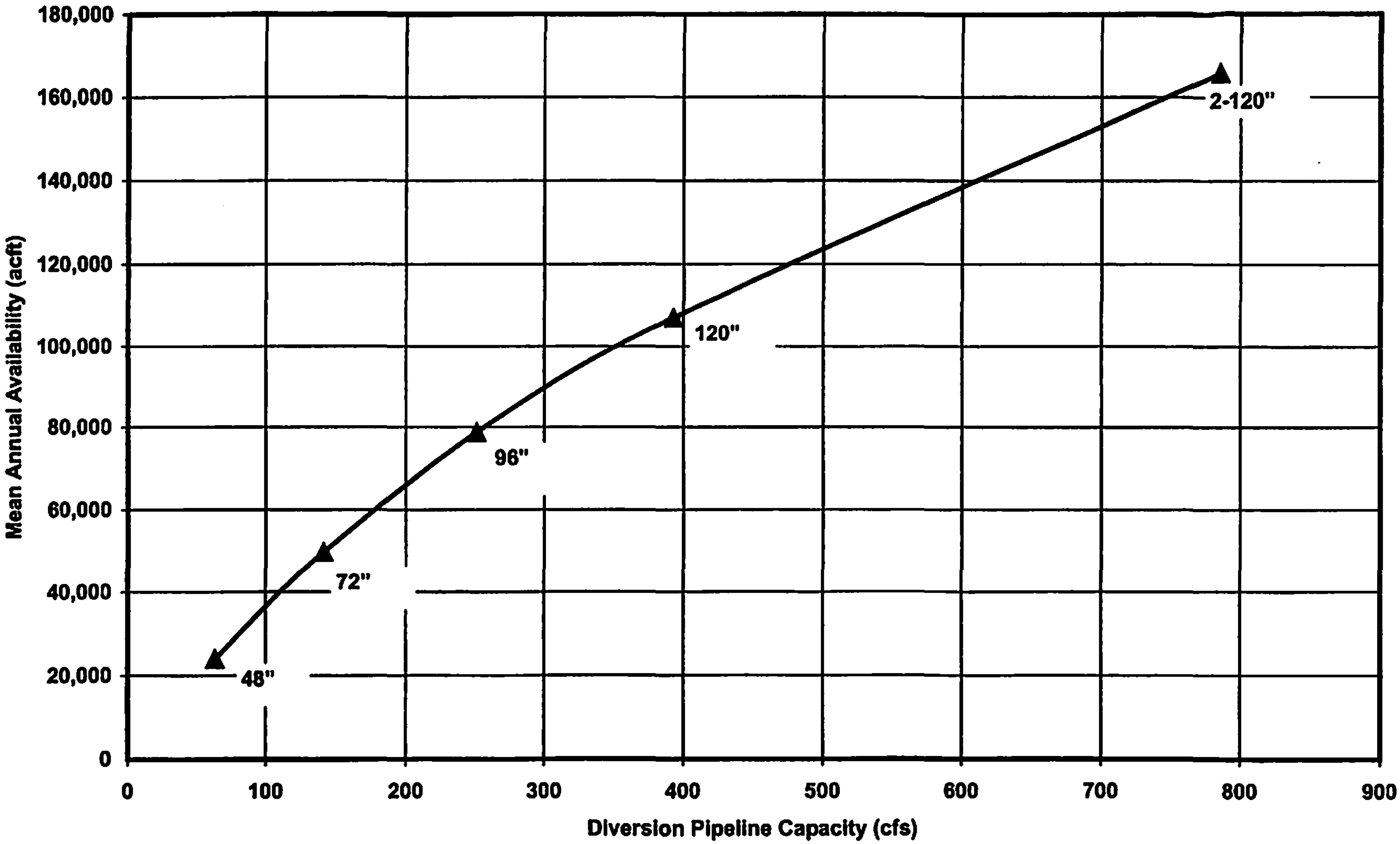


Figure 5.11-2. Water Available for Guadalupe River Diversion into Sandies Creek Reservoir

Table 5.11-1.
Daily Natural Streamflow Statistics for Sandies Creek Reservoir

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	33	21
February	39	22
March	34	21
April	32	16
May	40	15
June	34	14
July	19	6[1]
August	14	2[1]
September	21	8
October	23	10
November	28	14
December	30	18
Zone 3 Pass-Through Requirement[1,2] (acft/day)		7

[1] When the Zone 3 pass-through requirement is greater than the 25th percentile flow, the 25th percentile flow is superceded by the Zone 3 pass-through requirement.
[2] HDR Natural 7Q2 (1934 to 1989).

to extremely low naturalized flows in 1934. Available flows for 1935 and 1936 are sufficient to fill the reservoir, accounting for evaporation and the estimated firm yield. The firm yield assumes a Zone 3 pass-through requirement (629 acft/day) at the Guadalupe River diversion location based upon maintenance of dissolved oxygen at 5 mg/L, subject to current maximum effluent quantity and constituent concentrations.[5] The TNRCC has established a Water Quality Standard for the stream segment containing the proposed Guadalupe River diversion based on the 7Q2 flow statistic for 1969 to 1989. The firm yield of this project based upon honoring a Zone 3 pass-through requirement of 1,203 acft/day (rather than 629 acft/day) at the Guadalupe River diversion location is 69,078 acft/yr, a reduction of more than 14 percent.

[5] HDR and Paul Price Associates, Inc., "Guadalupe-San Antonio River Basin Environmental Criteria Refinement, Trans-Texas Water Program, West Central Study Area, Phase II," San Antonio River Authority, May 1998.

Table 5.11-2.
Daily Natural Streamflow Statistics
for the Guadalupe River Diversion Point

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	1,872	1,171
February	2,014	1,272
March	2,013	1,227
April	2,067	1,205
May	2,461	1,331
June	2,222	1,198
July	1,676	946
August	1,310	692
September	1,445	835
October	1,662	962
November	1,688	1,063
December	1,748	1,127
Zone 3 Pass-Through Requirement[1,2] (acft/day)		629

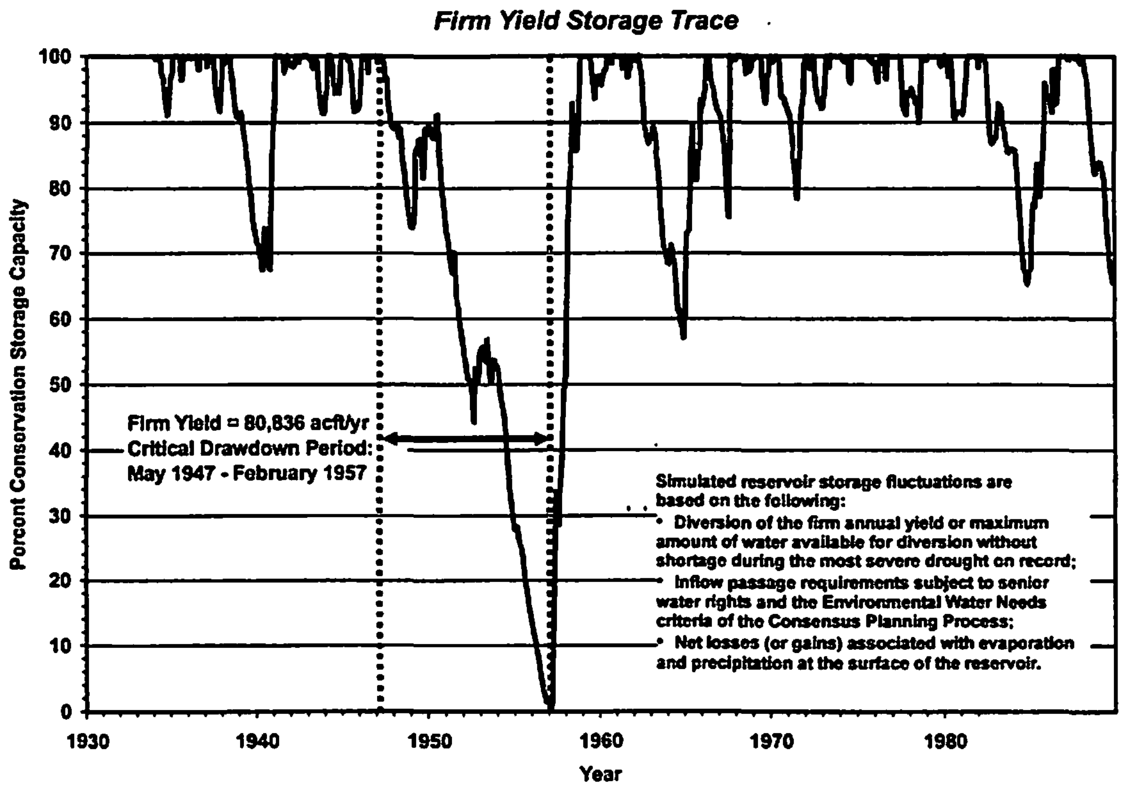
[1] Streamflow required for maintenance of dissolved oxygen at 5 mg/L. (HDR and Paul Price Associates, Inc., "Guadalupe-San Antonio River Basin Environmental Criteria Refinement, Trans-Texas Water Program, West Central Study Area, Phase II," San Antonio River Authority, March 1998.

[2] The current TNRCC Water Quality Standard (7Q2) for this segment is 1,203 acft/day.

The Texas Water Development Board (TWDB) estimated the firm yield of this option to be about 80,000 acft/yr, assuming flows passed through the reservoir for environmental maintenance of 3,175 acft/yr.[6]

Figure 5.11-3 illustrates the simulated Sandies Creek Reservoir storage fluctuations for the 1934-1989 historical period, subject to the firm yield of 80,836 acft/yr based on delivery of Guadalupe River diversions via two parallel 120-inch pipelines. Simulated reservoir contents remain above the Zone 2 trigger level (80 percent capacity) about 76 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 92 percent of the time over the 1934 to

[6] TWDB, "Water for Texas, A Consensus-Based Update to the State Water Plan, Volume II, Technical Planning Appendix," Document No. GP-6-2, August 1997.



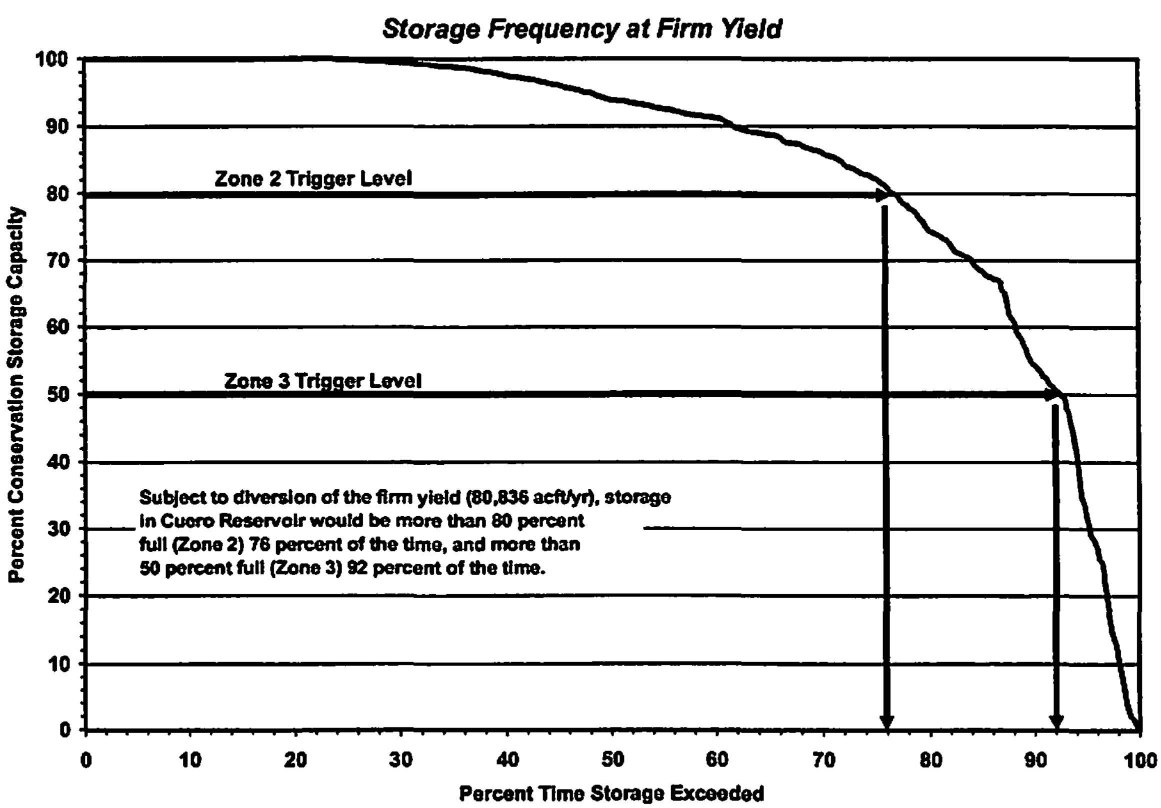


Figure 5.11-3. Sandies Creek Reservoir Storage Considerations

1989 historical period. Figure 5.11-4 illustrates the changes in Guadalupe River streamflow medians and frequencies caused by the project as reflected at the Cuero gage downstream from the confluence of Sandies Creek and at the Guadalupe River Saltwater Barrier. Monthly median freshwater inflows to the Guadalupe Estuary, as measured at the Saltwater Barrier, would be reduced about 17 percent.

5.11.3 Environmental Issues.

The Sandies Creek Reservoir project involves dam construction and inundation of approximately 26,875 acres along a 30-mile reach of Sandies Creek, a tributary of the Guadalupe River. The proposed reservoir spans portions of Gonzales and DeWitt Counties. It is located in the Texas Blackland Prairies ecoregion,[7] in the ecotonal region between the Post Oak Savannah and Blackland Prairie vegetational regions,[8] and within the Texan biotic province.[9]

Soils of the Meguin-Trinity association are found within the floodplains. These soils are somewhat poorly drained, calcareous loamy and clayey soils. They are well suited to range, improved pasture and crops. The Sarnosa-Shiner association is found on uplands. These are nearly level, well-drained, moderately permeable, calcareous loamy soils used for range and wildlife, but also suited to pasture.[10]

The upland forest community type comprises approximately 20 percent of the total woodland acreage within the reservoir boundaries. Dominant overstory species within the upland forest community type include post oak, cedar elm, honey mesquite, and live oak. In the understory and shrub layers, honey mesquite, acacias, cedar elm, and prickly pear (*Opuntia* spp.) occur. Grasses and forb species comprise the herbaceous stratum in this community type.[11]

Bottomland and riparian forests comprise approximately 80 percent (about 4,306 acres) of the wooded acreage within the proposed reservoir boundaries. A variety of reptiles, amphibians, mammals, and bird species rely on the bottomland/riparian forests for food and cover.[12]

[7] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1). pp. 118-125, 1986.
[8] Gould, F.W., The Grasses of Texas, Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1975.
[9] Blair, W.F., "The Biotic Provinces of Texas," Tex. J. Sci. 2:93-117, 1950.
[10] U.S. Department of Agriculture, Soil Conservation Service (SCS), "Soil Survey of DeWitt County, Texas," in cooperation with the Texas Agricultural Experiment Station, Texas A&M University, College Station, 1978a.
[11] EH&A, Op. Cit., February 1986.
[12] Ibid.

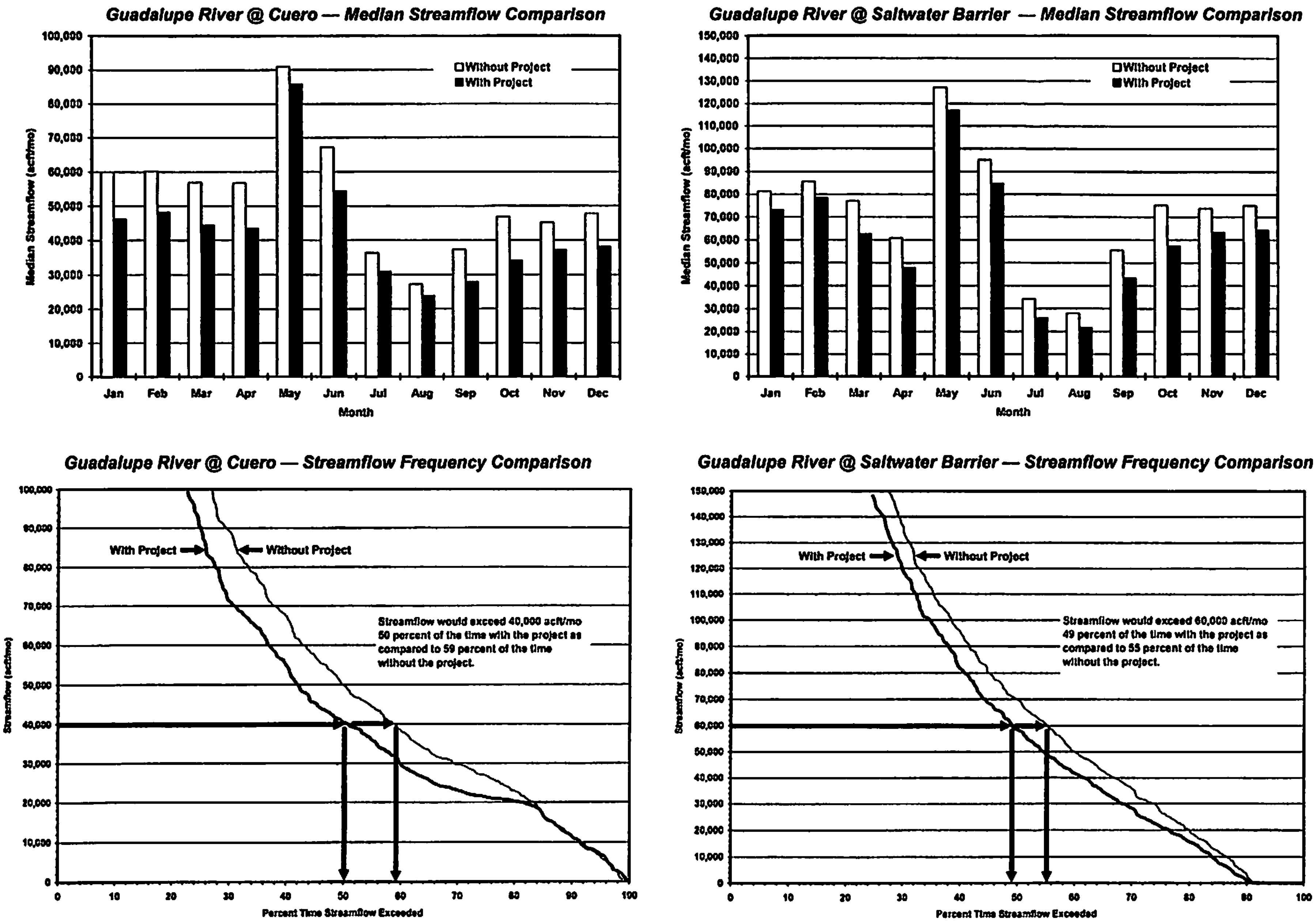


Figure 5.11-4. Sandies Creek Reservoir Streamflow Comparisons

Brushland, which occupies approximately 8,409 acres, is the dominant community type in the wooded upland portions of the proposed reservoir site, and is also present in some lowland areas. This community type occurs primarily as a result of overgrazing and fire suppression, which have allowed woody species to increase in areas that were formerly covered by grasslands or savannah community types. Brushlands are dominated by low trees and shrubs, with a ground cover of forbs and grasses.[13] The thick nature of the brushland vegetation makes this an excellent nesting habitat for a variety of bird species.

The grassland community types represent approximately 9,390 acres within the reservoir site, and include managed pastures, oilfields, and pipeline, utilities, and transportation rights-of-way. The majority of the grassland within the reservoir site is used as grazing land for livestock.[14] Woody species in the grassland habitats are either sparse or absent. Ground cover is occasionally thick, thus providing good cover for a variety of rodent species that in turn provide food for carnivores, such as the coyote, northern harrier, and common barn owl. A variety of reptiles, mammals, and birds also use grassland habitats for food and cover.[15]

Cropland is limited within the proposed reservoir site, occupying approximately 904 acres and occurring primarily within major floodplains. Principal crops grown in the region include grain sorghum, corn, cotton, wheat, and peanuts.[16]

Wetlands, which occupy approximately 2,789 acres (including 193 acres of riverine habitat) within the Sandies Creek Reservoir site, include riverine habitats; palustrine forested, scrub/shrub, emergent, and open-water wetlands; and limited areas of lacustrine open-water habitat. Forested wetlands (i.e., swamps) are limited to areas within major floodplains.[17]

The project area has a very dendritic creek system. Sandies Creek is the major aquatic habitat in the project area and is smaller than the Guadalupe River. Generally, the channel is no more than 20 to 25 feet wide. Bank slope is gentler than the Guadalupe River. Vegetation generally reaches to the water's edge, even under low-flow conditions. The channel is more of a shallow V-shape than U-shape. Therefore, as flow increases, the creek quickly widens out.

[13] Ibid.
[14] U.S. Department of Agriculture, Soil Conservation Service (SCS), "Soil Survey of Bandera County, Texas," in cooperation with Texas Agricultural Experiment Station, Texas A&M University, College Station, April 1977.
[15] EH&A, Op. Cit., February 1986.
[16] Ibid.
[17] Ibid.

Several of the tributaries of Sandies Creek are perennial, and have marshy areas associated with them. Gravel bars occur in the channels of several tributaries.[18]

Salt flats occur within the Sandies Creek Reservoir site in poorly drained areas with loamy, highly saline sediments. The climax plant community in these areas is an open grassland composed of salt-tolerant herbaceous species. Dominant species include Gulf cordgrass (*Spartina spartinae*), switchgrass (*Panicum virgatum*), seashore saltgrass (*Distichlis spicata*), alkali sacaton (*Sporobolus airoides*), bushy sea-oxeye (*Borrichia frutescens*), devilweed aster (*Aster spinosus*), and wild buckwheat (*Eriogonum* sp.). Gulf cordgrass and switchgrass decrease as a result of heavy grazing by livestock and continuous burning, leaving bushy sea-oxeye and devilweed aster as the dominant components of the habitat.[19,20] Portions of the salt flats, which retain water for long periods of time due to low permeability and poor drainage, may be considered wetlands by some definitions.

The primary impacts that would result from construction and operation of the Sandies Creek Reservoir include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. The Sandies Creek Reservoir would be permanently inundated to 232 ft-msl with a surface area of 26,875 acres. Approximately 9,390 acres of grassland, 8,409 acres of brushland, 5,383 acres of woodland, 904 acres of cropland, 2,596 acres of wetlands, and 193 acres of riverine habitat would be converted to open water.

Indirect effects of reservoir construction may include land use changes in the area surrounding the reservoir and in mitigation areas that may be converted to alternate uses to compensate for losses of terrestrial habitat.

Potential downstream impacts would include modification of the streamflow regime below the dam, and reduced freshwater inflows to the Guadalupe Estuary. As a large new reservoir without a current operating permit, Sandies Creek Reservoir would likely be required to meet environmental flow requirements determined by a site-specific study.

Subject to the firm yield of 80,836 acft/year, modeling results indicate that the monthly median streamflows on the Guadalupe River below the confluence with Sandies Creek (at

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[18] Ibid.

[19] SCS, Op. Cit., 1978a.

[20] Thomas, G.W., "Texas Plants - An Ecological Summary. *In:* F.W. Gould Texas Plants - A Checklist and Ecological Summary," Texas Agricultural Experiment Station, MP-585/Rev., College Station, Texas, 1975.

Cuero) are reduced throughout the year relative to without project conditions, with the greatest reduction (approximately 14,000 acft/month) occurring during January. Low flows (those exceeded about 85 percent of the time) will be unchanged, largely due to the requirements of the Consensus Criteria.

The criteria for freshwater inflow to bays and estuaries are assumed to be met if the Consensus Criteria are met. The monthly median streamflow at the Guadalupe River Saltwater Barrier would be reduced by a maximum of 24 percent in July and October, with the reduction for other months ranging from 8 to 22 percent. Mean annual flows of the Saltwater Barrier (excluding ungaged runoff below the Saltwater Barrier) are projected to decline from 1,636,545 to 1,504,781 acft/yr (approximately 8 percent). TPWD and TWDB recently concluded that fisheries harvest for the Guadalupe Estuary is maximized at an annual freshwater inflow of 1,147,350 acft received in a seasonal pattern preferable to selected species of interest.[21]

Plant and animal species listed by the USFWS and TPWD TOES as endangered or threatened, and those with candidate status for listing. Those species with potential habitat in the vicinity of the proposed reservoir and pipeline route are listed in Table 5.11-3. The Texas Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch records include reported occurrences of Texas meadow-rue (*Thalictrum texanum*), a USFWS candidate species for protection, in Gonzales County along the Guadalupe River just upstream of the town of Gonzales,[22] which is located near the Sandies Creek reservoir site. Of the species listed in Table 5.11-3, three are river dependent: Cagle's map turtle, blue sucker and the Guadalupe bass. The Cagle's map turtle has been observed within the proposed reservoir area.[23] The following mapped Species of Concern have been reported within the vicinity of the pipeline route: Crown Coreopsis (*Coreopsis nuecensis*), Big Red Sage (*Salvia penstemonoides*), Parks' Jointweed (*Polygonelia parksii*) and Elmendorf's Onion (*Allium elmendorfii*). Two species listed as endangered by TPWD, the Jaguarundi (*Felis yagouaroudi*) and Ocelot (*Felis pardalis*) have been reported in Wilson and Karnes Counties. The Jaguarundi prefers thick

[21] TWDB, "Texas Bays & Estuaries Program Determination of Freshwater Inflow Needs," Texas Parks & Wildlife Dept., Texas Natural Resource Conservation Commission, September 1998.

[22] Texas Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch (TNHP), Unpublished data from element records, Austin, Texas, 1985 and 1994.

[23] Killebrew, F.C., "Habitat Characteristics and Feeding Ecology of Cagle's Map Turtle (*Graptemys caglei*) Within the Proposed Cuero and Lindenau Reservoir Sites," prepared for Texas Parks and Wildlife Department under interagency contract with the Texas Water Development Board, 15 pp., 1991.

Table 5.11-3.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Sandies Creek Reservoir (G-17C1)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Blue Sucker	*Cycleptus elongatus*	Channels and flowing pools with exposed bedrock		T	WL	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C		C	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau				Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Crown Coreopsis	*Coreopsis nuecensis*	Endemic; sandy soils				Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau				Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks				Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/ Migrant
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroudi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident

Table 5.11-3 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3,4]	
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer				Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT			Nesting/Migrant
Mulenbrock's Umbrella Sedge	*Cyperus grayioides*	Prairie grasslands, moist meadows				Resident
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies				Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations				Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear				Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures				Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Meadow-rue	*Thalictrum texanum*	Coastal plains and savannah			WL	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, undergound burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

brushlands near water. The blue sucker has not been recently reported in the lower Guadalupe River.[24] If the species is present, it would render this reach unsuitable for the construction of an impoundment. A survey of the reservoir site may be required prior to dam construction to determine whether populations of or potential habitat for species of concern occur in the area to be impacted.

Although no cultural resource investigations have been conducted in the proposed Sandies Creek Reservoir, eleven sites were recorded adjacent to the upper reaches of Rocky Creek in Gonzales County. Located as a part of the University of Texas San Antonio Conquista Project,[25] all sites were reported as lithic scatter sites. One site revealed two *Angostura* fragments, suggesting a Paleo-Indian occupation. No other diagnostics were recorded.

One hundred eighty-five recorded cultural resources sites within Gonzales County have been listed by the Texas Archeological Research Laboratory. In addition, 258 sites are recorded in DeWitt County. Within the 26,875-acre study area encompassed by the 232 feet elevation of the proposed reservoir, no cultural resources sites have been recorded. The study area has not been subjected to a systematic cultural resources survey. It is probable that, if the area is surveyed, cultural resources sites will be located, some of which may exhibit the criteria necessary for nomination to the National Register of Historic Places (NRHP). A significant portion of the Sandies site is also within the Cuero I Archaeological District, whose boundaries were identified by latitude and longitude coordinates.

The NRHP lists six sites in Gonzales County and four sites in DeWitt County. There are no NRHP sites within the proposed reservoir area. The Guide to Official Texas Historical Markers lists 79 markers within Gonzales County and 64 markers within DeWitt County. One marker (Salt Flats) is located within the Sandies Creek Reservoir area. A second marker, located at 250 ft-msl in elevation, commemorates the town of Westhoff. A single State Historic Inventory Site, the Sandies Creek Bridge, is located within the Sandies study area. In the town of Westhoff, another Historic Inventory site, the First Baptist Church, is located at the 250 ft-msl contour. No previously recorded Historic Architectural Buildings Survey (HABS) structures, State Archeological Landmarks, Registered Log Cabins or Natural Landmarks are located within

[24]Academy of Natural Sciences (ANS), "A Review of Chemical and Biological Studies on the Guadalupe River, Texas," 1949-1989, Report No. 91-9, Acad. Nat. Sci. Phil. Philadelphia, PA., 1991.

[25]McGraw, A. Joachim, "A Preliminary Archaeological Survey for the Conquista Project in Gonzales, Atascosa and Live Oak Counties, Texas," Center for Archaeological Research, the University of Texas at San Antonio, Survey Report 76, 1979.

the proposed reservoir area. At least three cemeteries are located within the study site. Laws have been implemented by the Federal and Texas State governments to protect cemeteries. These resources should either be avoided or dealt with appropriately. Special procedures for handling cemeteries, as outlined in Vernon's Annotated Revised Civil Statutes of the State of Texas (Title 26, Article 912a-10 and 912a-11), will have to be followed for the Sandies Creek Reservoir site.

5.11.4 Engineering and Costing

The cost estimate for this option is shown in Table 5.11-4. The portion of the estimate pertaining to the dam and reservoir is based on a previous cost estimate developed by EHA.[26] Intake, pipeline, pumping station, operation and maintenance, and right-of-way acquisition costs were developed in accordance with the standard costing methodology presented in Appendix A. Land was assumed to be purchased within the 100-year flood pool (elevation 240.5 ft-msl; 39,879 acres). Financing the project under the Senate Bill 1 assumptions (40 years at 6 percent annual interest for the dam and reservoir; 30 years at 6 percent interest for transmission, treatment, and distribution system improvements) results in an annual expense of $50,226,000. Annual operation and maintenance and energy costs total $19,658,000. The annual cost, including debt service, operation and maintenance, and pumping energy totals $69,884,000. For an annual firm yield of 80,836 acft, the resulting annual cost of treated water delivered to the major municipal demand center of the South Central Texas Region is $865 per acft (Table 5.11-4).

5.11.5 Implementation Issues

Implementation of Sandies Creek Reservoir could directly affect the feasibility of other water supply options under consideration, including L-17, L-18, G-16C1, G-19, G-20, G-21, G-22, G-30, G-32, G-38C, G-40, S-15Db&c, S-15E, S-16C, SCTN-6, and/or SCTN-16b&c.

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

[26] EH&A Op. Cit., February 1986.

Table 5.11-4.
Cost Estimate Summary for
Sandies Creek Reservoir (G-17C1)
(Second Quarter 1999 Prices)

Item	Estimated Cost
Capital Costs	
Dam and Reservoir (Conservation Pool: 606,280 acft; 26,875 acres; 232 ft-msl)	$93,407,000
Intake and Pump Station (75.9 MGD)	8,144,000
Water Treatment Plant (75.9 MGD)	50,382,000
Transmission Pump Station(s) (2)	11,478,000
Transmission Pipeline (64-inch dia.; 73.7 miles)	88,112,000
Diversion Facilities (Intake, 510 mgd pump station, two 120-inch dia., 1.48 miles)	22,026,000
Distribution	78,527,000
Total Capital Cost	**$352,076,000**
Engineering, Legal Costs, and Contingencies	$116,739,000
Environmental & Archaeology Studies and Mitigation	70,816,000
Land Acquisition and Surveying (40,288 acres)	79,424,000
Interest During Construction (4 years)	99,050,000
Total Project Cost	**$718,105,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$29,346,000
Debt Service (6 percent for 40 years)	20,880,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	1,495,000
Dam and Reservoir	1,401,000
Water Treatment Plant	6,248,000
Pumping Energy Costs (175,235,321 kWh @ $0.06 per kWh)	10,514,000
Total Annual Cost	**$69,884,000**
Available Project Yield (acft/yr)	80,836
Annual Cost of Water ($ per acft)	$865
Annual Cost of Water ($ per 1,000 gallons)	$2.65

Reservoir Alternative

1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer Approval
   c. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. GLO Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. TPWD Sand, Gravel, and Marl permit.

2. Permitting, at a minimum, will require these studies:
   a. Bay and estuary inflow impact.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.

3. Land will need to be acquired through either negotiations or condemnation.

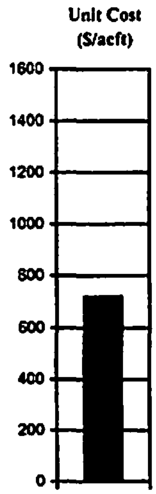
4. Relocations for the reservoir include:
   a. Highways and railroads
   b. Other utilities
   c. Structures of historical significance
   d. Cemeteries

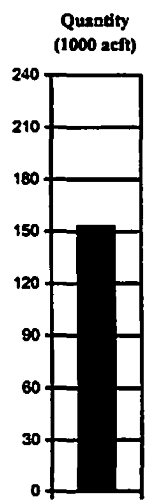
5. Other Coordination:
   a. The DeWitt-Gonzales River Association represents organized opposition to consideration of this reservoir option. Implementation of this option would require substantial coordination with this group and/or with others having specific local or regional interests.

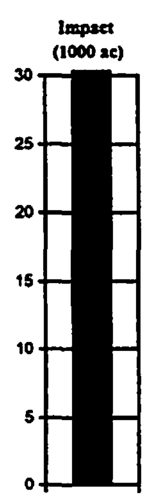
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

January 2001







OPTION NUMBER: G-16C1
OPTION NAME: Cuero Reservoir — Firm Yield

OPTION DESCRIPTION: *Firm yield of proposed Cuero Reservoir on Guadalupe River four miles north of Cuero, Texas would be diverted and transmitted to a water treatment plant at the major municipal demand center of the South Central Texas Region, via a 90-inch diameter, 79.6-mile pipeline.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☐ 5-15 yr. ☒ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	**$718**	**per acft[1]**	**Treated Water Distributed**
QUANTITY OF WATER:	**152,606**	**acft/yr[2]**	
LAND IMPACTED:	**41,886**	**acres[3]**	

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	**of**	**(1=lowest unit)**
QUANTITY OF WATER:	**of**	**(1=highest volume)**
LAND IMPACTED:	**of**	**(1=least acreage)**

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Dam and reservoir, intake and pump station, raw water pipeline and pump station, water treatment plant, finished water pipeline and pump station, and mitigation. Unit cost for raw water at the reservoir is $263 per acft.

[2]**QUANTITY OF WATER:** Level of Edwards Aquifer pumpage, instream flow requirements, and level of hydropower subordination.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, transmission facilities right-of-way, and water treatment plant site. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of about 50 miles of Guadalupe River streambed, about 11,000 acres of wooded bottomland, 7,000 acres of brushland in the upland portion of the reservoir site, 6,700 acres of cropland, 2,400 acres of wetlands, and 14,000 acres of pastureland. Habitat for candidate species for protection, location of 82 possible significant historic resources and 357 archeological sites, and 7 cemeteries; streamflow below the dam would be modified, but sufficient flow to maintain bay and estuary sustenance would remain. In 1974, a large part of the site was nominated to the National Register of Historic Places and was accepted for review.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and economic and social impacts in the local reservoir area.

ADDITIONAL FACTORS: Ability to obtain permits to use surface water from the Cuero Reservoir.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17, L-18, G-17C1, G-19, G-20, G-21, G-22, G-30, G-32, G-38C, G-40, S-15Db, S-15Dc, S-15E, S-16C, SCTN-6, SCTN-16b, and/or SCTN-16c.

5.12 Cuero Reservoir (G-16C1)

5.12.1 Description of Option

Cuero Reservoir is a proposed major impoundment on the Guadalupe River in DeWitt and Gonzales Counties and would be located about 4 miles north of the town of Cuero. Numerous studies of the reservoir have been performed,[1,2] including a study by Espey, Huston & Associates[3] in 1986, which provided the siting and basic data used herein. The location of the project is shown in Figure 5.12-1.

The dam would be an earthfill embankment with a gate-controlled concrete spillway to impound runoff from the 4,166 square mile watershed. The dam embankment would extend about 4.7 miles across the Guadalupe River valley and provide a conservation storage capacity of 1,167,000 acft at elevation 242 ft-msl; at full conservation pool the surface area would be 41,500 acres; the spillway design flood elevation would be 244.7 ft-msl, inundating approximately 44,075 acres; and approximately 50 miles of the Guadalupe River channel would be permanently inundated by the reservoir. Water supply developed by this project would be transported by a 90-inch diameter, 79.6-mile long pipeline to the major municipal demand center of the South Central Texas Region.

5.12.2 Estimated Firm Yield

The firm yield of the proposed Cuero Reservoir was computed utilizing the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendices B and F). The GSA Model[4] was used to estimate daily total streamflow and unappropriated streamflow available at the reservoir site. General assumptions for this application of the GSA Model are as adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

For modeling purposes, streamflows for the Guadalupe River at Cuero (USGS# 08175800), less those for Sandies Creek near Westhoff (USGS# 08175000), were assumed to be

[1] Texas Water Development Board (TWDB), "A Summary of the Preliminary Plan for Proposed Water Resources Development in the Guadalupe River Basin," July 1966

[2] U.S. Bureau of Reclamation, "Summary of Special Report, San Antonio-Guadalupe River Basins Study, Texas Basin Project," November 1978.

[3] Espey, Huston & Associates, Inc. (EH&A), "Water Availability Study for the Guadalupe and San Antonio River Basins," Guadalupe-Blanco River Authority, February1986.

[4] HDR Engineering, Inc. (HDR), "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.

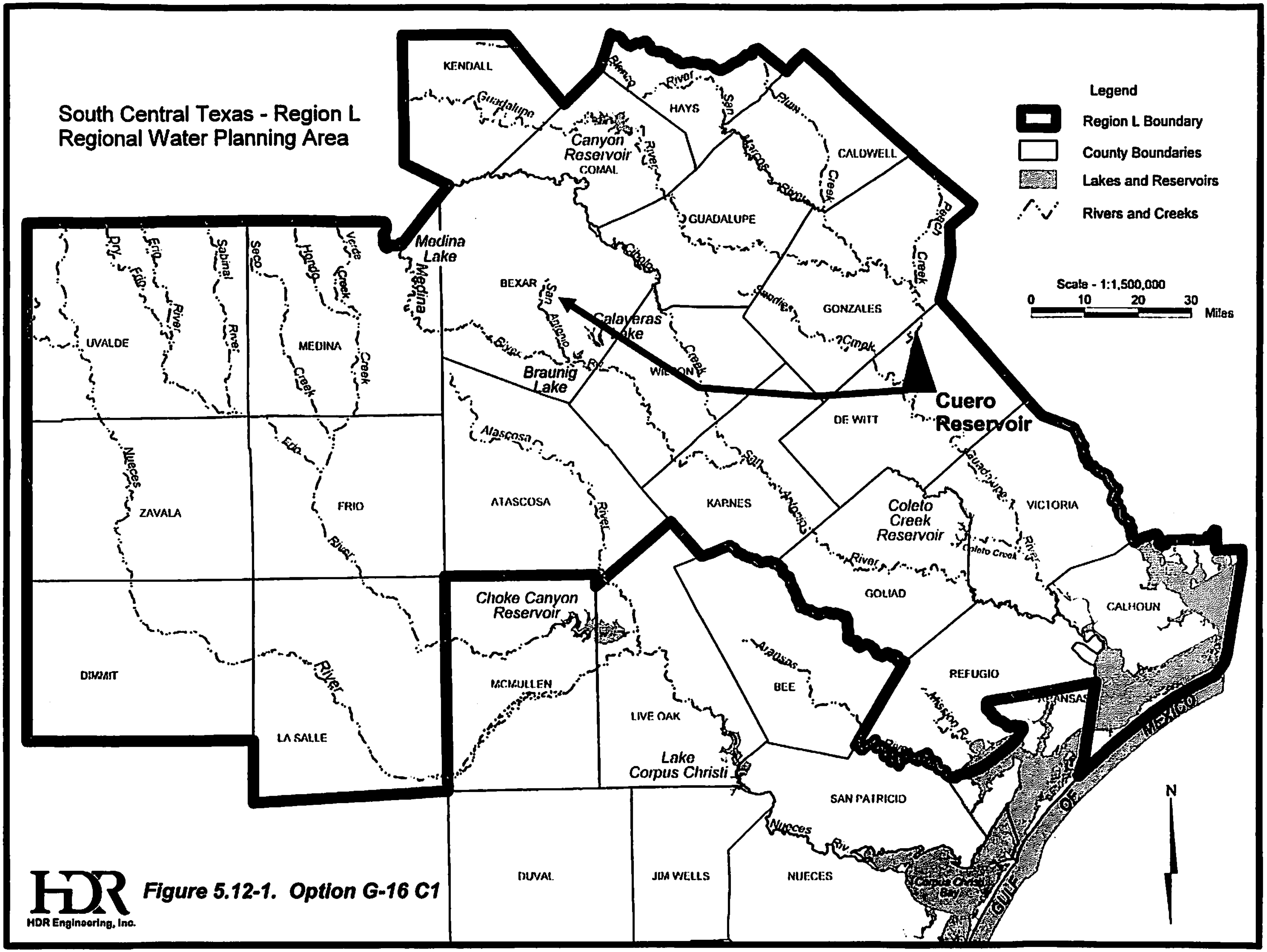


Figure 5.12-1. Option G-16 C1

representative of inflows to the Cuero Reservoir site. These inflows represent the naturalized flows from above the reservoir site, adjusted for upstream water rights and return flows. The GSA Model computes streamflow that is available for impoundment without causing increased shortages to downstream rights. Daily streamflows passed through the reservoir to meet the requirements of downstream water rights and environmental needs are also computed.

The firm yield of Cuero Reservoir was computed using the inflows and pass-through flows computed by the GSA Model, and a modified version of the SIMDLY reservoir operation model originally written by TWDB. The streamflow statistics used to set the Consensus Criteria pass-through requirements are presented in Table 5.12-1. Subject to a uniform seasonal demand, the firm yield of the project is 152,606 acft/yr. This estimate of firm yield is considered a reliable water supply based on the 56-year period of historical hydrologic record. In order to calculate an accurate firm yield estimate, the reservoir was assumed full at the start of the SYMDLY simulation due to extremely low naturalized flows in 1934. Available inflows for 1935 are sufficient to fill the reservoir, accounting for evaporation and the estimated firm yield. This firm yield assumes a Zone 3 pass-through requirement (629 acft/day) based upon maintenance of dissolved oxygen at 5 mg/L, subject to current maximum permitted effluent quantity and constituent concentrations.[5] The TNRCC has established a Water Quality Standard for this stream segment (1,203 acft/day) based on the 7Q2 flow statistics for 1969 to 1989. The firm yield of this project based upon honoring a Zone 3 pass-through requirement of 1,203 acft/day is 141,459 acft/yr.

Figure 5.12-2 illustrates simulated Cuero Reservoir storage fluctuations for the 1934 to 1989 historical period, subject to the firm yield of 152,606 acft/yr. Simulated reservoir storages remain above the Zone 2 trigger level (80 percent capacity) about 68 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 90 percent of the time over the 1934 to 1989 historical period. Figure 5.12-3 illustrates simulated changes in streamflow medians and frequencies caused by the reservoir as reflected at the project location and at the Saltwater Barrier. Monthly median freshwater inflows to the Guadalupe Estuary, as measured at the Saltwater Barrier, would be reduced about 14 percent.

[5] HDR and Paul Price Associates, Inc., "Guadalupe-San Antonio River Basin Environmental Criteria Refinement, Trans-Texas Water Program, West Central Study Area, Phase II," San Antonio River Authority, May 1998.

Table 5.12-1.
Daily Natural Streamflow Statistics
for the Cuero Reservoir (G-16C1)

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	1,872	1,171
February	2,014	1,272
March	2,013	1,227
April	2,067	1,205
May	2,461	1,331
June	2,222	1,198
July	1,676	946
August	1,310	692
September	1,445	835
October	1,662	962
November	1,688	1,063
December	1,748	1,127
Zone 3 Pass-Through Requirement[1,2] (acft/day)		629

1 Streamflow required for maintenance of dissolved oxygen at 5 mg/L. (HDR and Paul Price Associates, Inc., "Guadalupe-San Antonio River Basin Environmental Criteria Refinement, Trans-Texas Water Program, West Central Study Area, Phase II," San Antonio River Authority, March 1998.

2 The TNRCC Water Quality Standard (7Q2) for this segment is 1,203 acft/day.

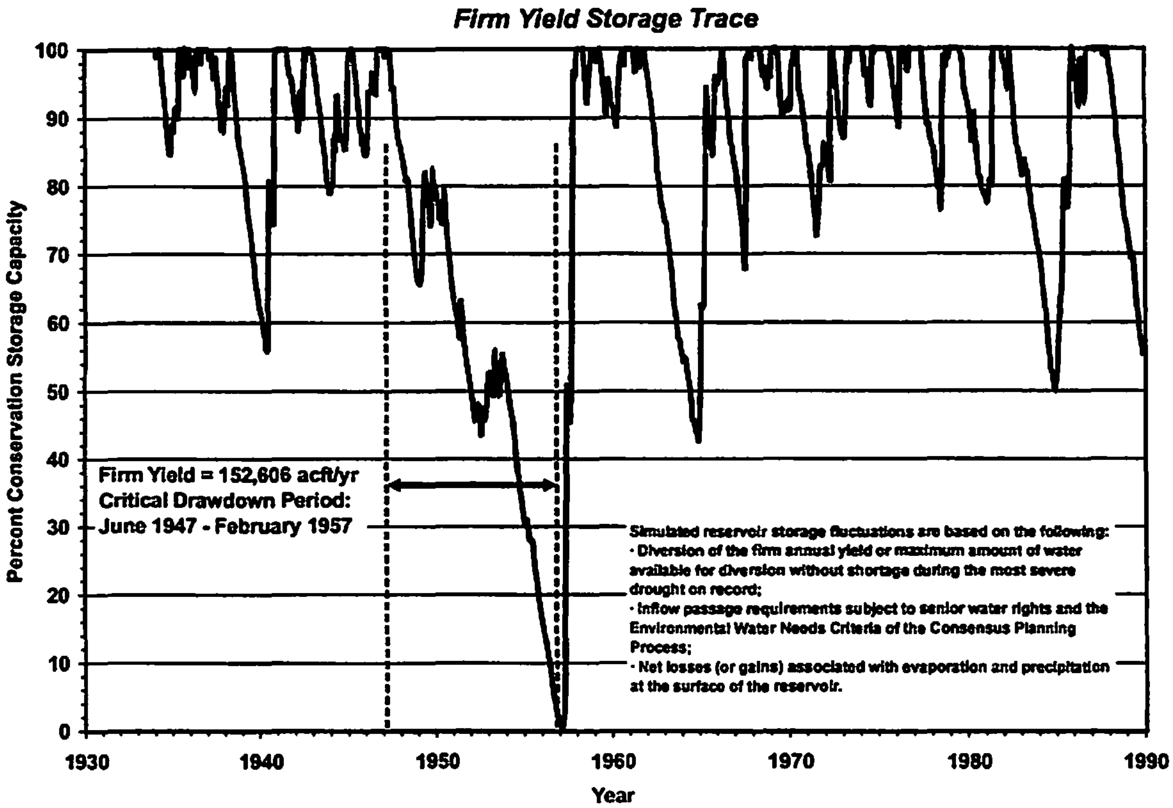
5.12.3 Environmental Issues

The Cuero Reservoir project involves dam construction and inundation of approximately 41,500 acres along a 50-mile reach of the Guadalupe River. The proposed reservoir spans portions of Gonzales and DeWitt Counties. It is located in the Texas Blackland Prairies ecoregion,[6] in the ecotonal region between the Post Oak Savannah and Blackland Prairie vegetational regions,[7] and within the Texan biotic province as described by Blair.[8]

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

7 Gould, F.W., "The Grasses of Texas," Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1975.

8 Blair, W.F., "The biotic provinces of Texas," Tex. J. Sci. 2:93-117, 1950.



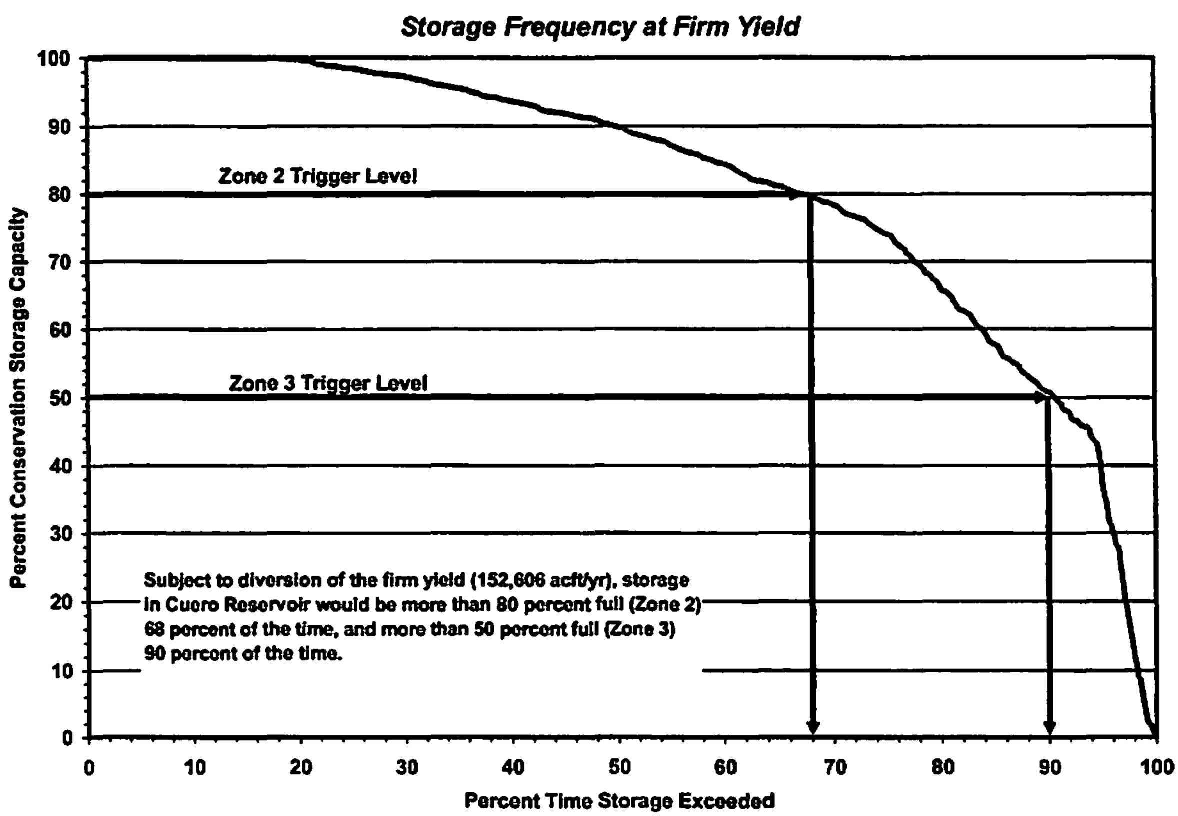


Figure 5.12-2. Cuero Reservoir Storage Considerations

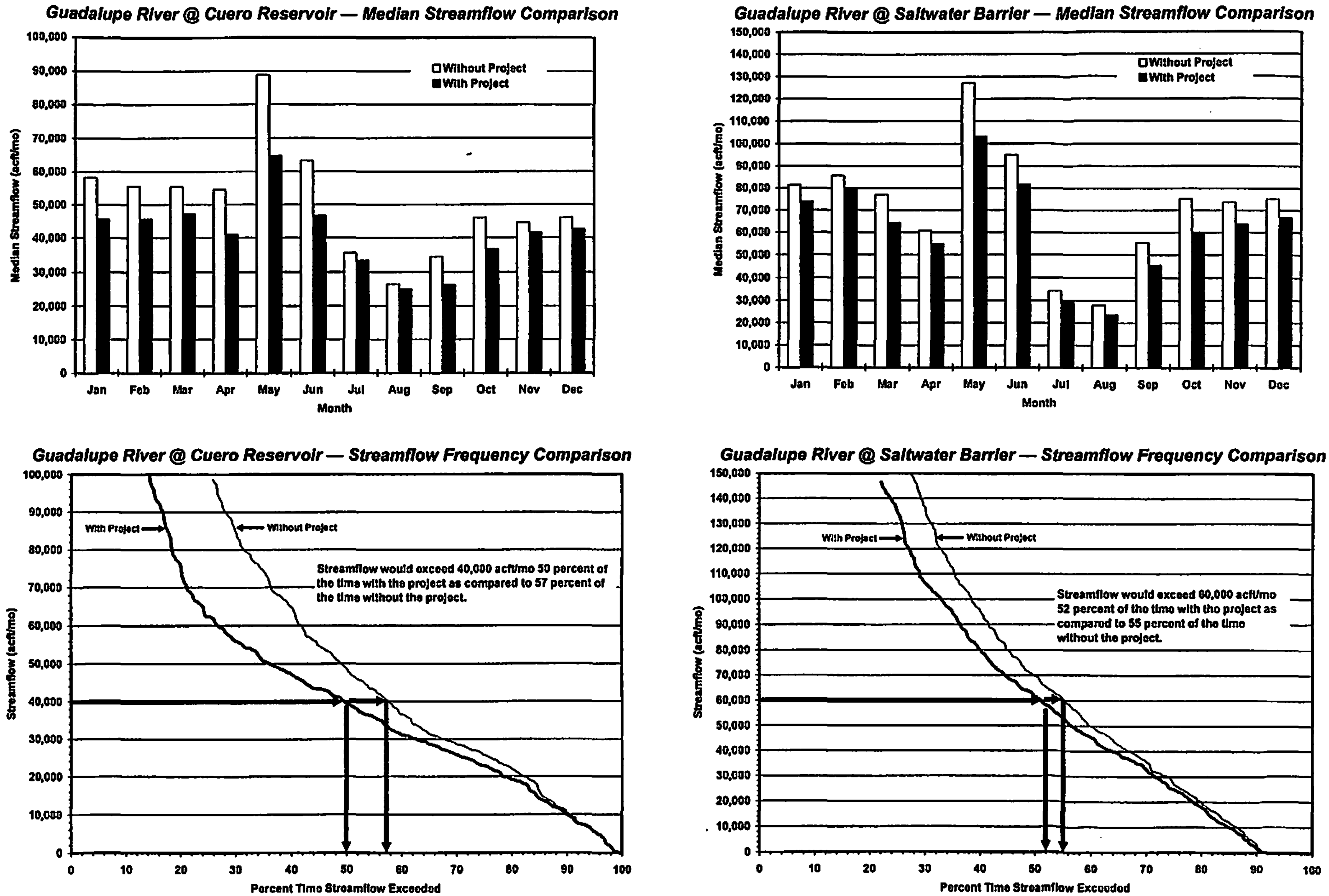


Figure 5.12-3. Cuero Reservoir Streamflow Comparisons

Within the floodplains, soils of the Meguin-Trinity association are found. These soils are somewhat poorly drained, calcareous loamy and clayey soils. They are well suited to range, improved pasture and crops. The Sarnosa-Shiner association is found on uplands. These are early level, well-drained, moderately permeable, calcareous loamy soils used for range and wildlife, but also suited to pasture.[9]

The upland forest community type is fairly limited in extent, comprising only about 5 percent of the woodland acreage within the boundaries of the reservoir site. Dominant overstory species within this community type include post oak, cedar elm, honey mesquite, and live oak. In the understory and shrub layers, honey mesquite, acacias, cedar elm, and prickly pear (*Opuntia* spp.) occur. Grasses and forb species comprise the herbaceous stratum in this community type.[10]

Bottomland and riparian forests comprise approximately 95 percent (about 10,792 acres) of the wooded acreage in the proposed reservoir site. A variety of reptiles, amphibians, mammals, and bird species rely on these habitats for food and cover. These forest types are similar in terms of species composition and in terms of certain edaphic and hydrologic factors, but differ in extent due to differences in floodplain characteristics. Bottomland forest stands, which occur along the Guadalupe River, and where floodplains are wide along major streams, are characterized by a dense overstory canopy and a well-developed understory and shrub layer. Riparian forest stands generally occur in narrow floodplains of minor streams, and are thereby limited to narrow bands of woody vegetation immediately adjacent to the streams.

Brushland, which occupies approximately 6,991 acres, is the dominant community type in the wooded upland portions of the proposed reservoir site, and is also present in some lowland areas. This community type occurs primarily as a result of overgrazing and fire suppression, which have allowed woody species to increase in areas that were formerly covered by grasslands or savannah community types. The thick nature of the brushland vegetation makes this an excellent nesting habitat for a variety of bird species. It also provides ample food and cover for a number of rodents and other mammalian species, including the white-tailed deer and collared

[9] U.S. Department of Agriculture, Soil Conservation Service (SCS), "Soil Survey of DeWitt County, Texas," in cooperation with the Texas Agricultural Experiment Station, Texas A&M University, College Station, 1978.
[10] EH&A, Op. Cit., February 1986.

peccary. The protected Texas tortoise utilizes brush habitats for cover, and for food in the form of cacti and herbaceous undergrowth.[11]

The grassland community types represent approximately 13,796 acres within the proposed reservoir site, and include managed pastures, oilfields, and right-of-ways. The majority of the grassland within the reservoir site is used as grazing land for livestock.

Substantial areas of cropland (approximately 6,691 acres) occur within the proposed reservoir site, primarily within the Guadalupe River floodplain. Principal crops grown in the region include grain sorghum, corn, cotton, wheat, and peanuts.[12]

Wetlands, which occupy approximately 2,402 acres within the proposed Cuero Reservoir site, include riverine habitats; palustrine forested, scrub/shrub, emergent, and open-water wetlands; and limited areas of lacustrine open-water habitat. Forested wetlands (i.e., swamps) are limited to areas within the Guadalupe River floodplain and occur primarily in association with oxbow lakes and sloughs. Scrub/shrub and emergent wetlands (i.e., marshes) occur in wet depressions and around the edges of aquatic habitats within the proposed reservoir site.

The aquatic habitats of the Guadalupe River in the Cuero Reservoir are dominated by the mainstream river and several major permanent creeks such as Peach, Denton McCoy, and Cuero. Both the mainstem river and permanent creeks are relatively low gradient streams with meandering channels. Numerous oxbows have been formed in the mainstem of the Guadalupe River. The banks of all permanent water bodies are generally relatively steep and comprised primarily of clay. However, some areas of Peach Creek and Denton Creek have sandy banks and sandy substrate. Generally, the bottom is clay in permanent water areas.[13]

The primary impacts that would result from construction and operation of the Cuero Reservoir include conversion of existing habitats and land uses within the conservation pool to open water, and potential downstream effects due to modification of the existing flow regime. The Cuero Reservoir site would be permanently inundated to 242 ft-msl with a surface area of 41,500 acres. Approximately 13,796 acres of grassland, 6,691 acres of cropland, 11,360 acres of woodlands, 6,991 acres of brushland, 1,464 acres of wetlands, 938 acres of riverine habitat, and 260 acres of developed land would be converted to open water upon dam construction. In

[11] Ibid.
[12] Ibid.
[13] Ibid.

addition to long-term impacts within the conservation pool, minor changes to existing resources situated between the conservation pool elevation and flood pool elevation could be anticipated due to occasional temporary inundation during flood events.

Potential downstream impacts would include modification of the streamflow regime below the dam, and reduced freshwater inflows to the Guadalupe Estuary. As a new reservoir without a current operating permit, Cuero Reservoir would likely be required to meet environmental flow requirements determined by a site-specific study.

Subject to the firm yield of 152,606 acft/yr, modeling results indicate that the monthly median streamflow on the Guadalupe River at Cuero is reduced throughout the year relative to without-project conditions, with the greatest reductions (approximately 12,700 to 24,100 acft/month) occurring in January, April, May and June. Low flows (those exceeded 85 percent or more of the time) will be unchanged, largely due to the requirements of the Consensus Criteria.

The criteria for freshwater inflow to bays and estuaries are assumed to be met if the Consensus Criteria are met. The monthly median streamflow at the Guadalupe River Saltwater Barrier would be reduced by a maximum of about 18 percent in October and May, with the reduction for other months ranging from 4 to 15 percent. Mean annual flows at the Saltwater Barrier (excluding ungaged runoff below the Saltwater Barrier) are projected to decline from 1,636,545 to 1,414,517 acft/yr (approximately 14 percent). TPWD and TWDB recently concluded that fisheries harvest for the Guadalupe Estuary is maximized at an annual freshwater inflow of 1,147,350 acft received in a seasonal pattern preferable to selected species of interest.[14]

Plant and animal species listed by the USFWS and TPWD as endangered or threatened, and those with candidate status for listing with potential habitat in the vicinity of the proposed reservoir and pipeline route are listed in Table 5.12-2. The Texas Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch records include reported occurrences of the Texas meadow-rue (*Thalictrum texanum*), a USFWS candidate species for protection, in Gonzales County along the Guadalupe River just upstream of the town of Gonzales,[15] which is located near the Cuero Reservoir site.

[14] TWDB, "Texas Bays & Estuaries Program Determination of Freshwater Inflow Needs," Texas Parks & Wildlife Dept., Texas Natural Resource Conservation Commission, September 1998.
[15] Texas Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Unpublished data from element records, Austin, Texas, 1985 and 1994.

Table 5.12-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Cuero Reservoir — Firm Yield (G-16C1)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3,4]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant in DeWitt, Bexar, Karnes, Wilson
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant in DeWitt, Bexar, Karnes, Wilson
Interior Least Tern	*Sterna antillarum athalassos*		E	E	E	Nesting/Migrant in DeWitt, Karnes
Whooping Crane	*Grus americana*	Potential migrant	E	E		Migrant in DeWitt, Bexar, Karnes, Wilson
Wood Stork	*Mycteria americana*	forages in prairie ponds, ditches, and shallow standing water formerly nested in TX		T	T	Migrant in DeWitt, Bexar, Wilson
Bald Eagle	*Haliaeetus leucocephalus*	Large Bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant in Bexar
Black-capped Vireo	*Vireo atricapillus*	oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces	E	E	T	Nesting/Migrant in Bexar
Golden-cheeked Warbler	*Dendroica chrysoparia*	juniper-oak woodlands; dependent on mature Ashe juniper (cedar) for nests	E	E	E	Nesting/Migrant in Bexar
White-faced Ibis	*Pelagis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields		T	T	Migrant in Bexar, Wilson
Mountain Plover	*Charadrius montanus*	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts	PT			Nesting/Migrant in Bexar, Wilson
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant in Bexar, Wilson
Cagle's Map Turtle	*Graptemys caglei*	Guadalupe River System, transition areas between riffles and pools, nests within 30 ft of water's edges	C		C	Resident in DeWitt, Bexar
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush		T	T	Resident in DeWitt, Bexar, Karnes, Wilson
Spot-tailed Lizard	*Holbrookia lacerata*	Central & Southern Texas; oak-juniper woodlands and mesquite-prickly pear				Resident in Bexar, Karnes
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident in Bexar, Karnes, Wilson
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Endemic grass prairies of South Texas Plains; usually thornbush, mesquite-blackbrush		T	T	Resident
Timber Rattlesnake	*Crotalus horridus*	floodplains, upland pine, deciduous woodlands, riparian zones, abandoned farms, dense ground cover		T	T	Resident in Bexar
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures				Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident in Bexar, Karnes

Table 5.12-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3,4]	
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident in DeWitt, Wilson
Blue Sucker	*Cycleptus elongatus*	Large rivers throughout Mississippi River Basin south and west in major streams of Texas to Rio Grand River		T	WL	Resident in
– River Darter	*Percina shumardi*	Guadalupe River				Resident in DeWitt
– Freshwater Prawn	*Macrobrachium carcinus*	Guadalupe River Basin				Historic in DeWitt
– American Eel	*Anguilla rostrata*	Guadalupe River Basin				Historic in DeWitt
Maculated Manfreda Skipper	*Stallingsia maculosus*	fast erratic flight, larvae feed inside a leaf shelter, pupate in cocoon made of leaves & silk			WL	Resident in Bexar, Karnes, Wilson
Big Red Sage	*Salvia penstemonoides*	Moist Creek and stream bed edges; historic; introduced in native plant nursery trade			WL	Resident in Bexar, Wilson
Texas Meadow-rue	*Thalictrum texanum*	Coastal plains and savannah of south east Texas; historic in Harris Co.			WL	Resident in Brazos, Waller, Gonzales
Mulenbrock's Umbrella Sedge	*Cyperus grayioides*	Prairie grasslands, moist meadows in Texas, Louisiana, Illinois				
Prairie Dawn (aka Texas Bitterweed)	*Hymenoxys texana*	Gulf Prairie and marshes in poorly drained depressions or at the base of mima mounds in open grasslands in almost barren areas	E	E		
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident in Bexar, Wilson
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident in Bexar, Wilson
Bracted twistflower	*Streptanthus bracteatus*	endemic, openings in juniper-oak woodlands, rocky slopes				Resident in Bexar
South Texas Rushpea	*Caesalpinia phyllanthoides*	Tamaulipan thorn shrublands or grasslands on shallow sandy to clayey soil over calcareous rock outcrops			WL	Resident in Bexar
Correll's false dragon-head	*Physostegia correllii*	wet soils including roadside ditches, irrigation channels			WL	Resident in Bexar
Glass Mountain coral root	*Hexalectris nitida*	mesic woodlands in canyons, lower elevations, under oaks				Resident in Bexar
Sandhill woolywhite	*Hymenopappus carrizoanus*	endemic, deep loose sands of Carrizo, disturbed areas				Resident in Bexar
Plains Spotted Skunk	*Spilogale putorius interrupta*	prefers wooded, brushy areas and tallgrass prairie, fields, prairies, croplands, fence rows, farmyards, forest edges				Resident in Bexar, Wilson
Ocelot	*Felis pardalis*	dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas	E	E	E	Resident in Karnes, Wilson
Jaguarundi	*Felis yagouaroudi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident in Karnes, Wilson

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

Of the species listed in Table 5.12-2, two are river dependent, Cagle's map turtle and the blue sucker. The Cagle's map turtle has been observed within the proposed reservoir area.[16] The blue sucker has not been recently reported in the lower Guadalupe River.[17] If the species is present, this reach would likely be rendered unsuitable for construction of a main-stem impoundment. A survey of the reservoir site will be required to determine whether populations of or potential habitat for species of concern occur.

Several important aquatic species that warrant attention are the river darter (Percina shumardi), the freshwater prawn (Macrobrachium carcinus), and the American eel (Anguilla rostrata). The river darter, an unprotected non-game fish, has been reported on the Guadalupe River in the Cuero project area.[18] The American eel and the freshwater prawn, although not recently collected, are known to have occurred historically in the Guadalupe River Basin. Reservoir development would alter the fishery from that of a stream (lotic) habitat to a reservoir (lentic) habitat. Species dependent on a lotic habitat for their life cycle would be eliminated within the lentic habitat. The proposed Cuero Reservoir has been subjected to an intensive cultural resources investigation. A total of 357 archaeological sites were recorded at or below the 270 ft-msl contour elevation, including five previously recorded sites that were revisited in a survey conducted by the Texas Historical Commission (THC) and the Texas Water Development Board.[19]

Sites containing prehistoric components accounted for 293 of the 357 sites recorded, and ranged from Paleo-Indian to Historic occupations. Archaeological testing and surface collection for 133 sites, additional survey of about 3,300 acres of land not accessible at the time of initial survey, extensive historical records research, and controlled excavations of 14 sites within and on the margin of the area to be flooded were recommended by Fox et al.[20] prior to project inundation. Areas not subjected to survey were not identified.

[16]Killebrew, F.C., "Habitat Characteristics and Feeding Ecology of Cagle's Map Turtle (*Graptemys caglei*) Within the Proposed Cuero and Lindenau Reservoir Sites," prepared for Texas Parks and Wildlife Department under interagency contract with the Texas Water Development Board, 15 pp., 1991.
[17]Academy of Natural Sciences (ANS), "A Review of Chemical and Biological Studies on the Guadalupe River, Texas, 1949-1989," Report No. 91-9, Acad. Nat. Sci. Phil., Philadelphia, PA, 1991.
[18] EH&A, Op. Cit., February 1986.
[19] Fox, D.E., R.J. Mallouf, Nancy O'Malley and W.M. Sorrow, "Archaeological Resources of the Proposed Cuero I Reservoir, DeWitt and Gonzales Counties, Texas," *Archaeological Survey Report* No. 12, Texas Historical Commission and Texas Water Development Board, Austin, 1974.
[20] Ibid.

Nominated to the National Register of Historic Places (NRHP) in June 1974 by the THC, virtually the entire proposed Cuero Reservoir was accepted by Federal review agencies as the Cuero I Archaeological District in October 1974. The Cuero I Archeological District, located in DeWitt and Gonzales Counties, extends over a 45-mile long area of the lower Guadalupe River Basin between Cuero and Gonzales. This area is larger than the area covered by the proposed Cuero Reservoir.

Outside the 242 ft-msl conservation pool, at about the 245 ft-msl contour, is the Braches Home, located about 12 miles southeast of Gonzales. The house is listed on the NRHP. One historical marker commemorating Dr. W. W. White is located within the Cuero Reservoir area. Four other markers commemorating the Cuero I Archaeological District, the Braches Home, the Sam Houston Oak, and the town of Concrete, are located between the 242 and 265 ft-msl contours. The State Historic Building Inventory lists one structure within the proposed reservoir, the Miles Squire Bennett House. This house is located in DeWitt County approximately 2 miles north of the dam site. Only the foundation, chimney and cistern remain. The frame house has been disassembled.

No previously recorded Historic Architectural Buildings Survey (HABS) structures, Registered Log Cabins or Natural Landmarks are located within the proposed reservoir area.

Within the 242 ft-msl conservation pool, an Espey, Huston & Associates reconnaissance survey[21] identified 82 possibly significant historic resources, including seven cemeteries. Excluding the cemeteries, the potential resources are farmsteads, houses, and other buildings that may have been associated with the early communities of the area. At least twenty other possible historic structures and 18 cemeteries are located between the 242 and 300 ft-msl contours. Downstream from the dam, four structures and three cemeteries were also recorded. These cultural resources are noted due to their proximity to the proposed dam.

Laws have been implemented by the Federal and Texas State governments to protect cemeteries. These resources should either be avoided or dealt with appropriately. Special procedures for handling cemeteries, as outlined in Vernon's Annotated Revised Civil Statues of the State of Texas (Title 26, Article 912a-10 and 912a-11), will have to be followed for the Cuero Reservoir site.

[21] EH&A, Op. Cit., February 1986.

Because the proposed Cuero Reservoir has been intensively surveyed and consequently placed on the NRHP as the Cuero I Archaeological District, resurvey most likely will not be called for in the permitting process. The 3,300 acres not surveyed by Fox, et al.[22] will most likely require survey.

5.12.4 Engineering and Costing

The cost estimate for this option is shown in Table 5.12-3. The portion of the estimate pertaining to the dam and reservoir is based on a previous cost estimate developed by EHA.[23] Intake, pipeline, pumping station, operation and maintenance, and right-of-way acquisition costs were developed in accordance with the standard costing methodology presented in Appendix A. Land was assumed to be purchased within the 100-year flood pool (elevation 257 ft-msl; 57,500 acres). Financing the project under the Senate Bill 1 assumptions (40 years at 6 percent annual interest for the dam and reservoir; 30 years at 6 percent interest for transmission, treatment, and distribution system improvements) results in an annual expense of $80,174,000. Annual operation, maintenance, and pumping energy costs total $29,458,000. The annual cost, including debt service, operation and maintenance, and pumping energy totals $109,632,000. For an annual firm yield of 152,606 acft, the resulting annual cost of treated water delivered to the major municipal demand center of the South Central Texas Region is $718 per acft (Table 5.12-3).

5.12.5 Implementation Issues

Implementation of Cuero Reservoir could directly affect the feasibility of other water supply options under consideration, including L-17, L-18, G-17C1, G-19, G-20, G-21, G-22, G-30, G-32, G-38C, G-40, S-15Db&c, S-15E, S-16C, SCTN-6, and/or SCTN-16b&c.

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

1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer Approval
   c. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.

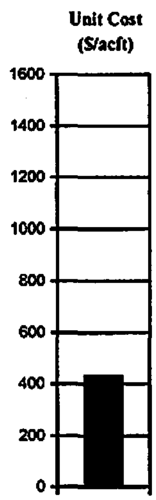
[22] Fox, D.E., et al, Op. Cit., 1974.
[23] EH&A Op. Cit., February 1986.

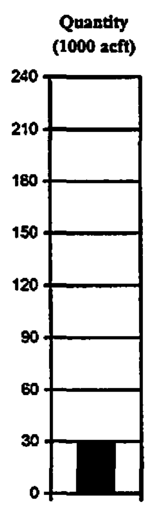
Table 5.12-3.
Cost Estimate Summary for Cuero Reservoir (G-16C1)
(Second Quarter 1999 Prices)

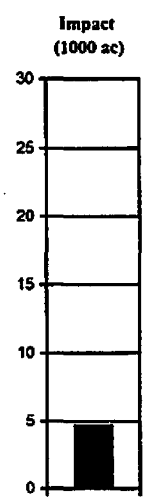
Item	*Estimated Cost*
Capital Costs	
Dam and Reservoir (Conservation Pool: 1,167,000 acft; 41,500 acres; 242 ft-msl)	$182,562,000
Intake and Pump Station (143.3 MGD)	17,029,000
Water Treatment Plant (143.3 MGD)	86,849,000
Transmission Pump Station(s) (2)	13,630,000
Transmission Pipeline (90-inch diameter; 79.6 miles)	133,739,000
Distribution	126,253,000
Total Capital Cost	**$560,062,000**
Engineering, Legal Costs, and Contingencies	$187,801,000
Environmental & Archaeology Studies and Mitigation	115,877,000
Land Acquisition and Surveying (44,502 acres)	128,975,000
Interest During Construction (4 years)	158,836,000
Total Project Cost	**$1,151,551,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$42,744,000
Debt Service (6 percent for 40 years)	37,430,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	1,903,000
Dam and Reservoir	2,738,000
Water Treatment Plant	10,612,000
Pumping Energy Costs (236,746,849 kWh @ $0.06 per kWh)	14,205,000
Total Annual Cost	**$109,632,000**
Available Project Yield (acft/yr)	152,606
Annual Cost of Water ($ per acft)	$718
Annual Cost of Water ($ per 1,000 gallons)	$2.20

   d. GLO Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. TPWD Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the reservoir include:
   a. Highways and railroads
   b. Other utilities
   c. Structures of historical significance
   d. Cemeteries
5. Other Coordination:
   a. The DeWitt-Gonzales River Association represents organized opposition to consideration of this reservoir option. Implementation of this option would require substantial coordination with this group and with others having specific local or regional interests.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **SCTN-13**
OPTION NAME: **Palmetto Bend Stage II Reservoir**

OPTION DESCRIPTION: *Delivery of water available from Palmetto Bend Stage II Reservoir to coastal areas in exchange for irrigation surface water rights now being met from streamflows and storage in the Guadalupe or Colorado Basins or delivery of water available from Stage II to Corpus Christi in exchange for surface water rights owned by Corpus Christi. Stage II Dam and Reservoir site is located in the Lavaca River Basin on the Lavaca River in Jackson County near Edna, Texas. The TWDB and the Lavaca-Navidad River Authority (LNRA) hold a TNRCC Certificate of Adjudication, #16-2096B, for Palmetto Bend Stage II Reservoir.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	$431	per acft[1]	Raw Water Delivered
QUANTITY OF WATER:	28,200	acft/yr[2]	
LAND IMPACTED:	4,701	acres[3]	

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST: Delivery to Corpus Christi:** $431 per acft represents the cost of delivering the firm yield of Stage II to Corpus Christi, which requires an intake pump station, a transmission line, an outlet structure, and upgrades the existing transmission facilities owned by LNRA and Corpus Christi. **Delivery to the Guadalupe River Basin:** The cost to deliver water to irrigation demands near the Saltwater Barrier is $585 per acft and requires an intake pump station, transmission line, and an outlet structure. **Delivery to the Colorado River Basin:** The cost to deliver water to irrigation demands near Bay City is $560 per acft and requires an intake pump station, transmission line, and an outlet structure.

[2]**QUANTITY OF WATER: Delivery to Corpus Christi:** 28,200 acft/yr represents the firm yield of Stage II if delivered to Corpus Christi. **Delivery to the Guadalupe River Basin:** The firm yield of Stage II delivered to the Saltwater Barrier is 28,100 acft/yr. **Delivery to the Colorado River Basin:** The firm yield of Stage II delivered to Bay City is 30,200 acft/yr.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity and transmission facilities right-of-way. This does not include land in the floodplain above the conservation pool at the reservoir or land purchased for mitigation. The amount of land impacted by delivery to the Guadalupe River or Colorado River is 4,891 acres and 4,902 acres, respectively.

ENVIRONMENTAL ISSUES: Impacts of reservoir on downstream streamflows and freshwater inflows to Lavaca Bay. Selection of facility sites and pipeline routes to minimize impacts on endemic species and cultural resources.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Willingness of other parties to exchange Stage II water for their existing surface water rights or supplies.

ADDITIONAL FACTORS: Revision of Certificate of Adjudication #16-2096B to reflect the yields at the alternative site, development of reservoir release schedule for the bay and estuaries, and interbasin transfer authorization.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: S-16C, G-16C1, C-17A, C-17B, C-18, SCTN-11, SCTN-14a, SCTN-14b, SCTN-16a, SCTN-16b, and/or SCTN-16c.

5.13 Palmetto Bend Stage II Reservoir (SCTN-13)

5.13.1 Description of Option

The TWDB and the Lavaca-Navidad River Authority (LNRA) hold TNRCC Certificate of Adjudication, #16-2096B, for the completion of Palmetto Bend Stage II Dam and Reservoir (Stage II) on the Lavaca River. Stage I, now known as Lake Texana, was completed in 1981 and is located on the Navidad River. Lake Texana is operated by LNRA primarily for water supply purposes and has a firm yield of 79,000 acft/yr. In 1999, facilities were completed to deliver 41,840 acft/yr from Lake Texana to the City of Corpus Christi. Stage II could contribute to the South Central Texas Region water supply in one of the following ways:

- Exchanging Stage II water for coastal area surface water rights and/or options owned by Corpus Christi for Colorado River streamflow that might be diverted at an upstream point near Columbus;
- Exchanging Stage II water for coastal area irrigation surface water rights now being met from streamflow and upstream storage in the Guadalupe River (delivery to the Saltwater Barrier for supplying the Calhoun Canal Division); and
- Exchanging Stage II water for coastal area irrigation surface water rights now being met from streamflow and upstream storage in the Lower Colorado River (delivery to Bay City for local irrigators).

Originally, the U.S. Bureau of Reclamation proposed that Stage II would be located on the Lavaca River and share a common pool with Stage I (Lake Texana). However, recent studies have shown that Stage II could be constructed more economically if operated separately from Lake Texana and located further upstream at an alternative site on the Lavaca River.[1] At the original site with a separate pool from Lake Texana, the Certificate of Adjudication states:

> "Upon completion of the Stage 2 dam and reservoir on the Lavaca River, owner Texas Water Development Board is authorized to use an additional amount of 18,122 acft/yr, for a total of 48,122 acft/yr, of which up to 7,150 acft/yr shall be for municipal purposes, up to 22,850 acft/yr shall be for industrial purposes, and at least 18,122 acft/yr shall be for the maintenance of the Lavaca-Matagorda Bay and Estuary System. The entire Stage 2 appropriation remains subject to release of water for the maintenance of the bay and estuary system until a release schedule is developed pursuant to the provisions of Section 4.B of this certificate of adjudication."[2]

[1] HDR Engineering, Inc., "Regional Water Planning Study Cost Update for Palmetto Bend Stage II and Yield Enhancement Alternative for Lake Texana and Palmetto Bend Stage II," February 1991.
[2] Texas Natural Resource Conservation Commission (TNRCC) Certificate of Adjudication No. 16-2096B, 1994.

For the purposes of this study, Stage II is assumed to be constructed at the alternative site located approximately 1.4 miles upstream of the original site. Since this site results in a different yield than stated in the certificate, the conditions in the certificate will need to be revised to account for the change in yield of Stage II. The revisions to the certificate should also reflect the impacts that joint operations of Lake Texana and Palmetto Bend Stage II could have on the releases necessary to maintain the bay and estuary system downstream of the projects. Recent studies of the Matagorda Bay[3] indicate the releases made from Lake Texana exceed the mitigation requirements and in some cases enhance the productivity of certain species in the bay and estuary. These results indicate that releases from Stage II for maintaining the bay and estuaries may be less restrictive than those called for in the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B). However, in addition to the bay and estuary requirements, releases from Stage II might be required for the 3.5-mile reach of the Lavaca River downstream of the dam site to the confluence with the Navidad River.[4] Therefore, it is assumed that releases from Stage II will be in accordance with the Consensus Criteria for maintenance of the river reach just below the dam.

Figure 5.13-1 shows the location of Stage II and three potential pipelines that could be used to deliver raw water from Stage II. One option delivers water from Stage II to Lake Texana to be pumped to the City of Corpus Christi via LNRA's existing West Water Delivery System and Corpus Christi's Mary Rhodes Memorial Pipeline. The two other potential projects deliver water from Stage II to coastal irrigation areas either near the Colorado River at Bay City or the Guadalupe River near the Saltwater Barrier. Each option will require an intake station at the Stage II reservoir site, a transmission line, and an outlet structure. The Bay City and Saltwater Barrier options include storage at the pipeline outfalls to accommodate seasonal diversion patterns associated with irrigation.

5.13.2 Available Yield

At the alternative site, the reservoir has a drainage area of 830 square miles. Based on the topography of the site, the top of dam was selected at elevation 55 ft-msl and the conservation pool was set at elevation 44 ft-msl. The initial conservation storage capacity of the

[3] Lower Colorado River Authority, "Freshwater Inflow Needs of the Matagorda Bay System," December 1997.
[4] Personal communications with Gary Powell, Texas Water Development Board (TWDB), July 1999.

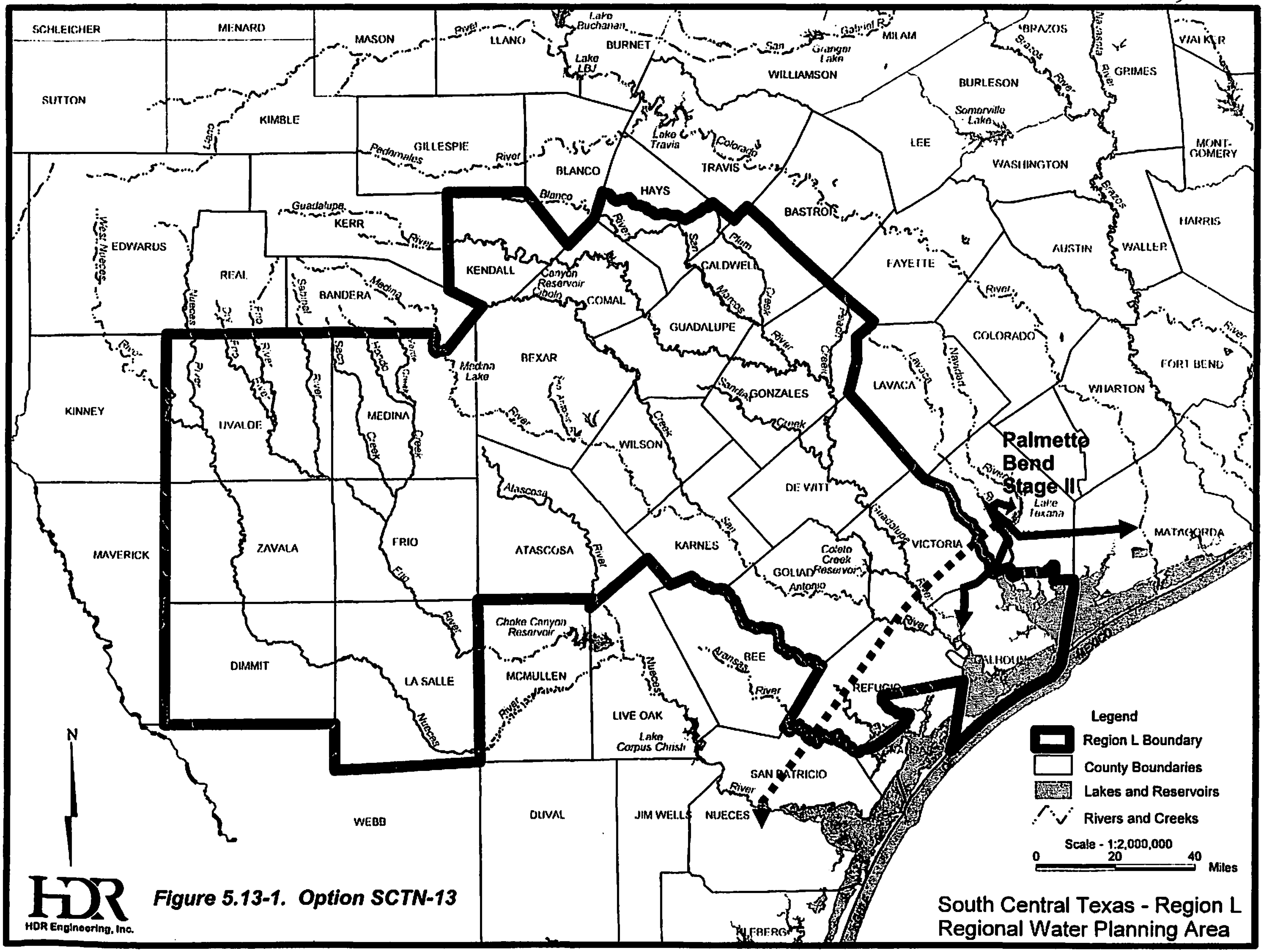


Figure 5.13-1. Option SCTN-13

reservoir would be 57,676 acft, and the reservoir area at elevation 44 ft-msl would be 4,679 acres. The reservoir area at the top of the dam would be approximately 8,200 acres.

The firm yield of Stage II operated separately from Lake Texana was calculated for each of the three potential projects and for a seasonal demand pattern used by the TWDB in determining the yield at the original Stage II site. The yield calculations required development of hydrologic data at the dam site, determination of release requirements in accordance with the Consensus Criteria (Appendix B) determination of seasonal demand factors for the three delivery options, and simulation of the Stage II reservoir operations.

A historical daily flow set for the Lavaca River was developed using naturalized monthly flows adjusted for senior upstream water rights. This monthly flow set was computed by the TNRCC using the Lavaca-Navidad River Basin Model and includes the period from 1940 through 1979. The monthly flows were adjusted using a drainage area ratio method to account for the location of the dam site in relation to the output points in the Lavaca-Navidad River Basin Model. The monthly flows were distributed to a daily time step using the flow pattern recorded at a nearby USGS gage on the Lavaca River near Edna, Texas. Evaporation was calculated utilizing the average of published[5] and supplemental monthly net evaporation rates developed by the TWDB.

The monthly median flows (Zone 1) and 25th percentile flows (Zone 2) used to define the Consensus Criteria release requirements (Appendix F) were computed from the monthly naturalized flows from the Lavaca-Navidad River Basin Model distributed to a daily time step. The Zone 3 requirement (7Q2) was taken from TNRCC's published water quality standards.[6] Table 5.13-1 shows the daily release (inflow passage) requirements from Stage II.

Since the potential projects involve different types of usage in different geographic regions, different demand patterns were used for calculating the yield in each option. Table 5.13-2 displays the monthly demand factors used for each delivery point. The first demand pattern in the table reflects the City of Corpus Christi's municipal demand pattern and the second two patterns represent the seasonal irrigation demands at the Guadalupe River Saltwater Barrier and at Bay City, respectively. The fourth demand pattern is the generic seasonal pattern used by the TWDB in their determination of Stage II firm yield.

[5] TWDB, "Monthly Reservoir Evaporation Rates for Texas, 1940 through 1965," Report 64, October 1967.
[6] Texas Administrative Code, Chapter 307, Texas Surface Water Quality Standards.

Table 5.13-1.
Consensus Criteria Release Requirements (cfs) for Palmetto Bend Stage II

	Consensus Criteria Zone		
	1	2	3
Month	>80% Capacity	<80% to >50% Capacity	<50% Capacity
January	63.0	26.1	21.6
February	92.8	39.0	21.6
March	76.9	37.6	21.6
April	78.9	36.8	21.6
May	92.2	35.4	21.6
June	47.5	22.6	21.6
August	37.3	21.6	21.6
September	41.2	21.6	21.6
October	39.2	21.6	21.6
November	48.3	21.6	21.6
December	55.1	24.3	21.6

Reservoir operations were simulated on a daily basis using the SIMDLY model developed by the TWDB. The yields calculated for each option and the pipeline sizes necessary to deliver the different quantities of water are shown in Table 5.13-2. The yields range from 27,900 acft/yr using the TWDB seasonal demand pattern to 30,200 acft/yr for the Bay City option. Table 5.13-3 shows the Stage II yields if no inflows were passed to the bay and estuaries. The releases made in accordance to the Consensus Criteria reduce the firm yield by an average of 4,100 acft/yr for the four cases analyzed.

Figure 5.13-2 displays the firm yield storage traces for Stage II operating under Consensus Criteria and with Stage II making no releases. Both traces use the TWDB demand pattern and have a critical drawdown occurring from May 1953 to January 1957. The Consensus Criteria operations result in less water being stored in Stage II throughout the period. The firm yield storage traces for the other simulations are not plotted but exhibit similar behavior to that shown in Figure 5.13-2. Storage frequency plots for each of the simulations are shown in Figure 5.13-3. Each plot shows the storage frequency at the firm yield of Stage II under

Table 5.13-2.
Firm Yield Estimates for Palmetto Bend Stage II[1]

Month	To Lake Texana Yield = 28,200 acft/yr		To Saltwater Barrier Yield = 28,100 acft/yr		To Bay City Yield = 30,200 acft/yr		TWDB Yield = 27,900 acft/yr	
	Municipal Demand Pattern[2]	Quantity (acft/month)	Irrigation Demand Pattern[3]	Quantity (acft/month)	Irrigation Demand Pattern[4]	Quantity (acft/month)	TWDB Demand Pattern[5]	Quantity (acft/month)
January	0.072	2,030	0.000	0	0.000	0	0.068	1,897
February	0.066	1,861	0.000	0	0.000	0	0.062	1,730
March	0.081	2,284	0.012	337	0.030	906	0.074	2,065
April	0.084	2,269	0.052	1,461	0.089	2,688	0.079	2,204
May	0.087	2,453	0.135	3,794	0.179	5,406	0.083	2,316
June	0.091	2,566	0.210	5,901	0.224	6,765	0.090	2,511
July	0.103	2,905	0.270	7,587	0.142	4,288	0.113	3,153
August	0.102	2,876	0.129	3,625	0.193	5,829	0.116	3,236
September	0.084	2,369	0.115	3,232	0.130	3,926	0.091	2,539
October	0.081	2,284	0.074	2,079	0.013	3,93	0.084	2,344
November	0.075	2,115	0.003	84	0.000	0	0.070	1,953
December	0.074	2,088	0.000	0	0.000	0	0.070	1,953
—	Pipe Size: 54-inch		Pipe Size: 64-inch		Pipe Size: 64-inch		—	

1 Dam at the alternative site for Stage II with conservation pool at 44 ft-msl.
2 Municipal Demand Pattern for the City of Corpus Christi.
3 Irrigation Demand Pattern for the Lower Guadalupe River.
4 Irrigation Demand Pattern for the Lower Colorado River.
5 Generic Demand Pattern used by TWDB to calculate Stage II firm yield.

Table 5.13-3.
Palmetto Bend Stage II Firm Yields
Consensus Criteria vs. No Releases

Option	Firm Yield (acft/yr)		
	Consensus Criteria	No Releases	Difference
Delivery to Lake Texana	28,200	32,300	4,100
Delivery to the Saltwater Barrier	28,100	32,000	3,900
Delivery to Bay City	30,200	34,700	4,500
TWDB Analysis	27,900	32,000	4,100

The Zone 2 and Zone 3 trigger levels dictated by the Consensus Criteria are shown for reference in each plot. For the simulation using the TWDB demand pattern, Stage II would be more than 80 percent full (Zone 2) about 72 percent of the time and more than 50 percent full (Zone 3) about 92 percent of the time when operated in accordance with the Consensus Criteria. When no releases are made under the same demands, Stage II would be more than 80 percent full about 82 percent of the time and more than 50 percent full about 95 percent of the time.

5.13.3 Environmental Issues

Environmental issues associated with the construction of Stage II can be categorized as follows:

- Effects of the construction and operation of the reservoir;
- Effects on the Lavaca River downstream from the dam; and
- Effects on Lavaca Bay.

The proposed dam would create a 4,679-acre conservation pool area at 44 ft-msl, inundating about 22 miles of the Lavaca River channel. Although no federal or state protected species are known to be present within the reservoir area, important species may be present in the surrounding areas and are listed in Table 5.13-4. Suitable habitat for protected species may be present at the reservoir site. Several species of migratory birds, marine turtles, and mammals considered by the USFWS and National Marine Fisheries Service to be endangered or threatened are believed to utilize the Lavaca Estuary.

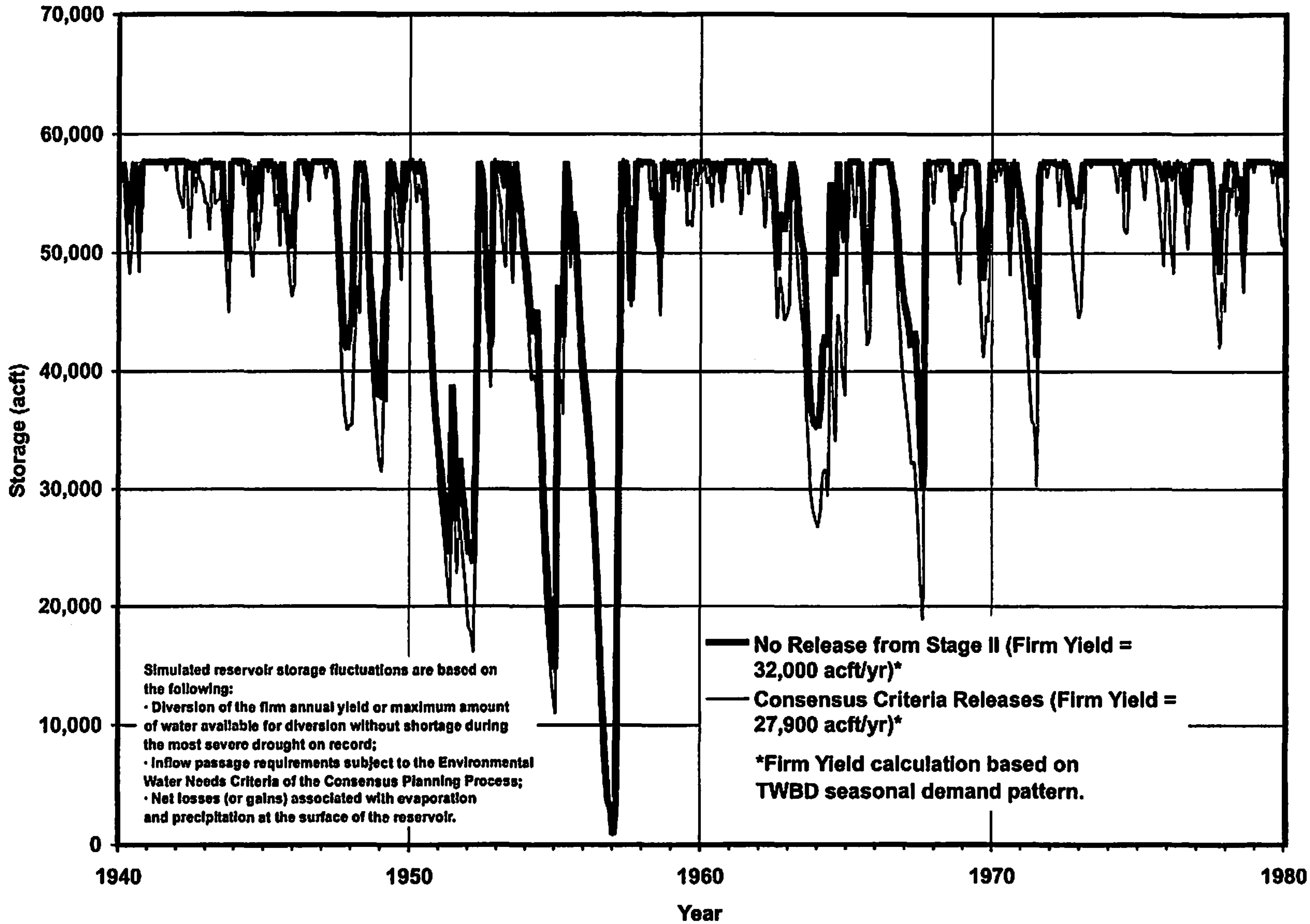


Figure 5.13-2. Palmetto Bend Stage II Reservoir Firm Yield Storage Trace

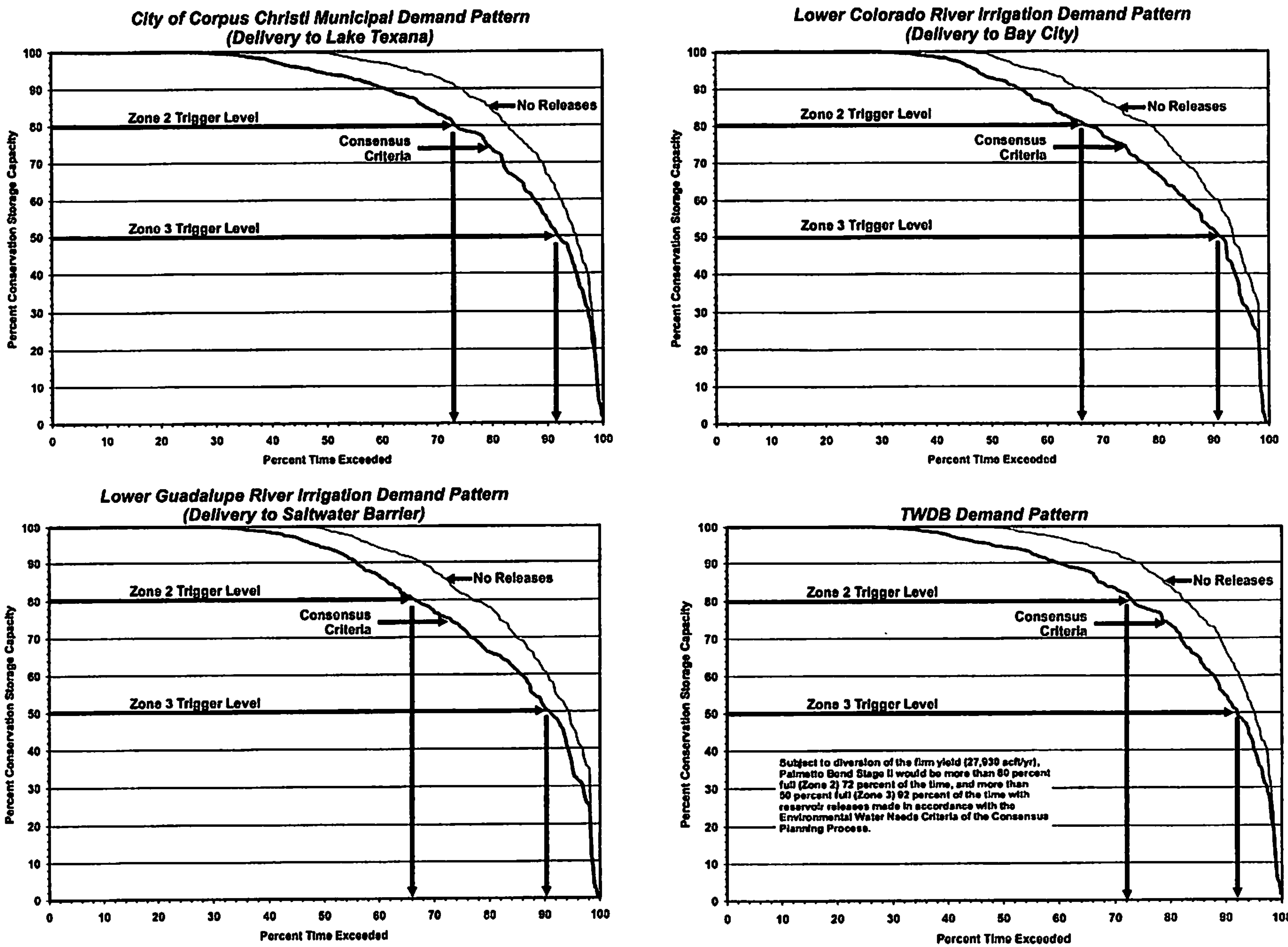


Figure 5.13-3. Palmetto Bend Stage II Reservoir Storage Frequency at Firm Yield

Table 5.13-4. Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Palmetto Bend Stage II Reservoir (SCTN-13)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3,4]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant
Atlantic Hawksbill Sea Turtle	*Eretmochelys imbricata*	Coastal waters	E	E	E	Resident
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Black Bear	*Ursus americanus*	Mountains, broken country, woods, brushlands, forests		T	T	Resident
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Brown Pelican	*Pelecanus Occidentalis*	Coastal islands; shallow Gulf and bays	E	E	E	Resident
Coastal Gay-feather	*Liatris bracteata*	Black clay soils of midgrass grasslands on coastal prairie remnants			WL	Resident
Eskimo Curlew	*Numenius borealis*	Coastal prairies	E	E	E	Migrant
Green Sea Turtle	*Chelonia mydas*	Gulf Coast	T	T	T	Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Gulf Saltmarsh Snake	*Nerodia clarkii*	Coastal waters		T		Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	Coastal waters; bays	E	E	E	Resident
Leatherback Sea Turtle	*Dermochelys coriacea*	Coastal and offshore waters	E	E	E	Resident
Loggerhead Sea Turtle	*Caretta caretta*	Coastal waters; bays	T	T	T	Resident
Mulenbrock's Umbrella Sedge	*Cyperus grayioides*	Prairie grasslands, moist meadows				Resident
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Piping Plover	*Charadrius melodus*	Beaches, flats	T	T	T	Resident
Red Wolf (extirpated)	*Canis rufus*	Woods, prairies, river bottom forests	E	E	E	Resident
Reddish Egret	*Egretta rufescens*	Coastal islands for nesting; shallow areas for foraging		T		Nesting/Migrant
Scarlet Snake	*Cemophora coccinea*	Sandy soils		T	WL	Resident
Smooth Green Snake	*Liochlorophis vernalis*	Coastal grasslands		T		Resident

Table 5.13-4 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
Snowy Plover	*Charadrius alexandrus*	Beaches, flats, streamsides				Winter resident
Sooty Tern	*Sterna fuscata*	Coastal islands for nesting; deep Gulf for foraging		T	WL	Resident
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Near slow moving water, wait in shady areas for host			WL	Resident
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Bays and coastal marshes		T	T	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures				Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March to November		T	T	Resident
Threeflower Broomweed	*Thurovia triflora*	Black clay soils of remnant coastal prairie grasslands			WL	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Welder Machaeranthera	*Psilactis heterocarpa*	Mesquite-huisache woodlands, shrub-invaded grasslands in clay and silt soils			WL	Resident
West Indian Manatee	*Trichechus manatus*	Warm, vegetated coastal waters	E	E	E	
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
[5] Peterson, R.T. 1990. A Field Guide to Western Birds. Houghton Mifflin Company, Boston. pg. 88.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

The importance of the flow reductions to the bay and estuary system is a complex function of bay physiography (estuarine volume, area/depth ratio, substrate composition, constrictions or compartmentalization), regional climate, and the flushing energy provided by tidal action, the effects of multiple freshwater inflows, and the estuarine population examined. The operating regime for Stage II meets the Consensus Criteria for both streamflow and estuary requirements, based on the results of "Freshwater Inflow Needs of the Matagorda Bay System" (LCRA, 1997). The changes in streamflow in the Lavaca River and the inflows into Lavaca Bay resulting from Stage II operation are shown in Figure 5.13-4. Both plots display the reduction in

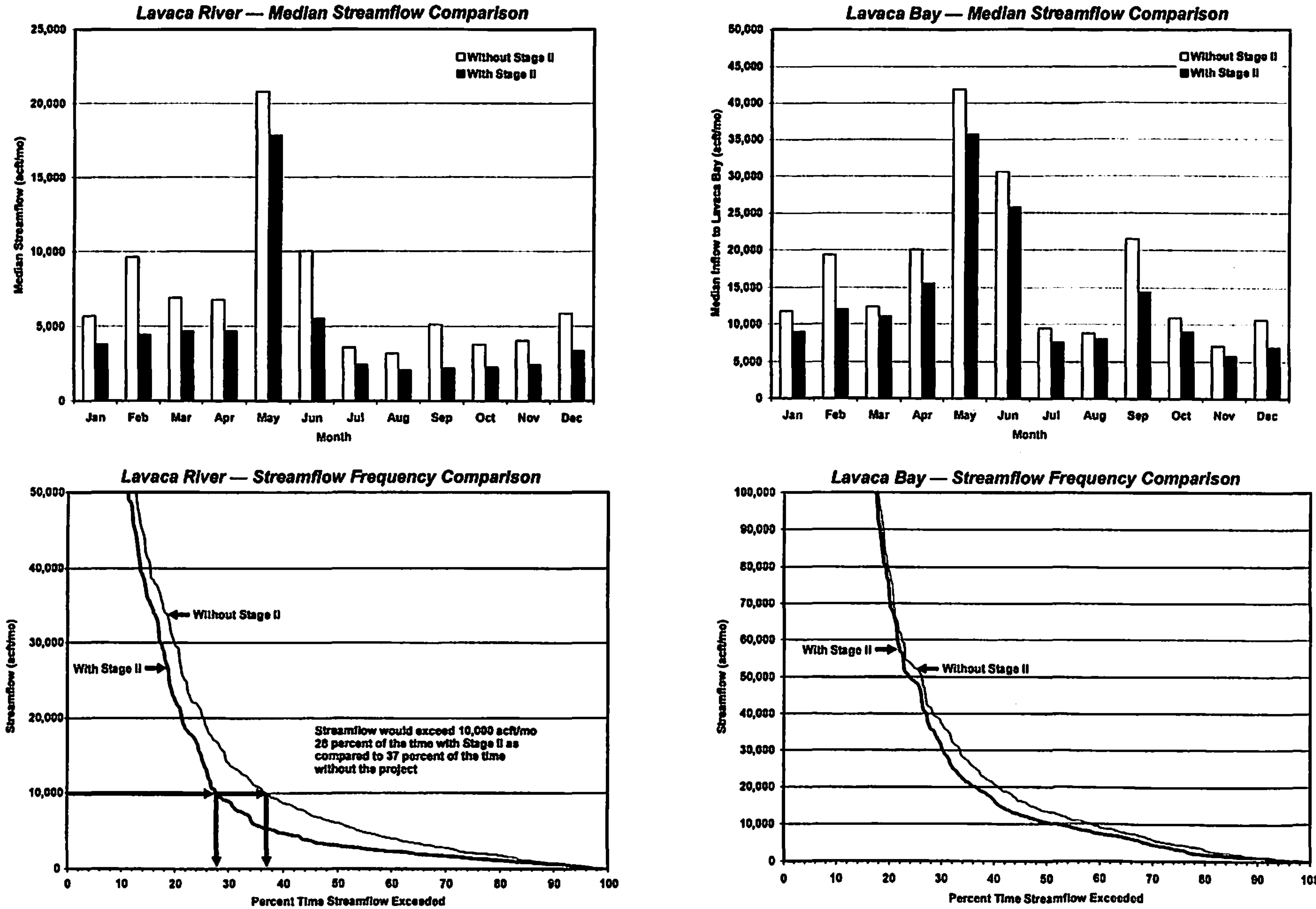


Figure 5.13-4. Palmetto Bend Stage II Reservoir Streamflow Comparisons

flows downstream of Stage II when operating in accordance with Consensus Criteria and simulating the TWDB seasonal demands. The top chart shows the monthly median flows in the Lavaca River downstream of Stage II with and without the project, while the bottom plot shows the reduction in combined Lavaca-Navidad River flows into Lavaca Bay, with Lake Texana in full operation, and with or without Stage II.[7]

Freshwater inflows play an important role in determining the distribution and abundance of estuarine populations. Most importantly, inflows interact with the tidal regime to produce a range of salinity gradients that generally exhibit more or less predictable seasonal patters. Freshwater inflows may also be important in transporting sediments that play a role in maintaining tidal marsh elevations against subsidence and erosion, and nutrients that may support high levels of planktonic production and respiration.

Changes in streamflow in the Lavaca River and in the inflows to upper Lavaca Bay resulting from Stage II operating in accordance with the consensus criteria and the TWDB seasonal demand schedule are characterized in Figure 5.13-4. Monthly median flows with and without Stage Ii in place are presented for a location on the Lavaca River below the proposed dam site, and for combined Lavaca-Navidad River inflows to upper Lavaca Bay in the bar graphs on the top of the page. The frequencies of monthly streamflows with and without Stage Ii in operation are shown for the Lavaca River and for combined inflows are shown in the graphs on the bottom of the page.

The Lavaca River is tidally influenced at the proposed dam site; consequently, its biota is variable depending on its recent history of tidal stages and stream discharge, but is typically dominated by a brackish or salt-tolerant fauna. Following completion of the dam for Stage II, a continuous release requirement might prevent the development of adverse salinity and dissolved oxygen conditions below the dam that now accompany episodes of very low flow. Streamflows will tend to be more uniform over time than would be the case without the project, with most of the reduction occurring at flows above the median, while storage is taking place.

The characteristically large runoff events typical of this region have produced sufficient spills and releases from Lake Texana to maintain the Navidad River channel below the dam, and Stage II is expected to operate similarly. Migration will be blocked in the Lavaca River as it is in

[7] R.J. Brandes Company, "Analysis of Lavaca Bay Salinity Impacts of a Proposed Release Program from Lake Texana," Texas Parks and Wildlife Department, Austin, TX, November 1990.

the Navidad River by Stage I, but strongly migratory species do not have any particular community importance in the present river-estuary system, and none are known that would be extirpated by construction of Stage II.

The slight decrease in estuarine inflows associated with implementation of Stage II (Figure 5.13-4) would have no net adverse effect on Lavaca Bay or the larger Matagorda Estuarine System. Inflows from the Lavaca-Navidad and Colorado Rivers, together with inflows from Tres Palacios and Garcitas Creeks and numerous, small local drainages are more than sufficient to maintain historic productivity levels with Stage II in place (LCRA, 1997).

In addition to the Palmetto Bend Stage II Reservoir, Option SCTN-13 includes three alternatives for the diversion of Stage II water. The alternative pipelines would divert water from Palmetto Bend to one of the three following areas: Lake Texana, the Guadalupe River near the Saltwater Barrier, or Bay City in Matagorda County. The reservoir and all three pipeline routes are in the gulf Prairies vegetational area, the Western Gulf Coastal Plan ecoregion, and the Texan biotic province. Post oak savannah and tall grass prairies dominated by oaks, mesquites (*Prosopis glandulosa*), acacias and prickly pears (*Opuntia spp.*) characterize the Gulf Prairies vegetational area. This vegetation is supported by acidic clays and clay loams interspersed by sandy loams.

Plant and animal species listed by TPWD, USFWS, and TOES that may be within the vicinity of the three pipeline routes or the reservoir are listed in Table 5.13-4. The Texas Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch (NHP) maps two plants, the Threeflower Broomweed (*Thurovia triflora*) and Welder Machaeranthera (*Psilactis heterocarpa*), on the pipeline route from Palmetto Bend to the Guadalupe River. The Threeflower Broomweed is found in black clay soils of remnant coastal prairie grasslands, while the Welder Machaeranthera thrives in shrub-invaded grasslands in clay and silt soils. This proposed route also passes through two rookeries, a wildlife management area, and ends near an area where endangered Attwater's Greater Prairie Chickens have been sighted.

All three pipeline routes pass through or in the vicinity of Bald Eagle (in 1999, downgraded from endangered to threatened status) habitat. The NHP has mapped Bald Eagle habitat on the Guadalupe River near the Saltwater Barrier, which the proposed pipeline to this area would border for approximately 10 miles. A second Bald Eagle habitat, which extends south from Lake Texana along the Lavaca and Navidad Rivers, could be affected by the construction of Palmetto Bend Stage II Reservoir or the proposed pipelines to Lake Texana or Bay City. Bald Eagles usually inhabit areas around large bodies of water with nearby resting sites.

Other protected species that were not mapped in the project area but that could have habitat in the vicinity of the reservoir or one of the three proposed pipelines, include the Black Bear, Jaguarundi, Ocelot, and the Texas Tortoise. The animals depend on brushland and mesquite scrubland habitats in the coastal prairies. The Texas Tortoise occupies shallow depressions at the base of bushes and cacti and underground burrows. Another reptile, the Timber/Canebrake Rattlesnake is usually found in bottomland habitats that support hardwoods.

The White-tailed Hawk (*Buteo albicaudatus*), Interior Least Tern (*Sterna antillarum athalassos*), and Eskimo Curlew (*Numensis borealis*) also inhabit the coastal prairies. The White-tailed Hawk can be found in open prairies and mesquite/oak savannah, while the Interior Least Tern inhabits barren to sparsely vegetated sandbars along river, lake, and reservoir shorelines. The Eskimo Curlew has historically migrated through the coastal prairies in March and April.

Implementation of this option is expected to require field surveys for protected species, vegetation, habitats, and cultural resources during right-of-way selection to avoid or minimize impacts. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and vegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

5.13.4 Engineering and Costing

The annual costs associated with constructing Palmetto Bend Stage II Dam and Reservoir at the site 1.4 miles upstream of the original site are shown in Table 5.13-5. With a total project cost of $124,414,000 financed over 40 years at 6 percent, the annual debt service of constructing Stage II is $8,269,000. Annual operation and maintenance costs are estimated at $1,019,000, resulting in a total annual cost of $9,288,000 for constructing and maintaining Stage II. For an

Table 5.13-5.
Cost Estimate Summary for
Palmetto Bend Stage II Dam and Reservoir
Second Quarter 1999 Prices

Item	Estimated Costs
Capital Costs	
Dam and Reservoir (Conservation Pool: 57,676 acft; 4,679 acres; 44 ft-msl)	$3,226,000
Mobilization	1,183,000
Care of Water	2,283,000
Spillway	32,428,000
Excess Excavation Disposal Berms & Drainage Channels	5,217,000
Upstream Slope Protection	1,135,000
Underdrain System	583,000
Channel Slope Protection	1,239,000
Revegetation	785,000
Clearing	1,312,000
Relocations	18,014,000
Total Capital Cost	**$67,967,000**
Engineering, Legal Costs, and Contingencies	$23,788,000
Environmental & Archaeological Studies and Mitigation	7,380,000
Land Acquisition and Surveying (8,200 acres)	8,118,000
Interest During Construction (4 years)	17,161,000
Total Project Cost	**$124,414,000**
Annual Costs	
Reservoir Debt Service (6 percent for 40 years)	$8,269,000
Operation and Maintenance	1,019,000
Total Annual Cost	**$9,288,000**
Available Project Yield (acft/yr)	**28,200**
Annual Cost of Water ($ per acft) Raw Water at Reservoir	**$329**
Annual Cost of Water ($ per 1,000 gallons) Raw Water at Reservoir	**$1.01**

estimated firm yield of 28,200 acft/yr, the annual cost of raw water at the reservoir would be $329 per acft. The facilities and costs involved with delivering Stage II raw water to the three potential usage locations are discussed below. Each option includes the total annual costs of constructing and maintaining Stage II.

In order to deliver Stage II water to Corpus Christi via the existing transmission facilities from Lake Texana to Corpus Christi, an intake pump station at Stage II, a 4.5-mile transmission line, and an outlet structure would be necessary to transfer water from Stage II to Lake Texana. The capital costs associated with these facilities are shown in Table 5.13-6. The total estimated capital cost of the new facilities is $7,097,000. An additional $1,639,000 of capital would be necessary to upgrade the existing pumping facilities to deliver the additional 28,200 acft/yr. The total project cost with the reservoir is $138,056,000. The annual debt service with the transmissions facilities financed over 30 years at 6 percent interest and the reservoir costs financed at 6 percent over 40 years comes to $9,260,000. The annual costs for operations and maintenance and power are estimated at $2,896,000, which includes $1,764,000 of annual power costs incurred at the existing facilities for delivering the additional water. The total annual cost of constructing Stage II and delivering the firm yield to Corpus Christi is $12,156,000. Dividing annual cost by the firm yield equates to an annual cost of $431 per acft (Table 5.13-6).

If Stage II raw water is delivered to coastal irrigation areas in the lower Guadalupe River, an intake pump station, a 44-mile transmission line, and an outlet structure will be necessary. The total capital costs of the facilities is estimated at $55,265,000. The annual debt service of the new transmission facilities is $6,328,000. The total annual cost, including the reservoir, equals $16,448,000. Dividing the annual cost of the transmission facilities and the reservoir by the firm yield of 28,100 acft/yr results in an annual raw water cost of $585 per acft (Table 5.13-6).

Delivering Stage II raw water to coastal irrigation areas near Bay City will require an intake and pump station, a 46-mile transmission line, and an outlet structure. The total capital cost of the facilities is estimated at $57,404,000. The annual debt service of the transmission facilities is $6,576,000. The total annual cost, including the reservoir, equals $16,910,000. Dividing the annual cost of the transmission facilities and reservoir by the firm yield of 30,200 acft/yr results in an annual raw water cost of $560 per acft (Table 5.13-6).

Table 5.13-6.
Cost Estimate Summary
Palmetto Bend Stage II Dam and Reservoir
Second Quarter 1999 Prices

Item	To Lake Texana	To Saltwater Barrier	To Bay City
Capital Costs			
Dam and Reservoir (Conservation Pool: 57,676 acft; 4,679 acres; 44 ft-msl)	$67,966,000	$67,966,000	$67,966,000
Intake and Pump Station (33 MGD; 85 MGD; 76 MGD)	3,286,000	9,748,000	9,422,000
Outlet Structure	139,000	1,668,000	1,668,000
Transmission Pipeline (54-inch 4.5-mile; 64-inch 44-mile; 64-inch 46-mile)	3,672,000	43,849,000	46,314,000
Improvements to Lake Texana System	1,639,000	0	0
Total Capital Cost	**$76,702,000**	**$123,231,000**	**$125,370,000**
Engineering, Legal Costs, and Contingencies	$26,491,000	$40,368,000	$41,009,000
Environmental & Archaeological Studies and Mitigation	7,493,000	8,528,000	8,585,000
Land Acquisition and Surveying (8,222 acres; 8,412 acres; 8,423 acres)	8,327,000	10,209,000	10,315,000
Interest During Construction (4 years)	19,043,000	29,175,000	29,646,000
Total Project Cost	**$138,056,000**	**$211,511,000**	**$214,925,000**
Annual Costs			
Debt Service (6 percent for 30 years)	$991,000	$6,328,000	$6,576,000
Reservoir Debt Service (6 percent for 40 years)	8,269,000	8,269,000	$8,269,000
Operation and Maintenance			
Intake, Pipeline, Pump Station	113,000	632,000	643,000
Dam and Reservoir	1,019,000	1,019,000	1,019,000
Pumping Energy Costs (294,000 MWh; 3,332 MWh; 4,247 MWh @ $0.06 per kWh)	1,764,000	200,000	403,000
Total Annual Cost	**$12,156,000**	**$16,448,000**	**$16,910,000**
Available Project Yield (acft/yr)	**28,200**	**28,100**	**30,200**
Annual Cost of Water ($ per acft) Raw Water Delivered[1]	**$431**	**$585**	**$560**
Annual Cost of Water ($ per 1,000 gallons) Raw Water Delivered[1]	**$1.32**	**$1.80**	**$1.92**

1 Reported Annual Cost of Water is for raw water delivered to specified location and does not include costs associated with treatment and distribution within municipal systems.

The option to deliver the water to Corpus Christi has a lower annual cost since there are existing facilities in place at Lake Texana that can be upgraded to deliver the Stage II raw water to Corpus Christi. It should be noted that the costs reported in this option only reflect the costs for Stage II and the delivery of raw water to specified locations. They do not include the additional costs necessary to deliver water to the South Central Texas Region in exchange for Stage II water.

5.13.5 Implementation Issues

Implementation of Palmetto Bend Stage II Reservoir with potential delivery of raw water to Corpus Christi (via Lake Texana), to the Guadalupe River Saltwater Barrier, or to the Bay City area could directly affect the feasibility of other water supply options under consideration, including S-16C, G-16C1, C-17A, C-17B, C-18, SCTN-11, SCTN-14a, SCTN-14b, SCTN-16a, SCTN-16b, and/or SCTN-16c.

Since the alternative site of Palmetto Bend involves a different yield than that stated in Certificate of Adjudication #16-2095B, the certificate would need to be amended to reflect the yield at the proposed site and release requirements necessary for the bay and estuary system. An interbasin transfer permit from TNRCC will also be required to implement any of the option discussed above.

Requirements Specific to Reservoirs

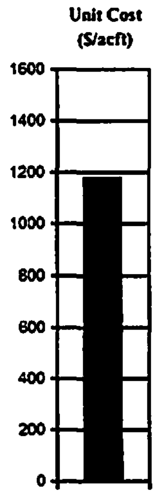
1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits, including interbasin transfer authorization.
   b. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. GLO Sand and Gravel Removal permits.
   d. GLO Easement for use of state-owned land.
   e. Coastal Coordination Council review.
   f. TPWD Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Assessment of effects on bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the reservoir may include:
   a. Highways and railroads.
   b. Petroleum pipelines.
   c. Other utilities.
   d. Structures of historical significance.

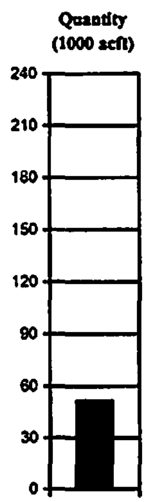
e. Cemeteries.

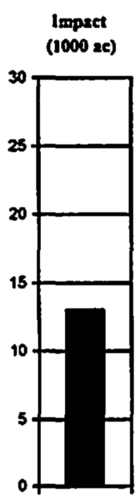
Requirements Specific to Pipelines

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

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: C-18
OPTION NAME: Shaws Bend Reservoir — Firm Yield (Colorado River Basin)

OPTION DESCRIPTION: *The firm yield of the proposed Shaws Bend Reservoir, located 5 miles west of the City of Columbus, Texas, would be diverted through an intake and pumped at a uniform rate through a transmission pipeline to a water treatment plant at the major municipal demand center of the South Central Texas Region and distributed to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	$1,178	per acft[1]	Treated Water Distributed
QUANTITY OF WATER:	51,576	acft/yr[2]	
LAND IMPACTED:	13,023	acres[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Large mainstem dam on Colorado River, river intake and pump station, 125-mile raw water pipeline and two transmission pump stations, water treatment plant, and distribution to municipal systems or recharge zone.

[2]**QUANTITY OF WATER:** Firm yield of reservoir subject to water rights and environmental flow needs.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, water treatment plant site, and pipeline right-of-way. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Up to approximately 5,700 acres of hardwood riparian forest and forested wetlands in the reservoir site. Numerous prehistoric and historic cultural resource sites. The Colorado River from Longhorn Dam in Travis County downstream to Matagorda Bay is recommended for designation as an Ecologically Unique River Segment by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, mitigation requirements, and ability to incorporate into a regional plan that realizes economies of size that benefit all of the participants.

ADDITIONAL FACTORS: Ability to obtain permits for a large dam on Colorado River and water right to transfer Colorado River Basin water to the South Central Texas Region.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: S-15Dc, S-15Eb, C-13C, C-17A, C-17B, SCTN-11, SCTN-12b, SCTN-15, and/or SCTN-20.

5.14 Shaws Bend Reservoir (C-18)

5.14.1 Description of Option

This water supply option involves the construction of a major dam and reservoir on the Colorado River between La Grange and Columbus in Fayette and Colorado Counties. This reservoir, known as Shaws Bend Reservoir, was proposed and studied by the U.S. Bureau of Reclamation (USBR), culminating in a 1986 report.[1] The site for the Shaws Bend Reservoir is shown in Figure 5.14-1. As originally proposed by the USBR, the dam would be located approximately 5 miles west of the City of Columbus. An earthfill embankment would form the reservoir and releases would be controlled through a gated spillway. The dam embankment would extend approximately 5,600 feet across the Colorado River valley, with a crest elevation of 241 ft-ms). The reservoir would provide a conservation storage capacity of 132,220 acft at elevation 220 ft-msl and inundate 12,400 acres at this elevation. The reservoir would extend about 34.5 river miles upstream.

5.14.2 Available Yield

The 1986 USBR study found that Shaws Bend Reservoir would have a firm yield of 140,000 acft/yr, assuming that O.H. Ivie (Stacy) Reservoir would be in place upstream, although, at that time, it had not been constructed. However, this estimated firm yield did not consider requirements for instream flows or freshwater flows for the downstream estuary. Determining a new firm yield for this reservoir, subject to the applicable environment flow constraints of the Lower Colorado River Basin, was the major hydrological task for evaluating this water supply option.

There is a specific set of Instream Flow (IF) and Bay and Estuary (B&E) flow requirements for the Lower Colorado River Basin as opposed to the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B). The Lower Colorado River Basin basin-specific criteria have been developed by the LCRA and approved by TPWD and TNRCC. While these criteria are specific to the LCRA's water rights, staff at TPWD and TWDB believe that these criteria are the most applicable for planning a new project on the mainstem of the Colorado River.[2,3]

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[1] U.S. Bureau of Reclamation, "Colorado Coastal Plains Project," July 1986, revised August 1986.
[2] Personal communication with Cindy Loeffler of Texas Parks and Wildlife Department, August 9, 1999
[3] Personal communication with Gary Powell, Texas Water Development Board, August 6, 1999

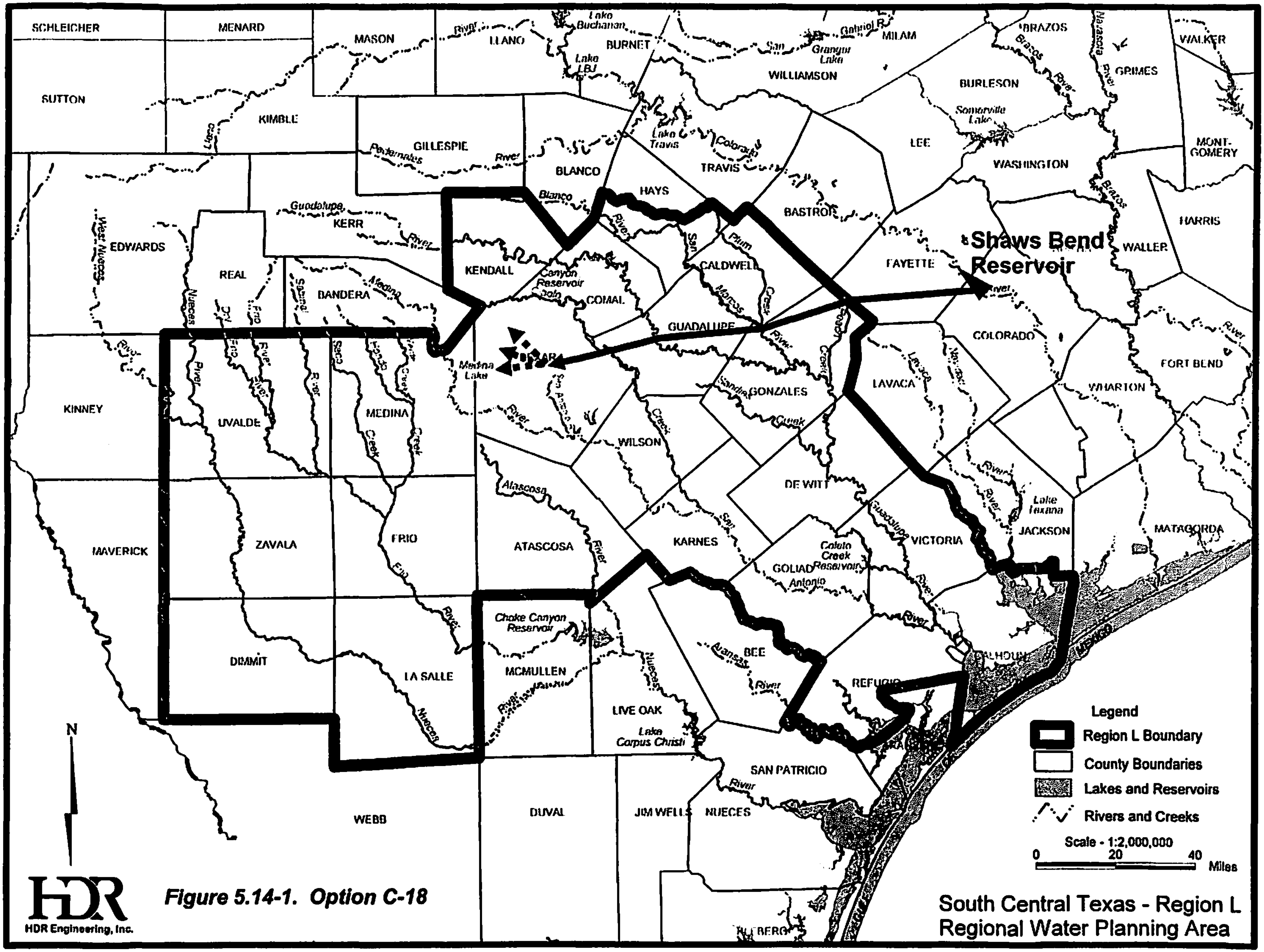


Figure 5.14-1. Option C-18

These Lower Colorado River Basin criteria include separate environmental criteria for instream flows and for bay and estuary flows. Furthermore, each of these sets of criteria are broken into a two-tiered system of "target" and "critical" flows, with the applicable criteria based on the beginning of the year storage in the Highland Lakes System. If stored water is above a certain trigger level at the beginning of the year, then the higher target flows are applicable. Below this trigger level, the lower critical flows are invoked. In either case, the applicable criteria is met "up to the extent of inflows," meaning that a flow up to the magnitude of the inflow to the Highland Lakes System would be passed downstream. The logic of the two-tiered approach to these criteria is similar to that of the general statewide criteria: as conditions become drier there is a "sharing of the adverse impact of drought by humans and the environment." The Lower Colorado River Basin instream flow criteria and bay and estuary flow criteria and the applicable trigger levels are summarized in Table 5.14-1 and Table 5.14-2, respectively.

To determine the unappropriated water in the Lower Colorado River Basin that the Shaws Bend Reservoir would be able to impound, the LCRA's RESPONSE model was utilized. The RESPONSE model determines what portion of the inflows to the Highland Lakes System must be passed to the senior downstream water rights listed in Table 5.14-3. The latest version of the RESPONSE model also will determine if extra inflows must be passed in order to meet the applicable instream flow and bay and estuary environmental criteria shown in Tables 5.14-1 and 5.14-2. In order to make this determination, the model must first determine what portion of the senior water rights demands could be met on a daily basis from run-of-river flows originating in the reaches of the Colorado River below the Highland Lakes.

One of the critical variables of the RESPONSE model is the level of assumed return flows from the City of Austin's wastewater treatment plants. This can be a considerable input volume, especially during the critical drought period, and is important for supplying downstream water rights demands. As a result of the 1987 agreement between the City of Austin and the LCRA, approximately 272,000 acft/yr of the City's Certificate of Adjudication 14-5471 (7 and 8 in Table 5.14-3) is backed up by stored water in the Highland Lakes. Recent estimates of Austin's return flow percentages are in the range of 55 percent. In this analysis, it was assumed that this would be reduced to 44 percent, a 20 percent reduction in return flow due to reuse initiatives. This gives a future volume of 120,000 acft/yr at that point in time when the full 272,000 acft is utilized.

Table 5.14-1.
Instream Flow Requirements for the Lower Colorado River Basin

Month	Target Flows (cfs)[1]			Subsistence/Critical Flows (cfs)[1]	
	Bastrop	Columbus	Wharton	Austin	Bastrop
January	370	300	240	46[3]	120
February	430	340	280	46[3]	120
March	560	500[2]	360	46[3]	500[4]
April	600	500[2]	390	46[3]	500[4]
May	1,030	820	670	46[3]	500[4]
June	830	660	540	46[3]	120
July	370	300	240	46[3]	120
August	240	200	160	46[3]	120
September	400	320	260	46[3]	120
October	470	380	310	46[3]	120
November	370	290	240	46[3]	120
December	340	270	220	46[3]	120

[1] Target flows apply when the beginning of year storage in the Highland Lakes is greater than 1,100,000 acft; otherwise, subsistence/critical flows apply.

[2] Since target flow at Columbus (based on overall community habitat availability) were insufficient to meet Blue Sucker (*Cycleptus elongatus*) spawning requirements during March and April, target flows were superceded by critical flow recommendations for this reach.

[3] LCRA will maintain a mean daily flow of 100 cfs at the Austin gage at all times, to the extent of inflows each day to the Highland Lakes as measured by upstream gages, until the combined storage of Lakes Buchanan and Travis reaches 1.1 million acft of water. A mean daily flow of 75 cfs, to the extent of inflows each day to the Highland Lakes as measured by upstream gages, will then be maintained until the combined storage of Lakes Buchanan and Travis reaches 1.0 million acft of water, then a subsistence/critical flow of 46 cfs will be maintained at all times, regardless of inflows.

In addition, if the subsistence/critical flow of 46 cfs should occur for an extended period of time, then operational releases will be made by LCRA to temporarily alleviate the subsistence/critical flow conditions. Specifically, should the flow at the Austin gage be below a 65-cfs daily average for a period of 21 consecutive days, LCRA will make operational releases from storage sufficient to maintain daily average flow at the Austin gage of at least 200 cfs for two consecutive days. If this operational release condition persists for three consecutive cycles (69 days), then a minimum average daily flow of at least 75 cfs will be maintained for the next 30 days.

[4] This flow should be maintained for a continuous period of not less than 6 weeks during these months. A flow of 120 cfs will be maintained on all days not within the 6-week period.

Source: LCRA, "Water Management Plan for the Lower Colorado River Basin," March 1999.

The REPONSE model was executed with all of the senior water rights in Table 5.14-3 attempting to divert their maximum permit amount each year. The environmental criteria of Table 5.14-1 and Table 5.14-2 were also utilized. The RESPONSE model first determines what portion of the water rights' demands are met on a daily basis. If these rights are not met, then inflows to the Highland Lakes are passed up to the amount necessary to satisfy the senior water rights. After this, the RESPONSE model checks to see if the applicable instream flow criteria of

Table 5.14-2.
Bay and Estuary Requirements for the Lower Colorado River Basin

Month	Target Needs[1] (acft)	Critical Needs[1] (acft)
January	44,100	14,260
February	45,300	14,260
March	129,100	14,260
April	150,700	14,260
May	162,200	14,260
June	159,300	14,260
July	107,000	14,260
August	59,400	14,260
September	38,800	14,260
October	47,400	14,260
November	44,400	14,260
December	45,200	14,260
Total	1,033,100[2]	171,100

Note: Total commitments of the Combined Firm Yield from the Highland Lakes for bays and estuaries (estuarine inflows) will be an average of 3,090 acft/yr, with a maximum of 11,200 acft in any one year; 19,700 acft in any two consecutive years; 24,200 acft in any three or four consecutive years; 28,200 acft in any five consecutive years; and 30,900 acft in any six to ten consecutive years.

1 Target needs apply when beginning of year storage in the Highland Lakes is above 1,700,000 acft; otherwise, critical needs apply.

2 The sum of the monthly target needs is 1,032,900 acft. The slight difference from the published total value is presumably due to rounding.

Source: LCRA, "Water Management Plan for the Lower Colorado River Basin," March 1999.

Table 5.14-1 are being met with the run-of-river flows below the lakes plus the Highland Lakes inflows passed thus far. If not, then additional Highland Lakes inflows are passed to attempt to satisfy the criteria. After this procedure is completed for a month, the model confirms that the sum of the daily flows that would have exited the river beyond the lowest gage at Bay City would meet the applicable bay and estuary criteria of Table 5.14-2. If not, then additional inflows may be passed to meet these criteria, but only subject to the multiple year constraints noted at the bottom of Table 5.14-2.

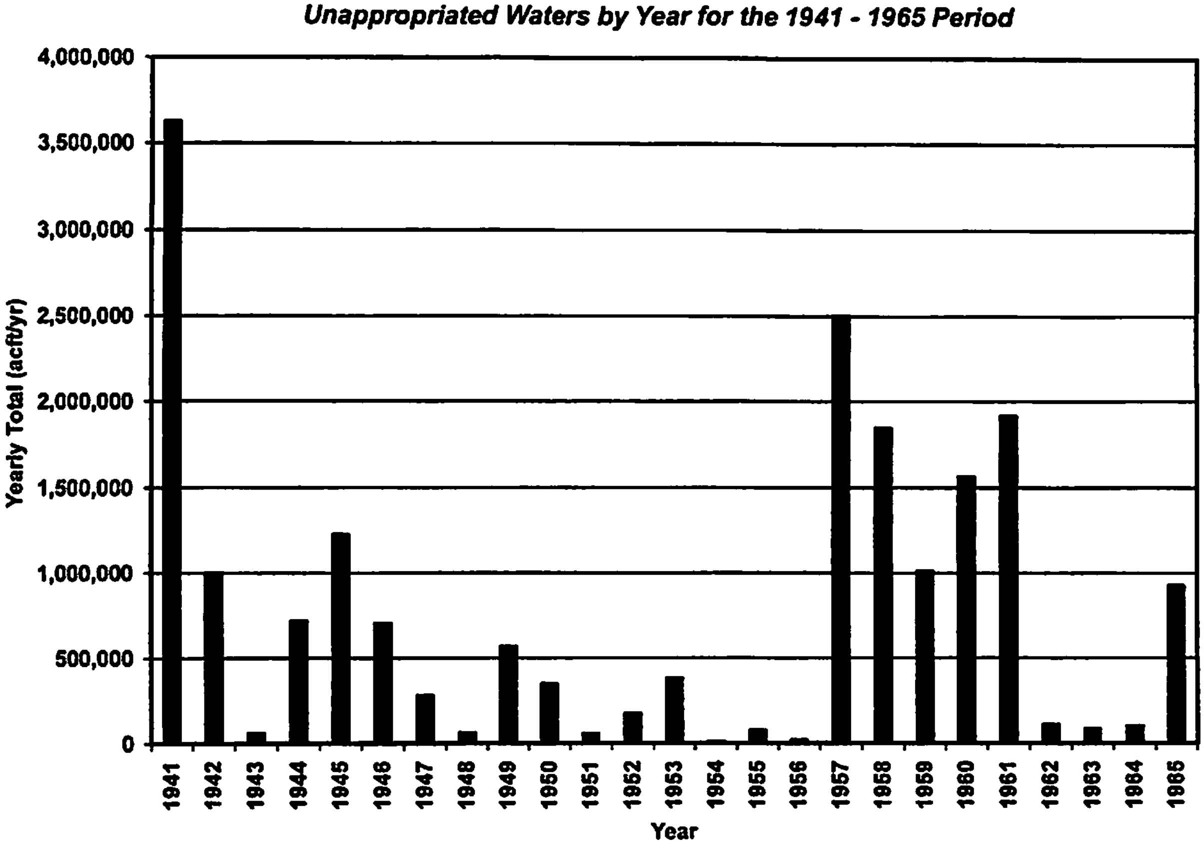
Table 5.14-3.
Summary of the Senior Water Rights in the Lower Colorado River Basin

	Description	Permit or Certificate Number	Priority Date	Annual Consumptive Use Authorized (acft)	Use Type
1	LCRA - Garwood	14-5434A	11/01/1900	133,000	Irrigation
2	Corpus Christi - Garwood	14-5434B	11/02/1900	35,000	Municipal
3	LCRA - Gulf Coast	14-5476	12/01/1900	228,570	Irrigation
4	LCRA - Lakeside	14-5475	01/04/1901	52,500	Irrigation
5	Pierce Ranch	14-5477A	09/01/1907	55,000	Irrigation
6	LCRA - Pierce Ranch	14-5477B	09/01/1907	55,000	Irrigation
7	City of Austin	14-5471	11/15/1913	250,000	Municipal
8	City of Austin	14-5471	1913, 1914	46,403[2]	Municipal
9	City of Austin	14-5489	1945, 1965	36,456[3]	Municipal
10	LCRA - Gulf Coast	14-5476A	1987	33,930	Irrigation
11	LCRA - Lakeside	14-5475	1987	78,750	Irrigation

[1] These three water rights held by LCRA are subordinated to the 250,000 acft of the City of Austin's water right (no. 7).
[2] 22,403 acft/yr of this right are for municipal use, the balance is for steam-electric.
[3] These water rights are for steam-electric generation and cooling.

For this water supply option, the unappropriated water in the Lower Colorado River Basin was determined by utilizing the final predicted gage flows at Columbus from the REPONSE model which are given on a daily basis. Unappropriated water was determined subject to three constraints. The first criterion was that for any given day, the bay and estuary flows were met for the month containing that day. Next all senior water rights demands must have been met for that day, and finally, the instream flow needs were being met. Only the amount of water over and above that needed for senior water rights below Columbus and the instream flows at Columbus or Wharton was deemed unappropriated.

The upper panel of Figure 5.14-2 shows the total unappropriated flows on an annual basis for the 1941 to 1965 period. The large annual values such as those of 1941 or 1957, represent years in which large flood flow events occurred. The lower panel of Figure 5.14-2 shows the unappropriated water on an average monthly basis. Generally, there is little water available



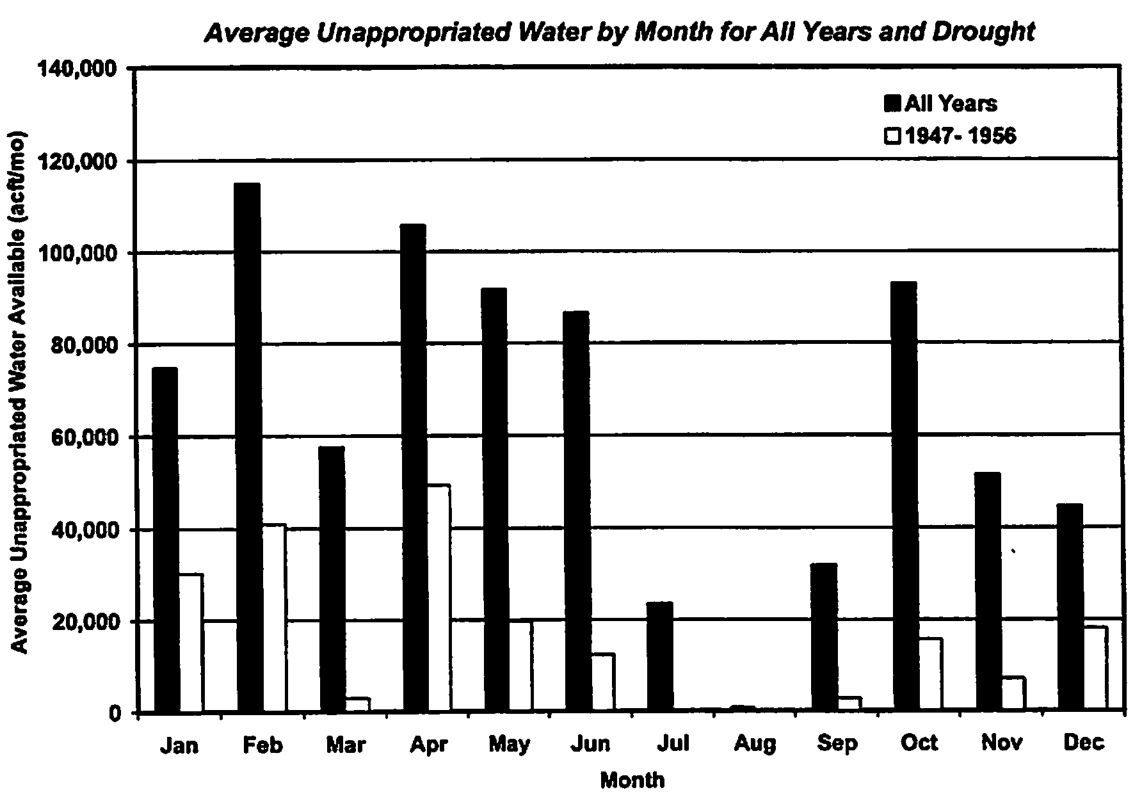


Figure 5.14-2. Availability of Unappropriated Waters of the Colorado River at Columbus

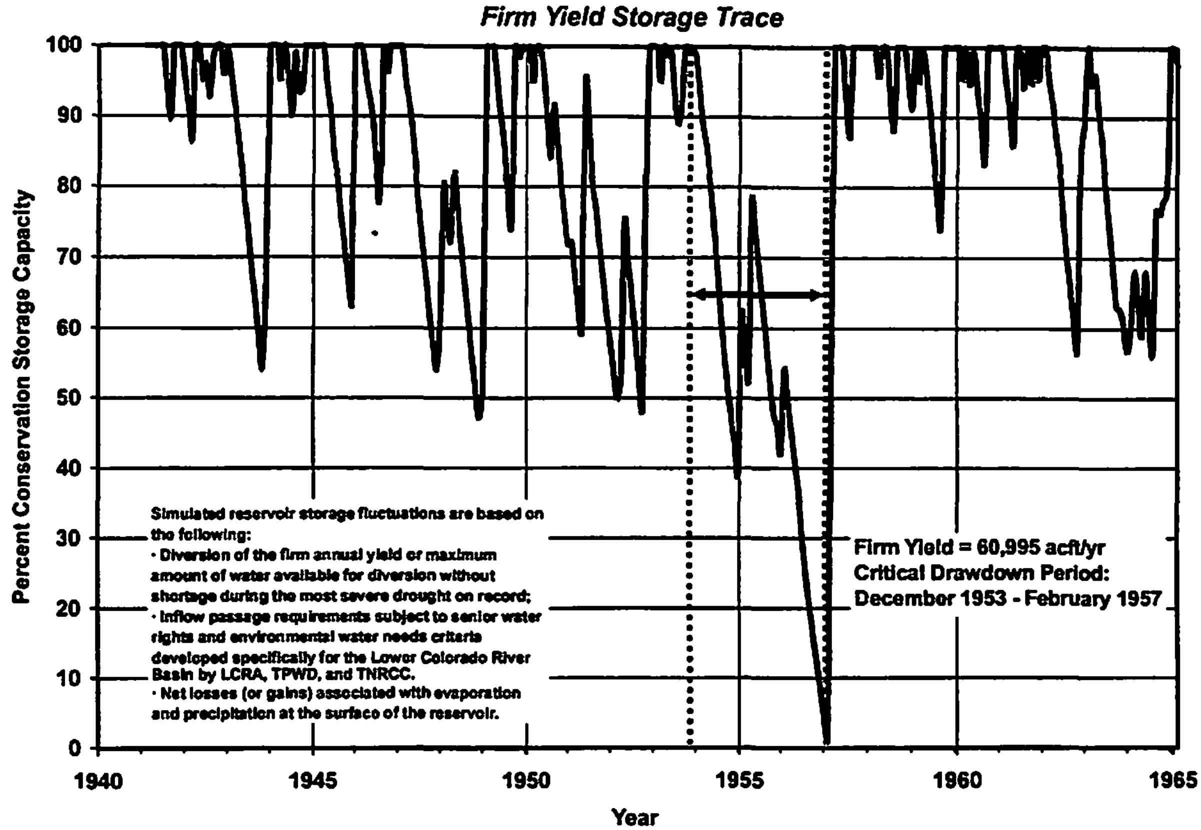
during the summer months due to the correspondence of low flows and high demands by the senior irrigation water rights (Table 5.14-3).[4] During 9 years of extended drought (1947 to 1956), no water would be available in the months of July or August. For the 1941 to 1965 period of record the July and August average unappropriated flows would be 23,444 acft/month and 744 acft/month, respectively. The winter months are much better on average, but even these months have much less water available during the critical drought period.

With the available water from the Colorado River quantified, subject to the senior water rights and applicable instream flow and bay and estuary criteria, it was then possible to make a new determination of the firm yield of the Shaws Bend Reservoir. This firm yield was computed with a modified version of the SIMDLY reservoir operation model (originally written by TWDB). The reservoir was assumed full at the start of the SIMDLY simulation. It was assumed that water would be withdrawn from the reservoir with a uniform demand pattern. Under these assumptions, the firm yield to the Shaws Bend Reservoir was determined to be 51,576 acft/yr., which represents a reliable supply based on the 1941 through 1965 period of historical hydrologic record.

The upper panel of Figure 5.14-3 illustrates the simulated reservoir storage fluctuations for Shaws Bend Reservoir for the 1941 to 1965 historical period subject to diversion of the firm yield. The lower panel of Figure 5.14-3 illustrates storage behavior of the reservoir in a storage-frequency curve. Reservoir contents remain above the Zone 2 trigger level[5] (80 percent capacity) about 62 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 92 percent of the time over the 1941 to 1965 simulation period.

The upper panel of Figure 5.14-4 illustrates the changes in median streamflows that would occur at Columbus, with the Shaws Bend Reservoir impounding the unappropriated waters of the Colorado River just upstream. The largest change would be a decline in median streamflow of 18,694 acft/month (337 cfs) during February. Other significant declines would occur in May and June with declines in median streamflow of 13,910 acft/month (226 cfs) and 16,065 acft/month (267 cfs), respectively. During the summer months of July-September there

[4] There is a strong seasonal concentration of the irrigation demand pattern during the late spring through summer period (May 15 to September 15), when 75 percent of the total irrigation demand is exercised.
[5] Although the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B) are not applicable to this reservoir, these storage benchmarks are given for comparative purposes.



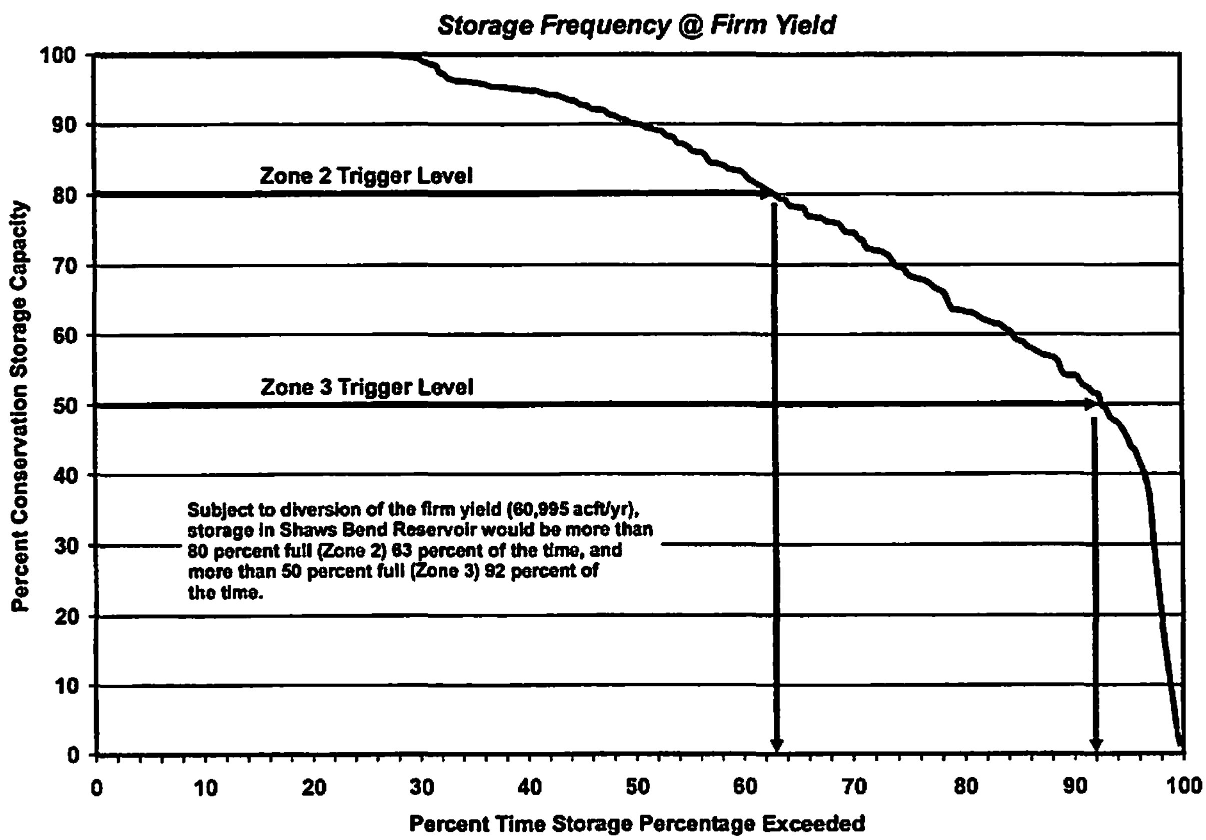
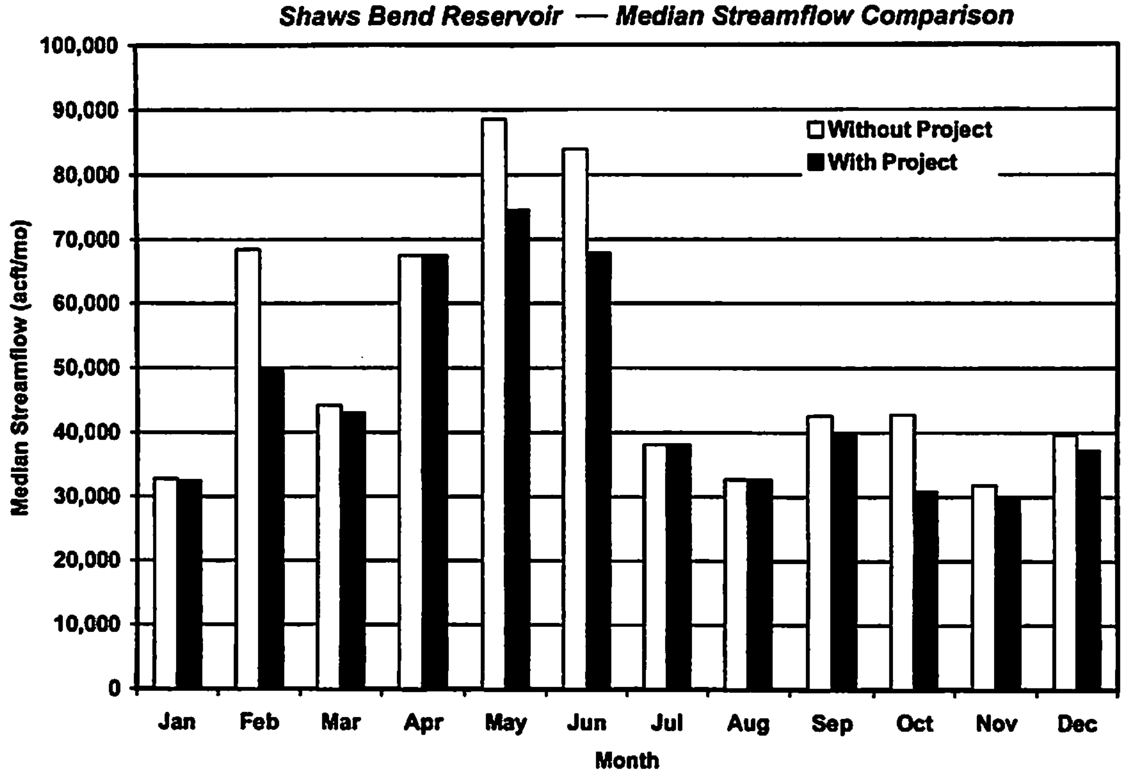


Figure 5.14-3. Shaws Bend Reservoir Storage Considerations



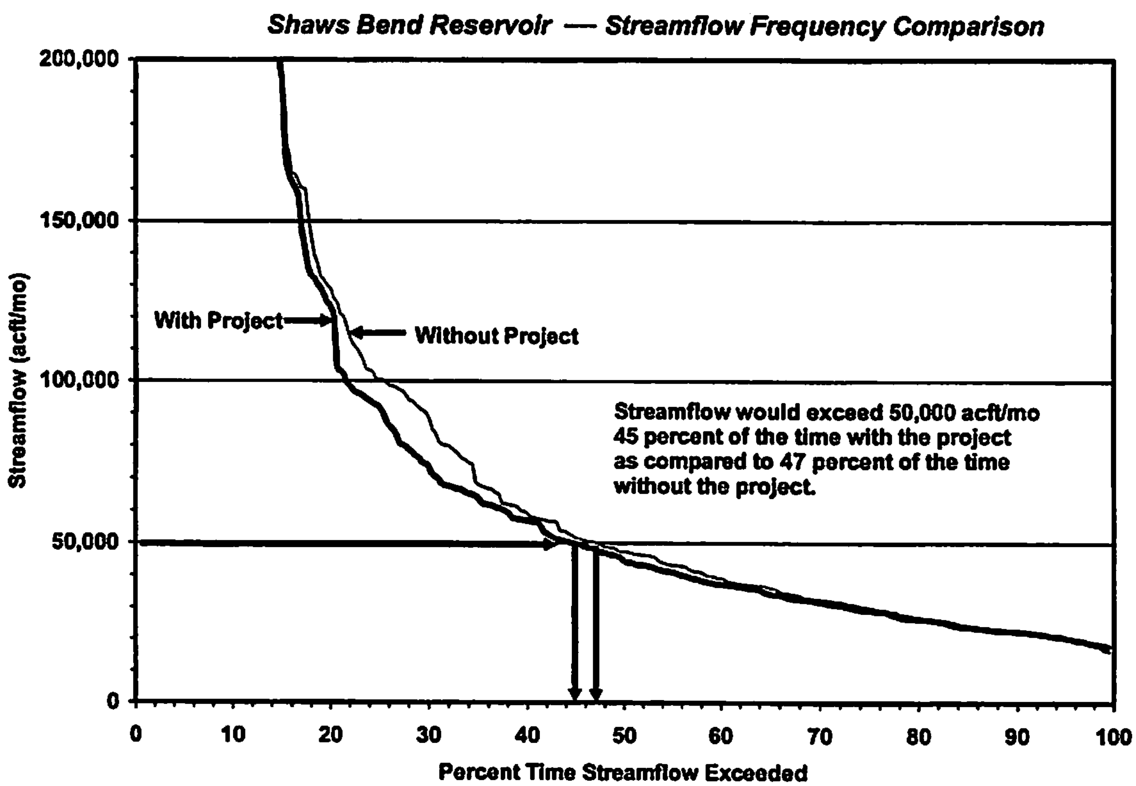


Figure 5.14-4. Shaws Bend Reservoir Streamflow Comparisons

would be little or no change in streamflow because the reservoir would only rarely be able to impound water in excess of that required for downstream senior water rights and environmental needs.

The lower portion of Figure 5.14-4 illustrates the streamflow frequency characteristics of the Colorado River at Columbus with the Shaws Bend Reservoir project in place. At low flows, there is little difference with the project because the reservoir would typically be passing all, or nearly all, inflows in order to satisfy senior water rights and/or environmental constraints. There is a more pronounced difference at higher Colorado River flows because, in this range, the reservoir would be able to impound water, since water rights and environmental needs would be satisfied more frequently.

5.14.3 Environmental Issues

The Shaws Bend Reservoir described in Option C-18 would impound the Lower Colorado River in Colorado and Fayette counties. The proposed dam site is located approximately 4.1 river miles above the U.S. Highway 71 bridge crossing near Columbus in Colorado County, Texas. The reservoir project description and much of the environmental characterization, is taken from two reports: the ECS Technical Services[6] April 1985 report to the USBR, and the USBR[7] "Report Concluding the Colorado Coastal Plains Project." The ECS report was an environmental inventory and impacts assessment that compared Shaws Bend Reservoir with a series of small reservoirs. The 1986 USBR Report selected Shaws Bend as the preferred alternative for the Colorado coastal Plains Project.

The reservoir lies entirely within the Texas Blackland Prairie Ecoregion, and the Post Oak Savannah[8] vegetational area of Texas lies immediately to the north of the upper reservoir boundary. The Blackland Prairie vegetational area (Blair's[9] regional classification) places the reservoir in the Texan Biotic Province, a "broad ecotone" between western grasslands and eastern forests. Blair's biogeographical listing of wildlife fauna of this region, like the vegetation, is a mix of western grassland-associated and eastern forest-associated organisms.

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[6] ECS, "Environmental Resources Assessment, Colorado Coastal Plains Project, Texas," ECS Technical Services. 1985.
[7] Bureau of Reclamation, "Report Concluding the Study on Colorado Coastal Plains Project, Texas," Southwest Region, Amarillo, Texas, 1986.
[8] Gould, F.W., "The Grasses of Texas," Texas A & M University Press, College Station, Texas, 1975.
[9] Blair, W.F., "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp.93-117, 1950.

The Post Oak Savannah is characterized by gently rolling to hilly terrain with an understory that consists typically of tall prairie grass and an overstory that is primarily post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*).[10] Most of the Post Oak Savannah has been converted to improved pastures and small farms. The Blackland Prairie's gently rolling to nearly level plain is largely under cultivation with a few areas in native hay meadows and improved pastures. The soils of the East Central Texas Plains are characteristically dry alfisols.[11] Within the reservoir site are clayey and loamy Brazoria–Norwood soils, typical of floodplains and river terraces.[12] Brazoria soils are poorly drained hydric soils[13] that support hydrophytic vegetation (i.e., they may be USCE jurisdictional wetlands).

The vegetation of the reservoir site is primarily influenced by its location in the Colorado River floodplain. The USBR study applied the USFWS Habitat Evaluation Procedure cover type categories to evaluate the vegetation communities to be affected by the proposed reservoir[14] as shown in Table 5.14-4. The wetlands and river terrace are primarily forested with pecans, cottonwoods, sycamores, and willows. Live oak, post oak and water oak cover the upper river terraces and upland areas. Grassland and pasture comprise about half of the reservoir area.

The vegetation cover types of Table 5.14-4 have been grouped into categories corresponding to those used throughout this report[15] for comparison with other projects. As these acreages are based on USFWS classification criteria, it is uncertain what proportion of the wetland categories will qualify as USCE jurisdictional areas under the wetland determination criteria and procedures currently in use.[16] However, next to actual riverine and forested wetlands, riparian woodlands presently rank among the highest priorities for conservation among both state and federal regulatory agencies.

[10] Correll, D.S., and M.C. Johnston, "Manual of the Vascular Plants of Texas," Texas Research Foundation, Renner, Texas, 1979.
[11] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.
[12] SCS, General Soils Map, Colorado County, Texas, Sheet 4R36426, 1978.
[13] SCS, "Hydric Soils of the United States," Miscellaneous Publication No. 1491, U.S. Dept. of Agriculture, 1991.
[14] Bureau of Reclamation, "Report Concluding the Study on Colorado Coastal Plains Project, Texas," Southwest Region, Amarillo, Texas, 1986.
[15] McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas, Including Cropland," Texas Parks and Wildlife Department, Austin, Texas, 1984.
[16] USCE. 1987. Corps of Engineers, "Wetlands Delineation Manual." Environmental Laboratory. Vicksburg, MS. ADA 176 734.

Table 5.14-4
Shaws Bend Reservoir
Habitats within Proposed Reservoir Conservation Pool[1]

Land Use Within Conservation Pool	Acres
Crop	0
Upland Woodland	3,092
Park	1,193
Brushland	0
Grassland and Pasture	5,781
Riverine (R2) Wetland	1,016
Forested Wetland	1,318
Total Acres	12,400

[1] U.S. Bureau of Reclamation 1986 report concluding the study on Colorado Coastal Plains Project, Texas. Southwest Region, Amarillo, Texas

The with and without project changes in the monthly median streamflows in the Colorado River below the Shaws Bend impoundment shown in Figure 5.14-4, result from operations designed to meet the instream flow guidelines established by LCRA and explained in Section 5.14.2. The annual hydrograph of the Colorado River has been disturbed for many years by the pattern of winter storage (normally a period of high flow) in the Highland Lakes and summer releases to meet downstream irrigation demand. It will continue to depart from pre-impoundment seasonal patterns as the Highland Lakes are operated to provide flood control and public water supply benefits.

The USBR[17] concluded that the continued existence of protected species or candidates for protection would not be affected by the project. Surveys for five protected or rare plant species failed to locate Texas meadow-rue, Navasota ladies'-tresses, blue-star, spikerush, or prairie dawn within the project area. Additional field studies revealed that the project area soils are unsuitable for populations of the endangered Navasota ladies'-tresses. However, the study recommended that the proposed dam site, adjacent uplands, and lands within the conservation pool should be thoroughly surveyed again for Texas meadow-rue prior to construction, since this plant adapts to prairie and oak forest with a shrub-grass understory. The USBR agreed to survey the reservoir

[17] Bureau of Reclamation, Op. Cit., 1986.

for evidence of nesting American bald eagles prior to project construction. Important species proposed or listed for protection that may be present in the project vicinity are listed in Table 5.14-5. The Texas garter snake may be present in wetland habitats and grasslands. The timber rattlesnake is associated with dense bottomland woods. The Texas horned lizard and the western smooth green snake may be present in grassland areas. Two fish, the blue sucker and the Guadalupe bass, are known to inhabit this portion of the Colorado River. The implementation of Shaws Bend Reservoir (C-18) would require field surveys for protected species, vegetation and habitats.

Two environmentally unique areas, Harvey Creek woodlands and Horseshoe Bend woodlands, would be affected by the proposed reservoir. Harvey Creek is about 30 acres of relatively undisturbed mature oaks, elms, and hackberry trees. The creek provides a continuous water supply to the numerous pools and riffles along the reach above the confluence with the Colorado River. This pristine bottomland with pools and riffles would be totally inundated by the conservation pool. Horseshoe Bend woodlands, relatively undisturbed for more than 30 years, is approximately 100 acres dominated by an elm-ash-hackberry community with relatively homogeneous stands of cottonwood, hackberry, and other bottomland trees. The central portion of this woodland has a remnant oxbow lake that was cut off from the Colorado River during the 1940s. Other area oxbow lakes have generally been cleared for agricultural purposes. The Horseshoe Bend woodlands would be 70 percent inundated by the conservation pool.

The USBR agreed to a mitigation plan with USFWS for the habitat inundated. Mitigation included planting 4,000 acres of bottomland with native hardwoods to create a forested wetland within a 6,000-acre wildlife management area. Mitigation plans included the areas directly affected by the reservoir inundation, areas disturbed by construction, and an estimated 2,180 acres of pecan orchard adjoining the reservoir site that may be killed by the raised groundwater table. Results of a Habitat Evaluation Procedure conducted by the USFWS indicated that about 46,000 acres managed to encourage woodland development could be needed to compensate for terrestrial habitat losses.

Table 5.14-5
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Shaws Bend Reservoir (C-18)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3,4]	
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	E			Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	E			Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Gulf coastal prairies	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-Capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-Spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C			Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau				Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau				Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen city and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks				Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	E			Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	E			Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant
Houston Meadow-Rue	*Thalictrum texanum*	Outskirts of mesic woodlands or forests			WL	Resident
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Madla's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	E			Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer				Resident

Table 5.14-5 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT			Nesting/Migrant
Mulenbrock's Umbrella Sedge	*Cyperus grayioides*	Prairie grasslands, moist meadows				Resident
Navasota Ladies'-Tresses	*Spiranthes parksii*	Margins of post oak woodlands within sandy loams	E	E	E	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies				Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	E			Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	E			Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations				Resident
Smooth Blue-Star	*Amsonia glaberrima*	Dense woods and low pinelands[5]				Resident
Smooth Green Snake	*Liochlorophis vernalis*	Coastal grasslands		T		Resident
Spot-Tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear				Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Spikerush	*Eleocharis austrotexana*	Fresh and moderately alkali marshes; along coasts in fresh and water marshes[6]				Resident
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Near slow moving water, wait in shady areas for host			WL	Resident
Texas Pink-Root	*Spigelia texana*	Wooded slopes and floodplains woods along rivers[5]				Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures				Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tauschia	*Tauschia texana*	Alluvial thickets or wet woods[5]				Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March through November		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	E			Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	E			Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
5 Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.
6 Hotchkiss, Neil. 1972. Common Marsh, Underwater & Floating-leaved Plants of the United States and Canada. Dover Publications, Inc., New York.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

With regard to cultural resources, about 200 to 250 prehistoric and historic sites were identified in the project area. Some sites would be destroyed by project construction and others would be less vulnerable to destruction as a result of inundation.[18] Burnham's Crossing, a historic ferry crossing and trade center, would be inundated regardless of conservation pool level since most of the site lies below the 200-foot contour. A site mitigation plan will be required to avoid loss of historically significant resources.[19] A systematic survey of the entire reservoir site would be required to search for surface indications of cultural deposits, while a geomorphic study to evaluate the potential for buried deposits is also a likely requirement. Sites located would have to be tested for archaeological or historic significance and for eligibility for listing on the National Register, and the need for additional study, salvage, or other mitigation determined prior to construction.

5.14.4 Engineering and Costing

This water supply option would require several major infrastructure items as summarized in Table 5.14-6. Obviously, the main item would be the construction of the Shaws Bend Dam itself. The dam would extend approximately 5,600 feet across the Colorado River valley with a crest elevation of 241 ft-msl. The reservoir would provide a conservation storage capacity of 132,220 acft. The cost for constructing this large dam is estimated to be approximately $83.25 million.

Other major items include the approximately 125-mile transmission pipeline to convey the firm yield of the reservoir to the major municipal demand center of the south Central Texas Region as shown in Figure 5.14-1. The uniform delivery rate would be approximately 48.5 MGD requiring a 60-inch diameter transmission pipeline costing approximately $119.29 million.

Associated with the pipeline are the reservoir pump station and the two transmission pump stations along the length of the line. These pump stations are estimated to cost approximately $15.49 million. Another important capital cost is $62.43 million for distribution of water to municipal systems or to an aquifer for enhancement of recharge.

[18] Ibid.
[19] Ibid.

Table 5.14-6.
Cost Estimate Summary for
Shaws Bend Reservoir (C-18)
Second Quarter 1999 Prices

Item	Estimate Costs
Capital Costs	
Dam and Reservoir (Conservation Pool: 132,220 acft; 12,400 acres; 220 ft-msl)	$83,246,000
Intake and Pump Station (48.5MGD)	6,288,000
Water Treatment Plant (48.5 MGD)	33,909,000
Transmission Pump Stations (2)	9,205,000
Transmission Pipeline (60-inch dia.; 125 miles)	119,285,000
Relocations	1,808,000
Distribution	62,426,000
Power Connection Costs ($125/HP)	1,808,000
Total Capital Cost	**$317,975,000**
Engineering, Legal Costs, and Contingencies	$104,552,000
Land Acquisition and Surveying (13,023 acres)	87,402,000
Interest During Construction (4 years)	94,953,000
Environmental and Archaeology Studies, Mitigation, and Permitting	83,529,000
Total Project Cost	**$688,411,000**
Annual Costs	
Debt Service (6 percent, 30 years)	$26,711,000
Debt Service (6 percent, 40 years)	21,317,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	1,580,000
Water Treatment Plant	3,865,000
Dam and Reservoir	1,249,000
Distribution Systems	624,000
Pumping Energy Costs (118,170,569 kWh @ $0.06 per kWh)	5,388,000
Total Annual Cost	**$60,734,000**
Available Project Yield (acft/yr)	**51,576**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$1,178**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$3.61**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

Another associated cost would be the purchase of the periodically inundated land of the reservoir. Although the normal conservation pool would be 12,400 acres, the total land area of the flood pool would be approximately 23,400 acres.[20] A general land cost of $2,000 per acre was used to value the land to be purchased. However, a 1,000-foot-wide corridor 34.5 miles in length along the Colorado River bottom was estimated to cost $10,000 per acre. The total land purchase cost for the reservoir area, including surveying, was $81.41 million. Land acquisition and surveying for the pipeline right-of-way and associated pump stations would be $5.99 million, for a total of $87.40 million.

With engineering, contingencies, legal costs, and other studies, the total project cost for the Shaws Bend Reservoir project would be $688.41 million.

The reservoir portion of the project would be financed for 40 years at 6 percent for a total annual payment of $21.32 million. The other portions of the project would be financed over 30 years at a 6 percent annual interest rate for an annual cost of $26.71 million. Operation and maintenance costs total $7.32 million annually.

Large annual costs are associated with the pumping of Colorado River water from the Shaws Bend Reservoir near Columbus to the major municipal demand center of the south Central Texas Region. The pumping costs for the conveyance of the Colorado River water, with the necessary vertical lift and friction losses along the pipeline, are estimated to be $5.39 million per year.

The total annual costs, including debt repayment, interest, and operation and maintenance, total $60.73 million. For an annual supply of 51,576 acft the resulting cost of water of would be $1,178 per acft/yr or $3.61 per 1,000 gallons.

5.14.5 Implementation Issues

Implementation of Shaws Bend Reservoir on the Colorado River could directly affect the feasibility of other water supply options under consideration, including S-15Dc, S-15Eb, C-13C, C-17A, C-17B, SCTN-11, SCTN-12b, and/or SCTN-15. An institutional arrangement would likely be needed to implement this option with financing on a regional basis.

[20] U.S. Bureau of Reclamation, Op. Cit., 1986.

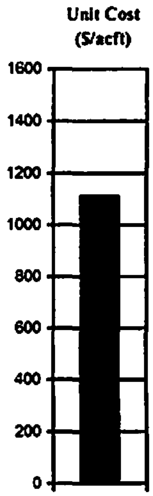
Requirements Specific to Reservoir

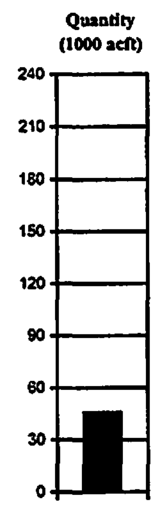
1. It will be necessary to obtain these permits for reservoir:
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer Approval.
   c. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. GLO Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. TPWD Sand, Gravel, and Marl permit
2. Permitting, at a minimum, will require these studies:
   a. Assessment of changes in instream flow and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired either through negotiations or condemnation.
4. Relocations for the reservoir may include:
   a. Highways and railroads
   b. Other utilities
   c. Structures of historical significance
   d. Cemeteries

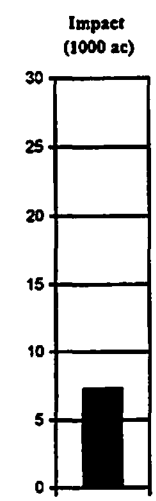
Requirements Specific to Pipelines

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

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **SCTN-15**
OPTION NAME: **Cummins Creek Reservoir (Colorado River Basin)**

OPTION DESCRIPTION: *Cummins Creek Reservoir site is located on Cummins Creek, a tributary of the Colorado River near Columbus. The site is near the confluence with the Colorado River, and has potential to be developed using: (A) only flows of Cummins Creek; and (B) utilizing flows of Cummins Creek plus diversion of unappropriated Colorado River flows.. Firm water supply would be delivered to a water treatment plant at the major municipal demand center of the South Central Texas Region and distributed to municipal systems or recharge zone.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	$1,111	per acft[1]
QUANTITY OF WATER:	45,712	acft/yr[2]
LAND IMPACTED:	7,274	acres[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** (A) off-channel reservoir on Cummins Creek; (B) off-channel reservoir on Cummins Creek, low-head channel dam on Colorado River, river intake, and pump station.
(A & B) 132-mile raw water pipeline and two transmission pump stations, water treatment plant and distribution to municipal system(s) or recharge zone.

[2]**QUANTITY OF WATER:** (A) 15,453 acft/yr from just Cummins Creek Reservoir; and (B) 45,712 acft/yr from Cummins Creek Reservoir with Colorado River diversion.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity, transmission facilities right-of-way, and water treatment plant site. This does not include land in the floodplain above the conservation pool at the reservoir, or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Mitigation for inundation of approximately 6,600 acres in reservoir (including riparian woodlands) although no endangered or threatened species are known to occur there. Instream flows and freshwater inflows to bays and estuaries. Portions of the Colorado River and Cummins Creek potentially affected by this option are recommended for designation as Ecologically Unique River or Stream Segments by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, and ability of the entities to develop a regional plan that realizes economies of size that benefit all of the participants.

ADDITIONAL FACTORS: Ability to obtain permits for Cummins Creek Reservoir and right to transfer Colorado River Basin water to the South Central Texas Region.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: S-15Dc, S-15Eb, C-13C, C-17A, C-17B, C-18, SCTN-11, SCTN-12b, and/or SCTN-20.

5.15 Cummins Creek Reservoir (SCTN-15)

5.15.1 Description of Option

This option involves the development of an off-channel reservoir on Cummins Creek in Colorado County near Columbus. The off-channel reservoir could be used in two manners: a) to store waters derived solely from the Cummins Creek watershed, or b) to store a combination of water from the Cummins Creek watershed and unappropriated water diverted from the nearby Colorado River. The firm yield from the off-channel reservoir could then be conveyed through a pipeline to the major municipal demand center of the South Central Texas Region for distribution to municipal systems or the Edwards Aquifer recharge zone. The approximate reservoir site, river diversion location, and transmission pipeline route are shown in Figure 5.15-1.

The Cummins Creek Reservoir has been investigated in prior studies by the USBR[1] and HDR.[2] The dam would be a 7,800-foot rolled earthfill structure, about 109 feet above the streambed at maximum height. The conservation pool elevation would be 256 ft-msl and would extend 12 miles upstream. The conservation storage capacity of the reservoir would be 132,700 acft, with a surface area of 6,600 acres. The flood pool of the reservoir would cover approximately 9,600 acres.

5.15.2 Water Potentially Available from Cummins Creek Reservoir

In order to evaluate the firm yield of Cummins Creek Reservoir, whether operated separately or in conjunction with the Colorado River diversion, it is necessary to know the inflows to the reservoir that originate in the watershed above the dam site. Since there is no streamflow gaging station on Cummins Creek, flows were estimated by using a similar nearby "partner" drainage basin. Streamflow data from the gaging station on the Lavaca River at Hallettsville (USGS #08163500), approximately 30 miles to the southwest, were utilized. This is the most upstream gaging station on the Lavaca River and the drainage above this point is similar

[1]U.S. Department of the Interior, Bureau of Reclamation, "Colorado Coastal Plains Project - Texas," December 1981.
[2] HDR Engineering, Inc. (HDR) "Population, Water Demand Projections, and Water Supply Alternatives," Trans-Texas Water Program, North Central Study Area Phase II Report, Volume 2, 1998.

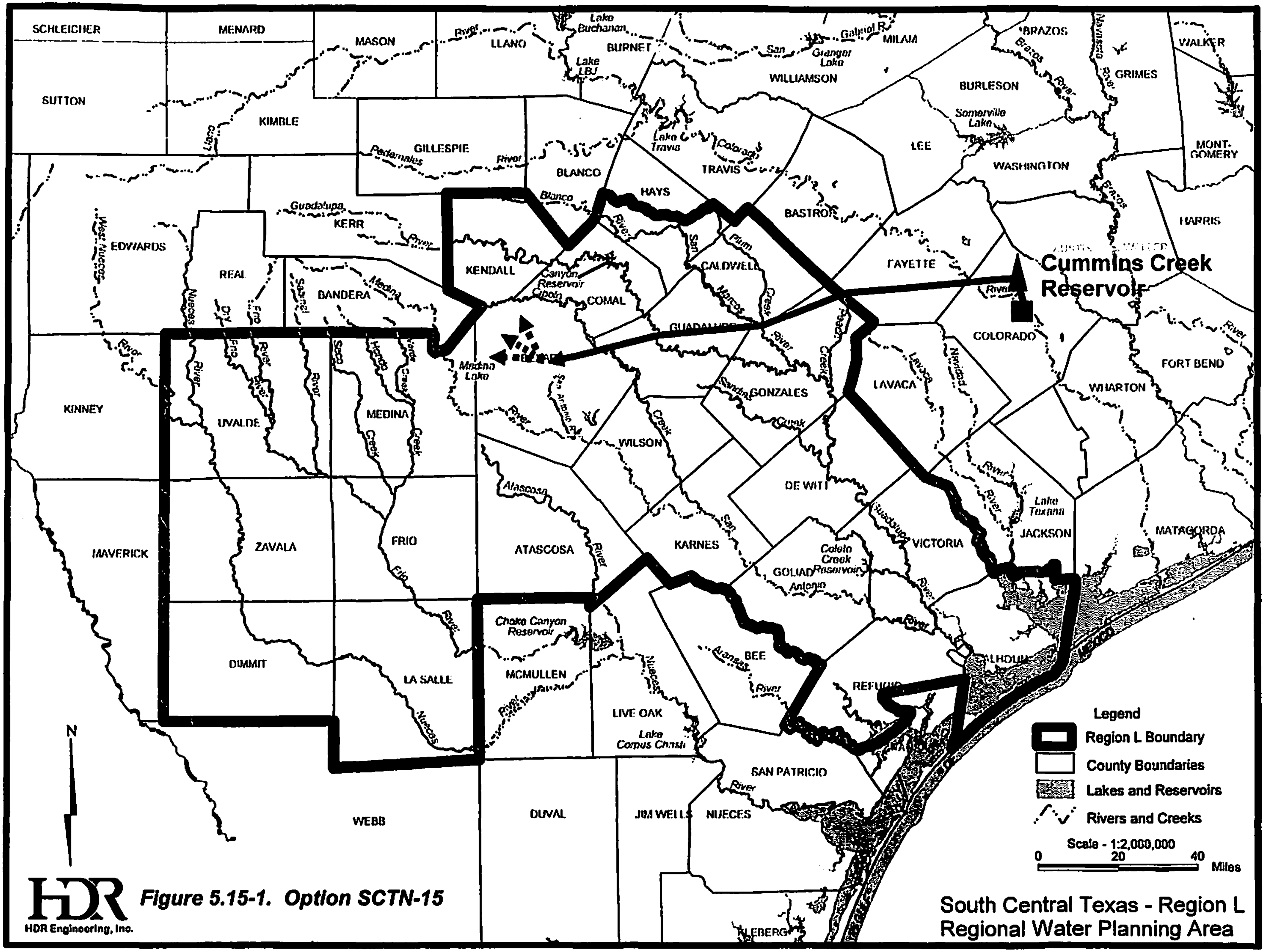


Figure 5.15-1. Option SCTN-15

in geology[3] and climate[4] to the Cummins Creek watershed. The desired streamflows were estimated by using the ratio of the drainage area of Cummins Creek (293 square miles) to that of the Lavaca River at the gaging site (108 square miles).

Cummins Creek Reservoir would have to pass inflows originating in the Cummins Creek watershed subject to the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B and F).[5] The streamflow data described above were used to compute the necessary statistics to quantify the Consensus Criteria pass-through requirements for Cummins Creek Reservoir. These pass-through requirement flows are summarized in Table 5.15-1.

Table 5.15-1. Daily Natural Streamflow Statistics for Cummins Creek

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	37.67	18.83
February	50.31	23.14
March	47.35	20.99
April	40.36	17.22
May	39.82	15.07
June	29.06	10.76
July	15.61	4.30
August	7.53	2.56[1]
September	11.84	3.90
October	13.45	5.38
November	20.99	8.07
December	29.06	15.61
Zone 3 Pass-Through Requirement[2] (acft/day)		3.52

[1] When the Zone 3 pass-through requirement is greater than the 25th percentile flow, the 25th percentile flow is superceded by the Zone 3 pass-through requirement.
[2] Water Quality Standard (7Q2).

[3] Primarily the Tertiary-age Oakville Sandstone and Fleming Formations; see Bureau of Economic Geology, University of Texas, "Geologic Atlas Of Texas, Seguin Sheet," 1979.
[4] Bomar, George W., "Texas Weather," University of Texas Press, 1983.
[5] Staff of Texas Water Development Board and Texas Parks and Wildlife Department indicate that Consensus Criteria would apply to tributaries of the Colorado River although there are specific criteria for instream flows and bay and estuary needs of the mainstem of the river (Section 5.14)

In addition to passing inflows for environmental needs, the Cummins Creek Reservoir would also have to pass water to downstream senior water rights on the Colorado River. The major existing water rights of the Lower Colorado River Basin are shown in Table 5.15-2. Those downstream from the proposed Cummins Creek Reservoir are underlined.

Table 5.15-2.
Summary of the Senior Water Rights in the Lower Colorado River Basin (rights below Cummins Creek Reservoir are underlined)

	Description	Permit or Certificate Number	Priority Date	Annual Consumptive Use Authorized (acft)	Use Type
1	LCRA - Garwood	14-5434A	11/01/1900	133,000	Irrigation[1]
2	Corpus Christi - Garwood	14-5434B	11/02/1900	35,000	Municipal[3]
3	LCRA - Gulf Coast[2]	14-5476	12/01/1900	228,570	Irrigation
4	LCRA - Lakeside[2]	14-5475	01/04/1901	52,500	Irrigation
5	Pierce Ranch	14-5477A	09/01/1907	55,000	Irrigation
6	LCRA - Pierce Ranch[2]	14-5477B	09/01/1907	55,000	Irrigation
7	City of Austin	14-5471	11/15/1913	250,000	Municipal
8	City of Austin	14-5471	1913, 1914	46,403	Municipal
9	City of Austin	14-5489	1945, 1965	36,456	Municipal
10	LCRA - Gulf Coast	14-5476A	1987	33,930	Irrigation
11	LCRA - Lakeside	14-5475	1987	78,750	Irrigation

[1] Currently the use type of this right is for irrigation, but in this study it was assumed that it would be converted to a municipal pattern.
[2] These three water rights held by LCRA are subordinated to the 250,000 acft municipal portion of the City of Austin's water right (no. 7).

In order to determine the periods during which the Cummins Creek Reservoir would have to pass inflows to senior water rights, the LCRA's RESPONSE Model of the lower Colorado River was utilized. The results of the RESPONSE Model indicate what portion of the senior water rights demands in Table 5.15-2 could be met on a daily basis over the 1941 to 1965 period from run-of-river flows[6] for the Colorado River below the Highland Lakes. Since the run-of-river flow values include the contribution of the Cummins Creek watershed, Cummins Creek Reservoir would be able to impound water only on days when all the downstream senior water rights (1 through 6, 10, 11 in Table 5.15-2) are satisfied. Furthermore, on those days, the

[6]Derived by Texas Department of Water Resources, "Present and Future Surface-Water Availability in the Colorado River Basin, Texas," Report LP-60, June 1978.

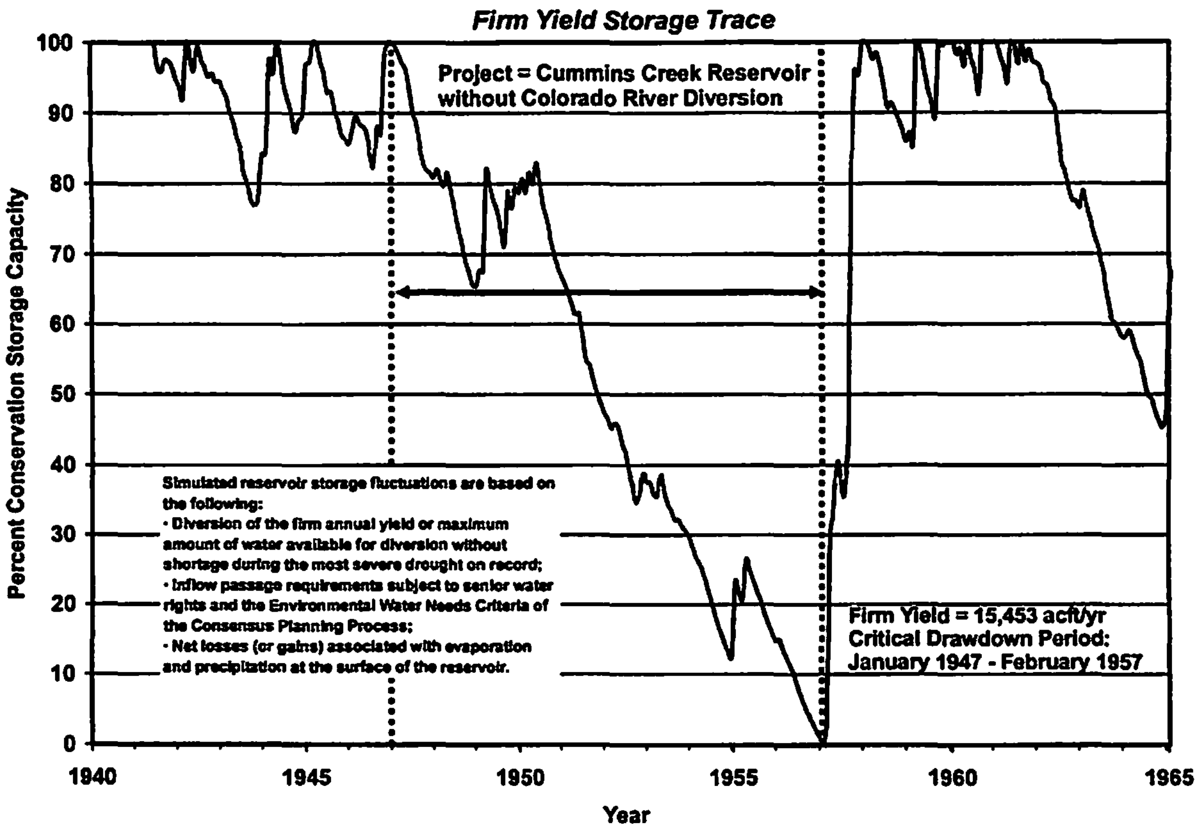
reservoir would be able to impound only an amount that would not cause a shortage to any of these water rights or a reduction in applicable instream flow or bay and estuary requirements (Section 5.14).

5.15.2.1 Alternative A — Cummins Creek Reservoir without Colorado River Diversion

With the Cummins Creek flows and environmental and water rights pass-through requirements quantified, it was then possible to calculate the firm yield of Cummins Creek Reservoir. First, the firm yield was determined with just the inflows from the Cummins Creek watershed. This firm yield was computed with a modified version of the SIMDLY reservoir operation model (originally written by TWDB). The reservoir was assumed full at the start of the SIMDLY simulation. It was assumed that water would be withdrawn from the reservoir with a uniform demand pattern. With only the inflows from its own watershed, and subject to environmental flows and senior water rights constraints, the firm yield of Cummins Creek Reservoir is 15,453 acft/yr.

The upper panel of Figure 5.15-2 illustrates the simulated reservoir storage fluctuations for the 1941 to 1965 historical period with just the waters derived from the Cummins Creek watershed. The lower panel of Figure 5.15-2 illustrates storage behavior of the off-channel reservoir in a storage-frequency curve. The reservoir contents are predicted to remain above the Zone 2 trigger level (80 percent capacity) about 52 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 75 percent of the time based on simulations for the 1941 to 1965 period.

The upper panel of Figure 5.15-3 illustrates the changes in median streamflows that would occur on the Colorado River at Columbus with the Cummins Creek Reservoir impounding just waters derived from its own watershed. There would be little change in flows associated with the project if configured in this way. The largest change would be a decline in median streamflow of 4,281 acft/month (77.1 cfs) during February. During the summer months, there would be no change in the median values. This is because the reservoir would only rarely be able to impound water derived from its own watershed in excess of senior water rights and environmental demands. The lower portion of Figure 5.15-3 illustrates the streamflow frequency



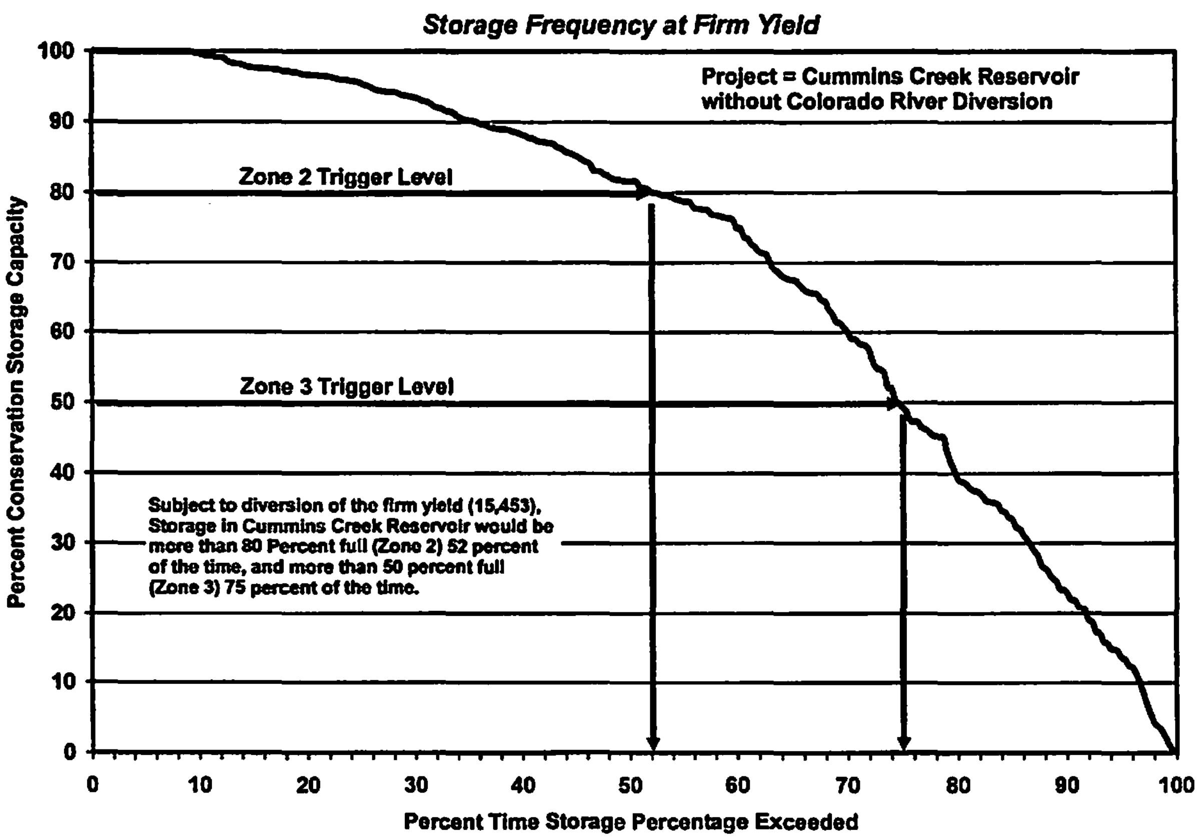


Figure 5.15-2. Cummins Creek Reservoir (Alternative A) Storage Considerations

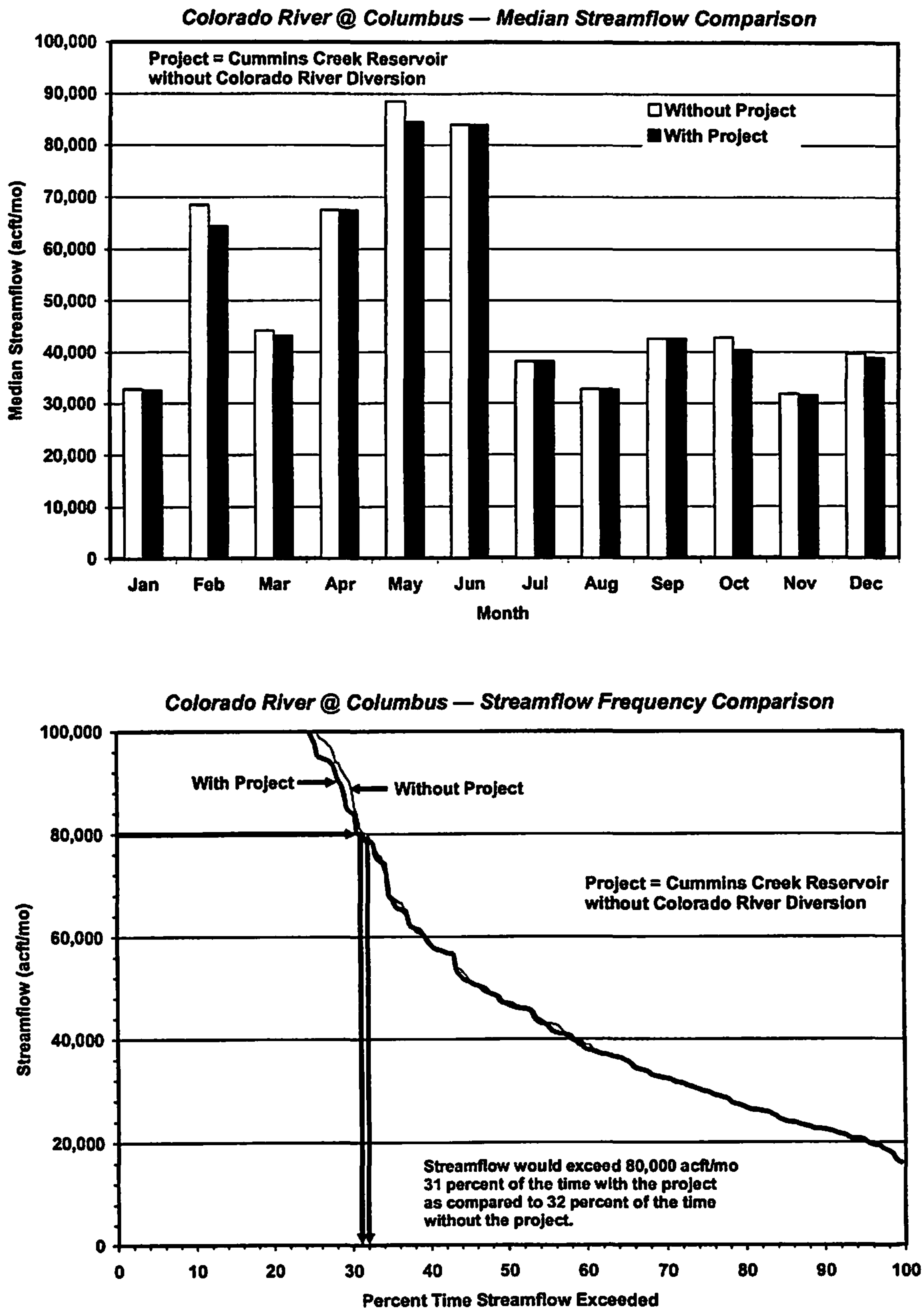


Figure 5.15-3. Cummins Creek Reservoir (Alternative A) Streamflow Comparisons

characteristics of the Colorado River at Columbus with the Cummins Creek project impounding waters from only its own watershed. At low flows, there is little difference with the project because the off-channel reservoir would typically be passing all, or nearly all, inflows in order to satisfy senior water rights and/or environmental constraints. There is a more pronounced difference at higher Colorado River flows because, in this range, Cummins Creek Reservoir would be able to impound more water, since water rights and mainstem environmental criteria would be satisfied more frequently.

5.15.2.2 Alternative B — Cummins Creek Reservoir with Colorado River Diversion

The second manner in which Cummins Creek Reservoir could be utilized is to pump unappropriated water from the nearby Colorado River into the reservoir and augment the firm yield. In order to determine the magnitude and time of occurrence of unappropriated streamflow in the Lower Colorado River Basin, the LCRA's RESPONSE Model was utilized. Computations were performed to quantify water available after all senior water rights (Table 5.15-2) are honored and the specific environmental flow criteria of the Lower Colorado River Basin are met. This procedure is described more fully in Section 5.14, devoted to Shaws Bend Reservoir (Option C-18).

Figure 5.14-2 summarizes the results of the determination of unappropriated water in the Lower Colorado River Basin. In general, there is little or no unappropriated water in the Lower Colorado River Basin during summer months because of the coincidence of typically low streamflows and peak demands of the senior water rights, as listed in Table 5.15-1. The unappropriated waters of the Colorado River are generally available only during short periods of high flood flows or during late fall and winter months of reasonably wet years when senior water rights demands are low and streamflows are higher.

In order to make use of these short-term unappropriated waters, it is necessary to capture them quickly by utilizing a high diversion rate from the river. This requires a very large diversion facility and parallel 3.79-mile pipelines from the Colorado River to the off-channel reservoir. As in a previous study of the Cummins Creek Reservoir,[7] in this analysis it was assumed that the diversion facility on the Colorado River and the short pipelines would be sized to deliver approximately 800 cfs to the reservoir.

[7] HDR, Op. Cit. 1998.

Figure 5.15-4 illustrates the average amount of water that could be diverted from the Colorado River by this diversion facility on a monthly basis. The pattern of water diverted reflects the pattern of unappropriated water availability: little or none in the summer and better availability in the late fall and winter months. Again, these diversions are only possible after all senior water rights and applicable environmental flow criteria have been met. The best month is February, during which an average of almost 23,000 acft could be diverted.

With the available water from the Colorado River quantified, it was then possible to make a new computation of the firm yield of Cummins Creek Reservoir. Cummins Creek Reservoir would have to pass inflows in accordance with Consensus Criteria, as shown in Table 5.15-1. With the addition of up to 800 cfs of unappropriated streamflow from the Colorado River, the firm yield of Cummins Creek Reservoir is increased to 45,712 acft/yr.

The upper panel of Figure 5.15-5 illustrates the simulated reservoir storage fluctuations for Cummins Creek Reservoir operated with the addition of the Colorado River diversion. The lower panel of Figure 5.15-5 illustrates the reservoir's storage-frequency curve. For the 1941 to 1965 period, reservoir contents are predicted to remain above the Zone 2 trigger level (80 percent capacity) about 60 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 88 percent of the time.

The upper panel of Figure 5.15-6 illustrates the changes in median streamflows that would occur on the Colorado River at Columbus with Cummins Creek Reservoir impounding waters derived from both its own watershed and from the Colorado River. The largest change, again in February, would be a decline in median streamflow of 18,387 acft/month (331 cfs). February is the month with the greatest availability of unappropriated streamflow (Figure 5.15-4). During the summer months, the changes in the median values would again be zero. In October, the median flow would decline 10,820 acft/month (176 cfs). These changes, however, would not cause any detrimental impact to senior water rights or environmental flows because these were accounted for in the derivation of the unappropriated flows (Section 5.14). The lower portion of Figure 5.15-6 illustrates the streamflow frequency characteristics of the Colorado River at Columbus with Cummins Creek Reservoir utilizing both the water from its own watershed and the Colorado River diversion.

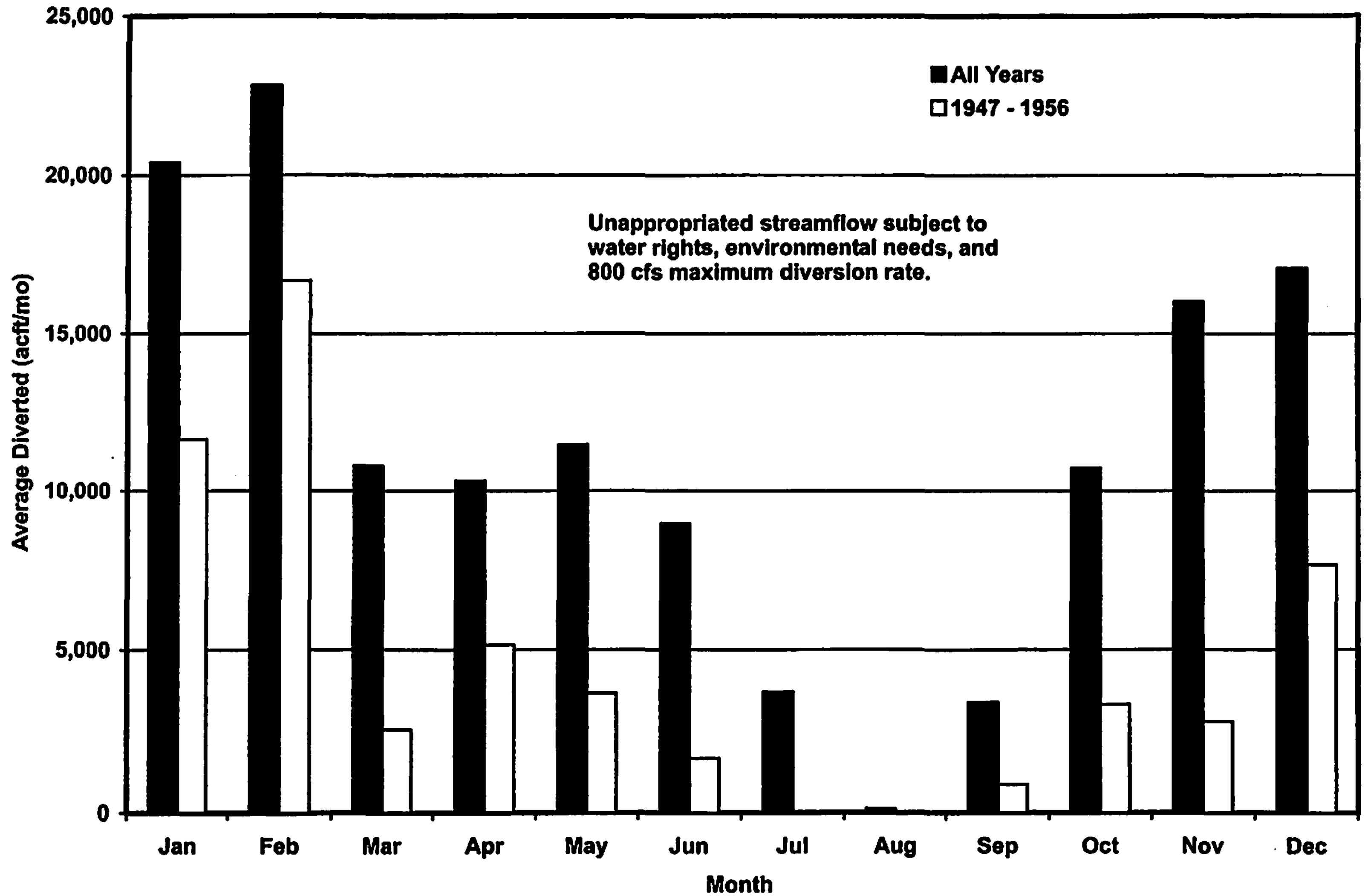
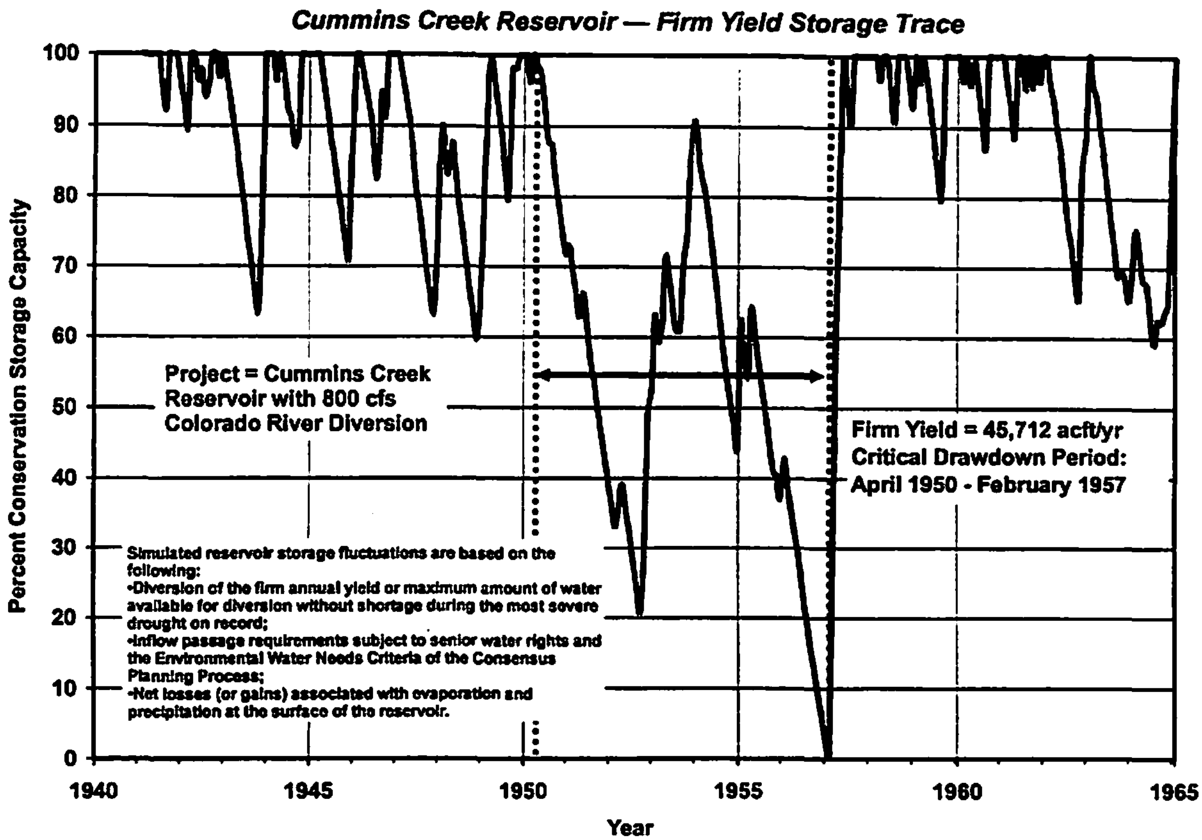


Figure 5.15-4. Average Availability of Unappropriated Steamflow, Colorado River at Columbus



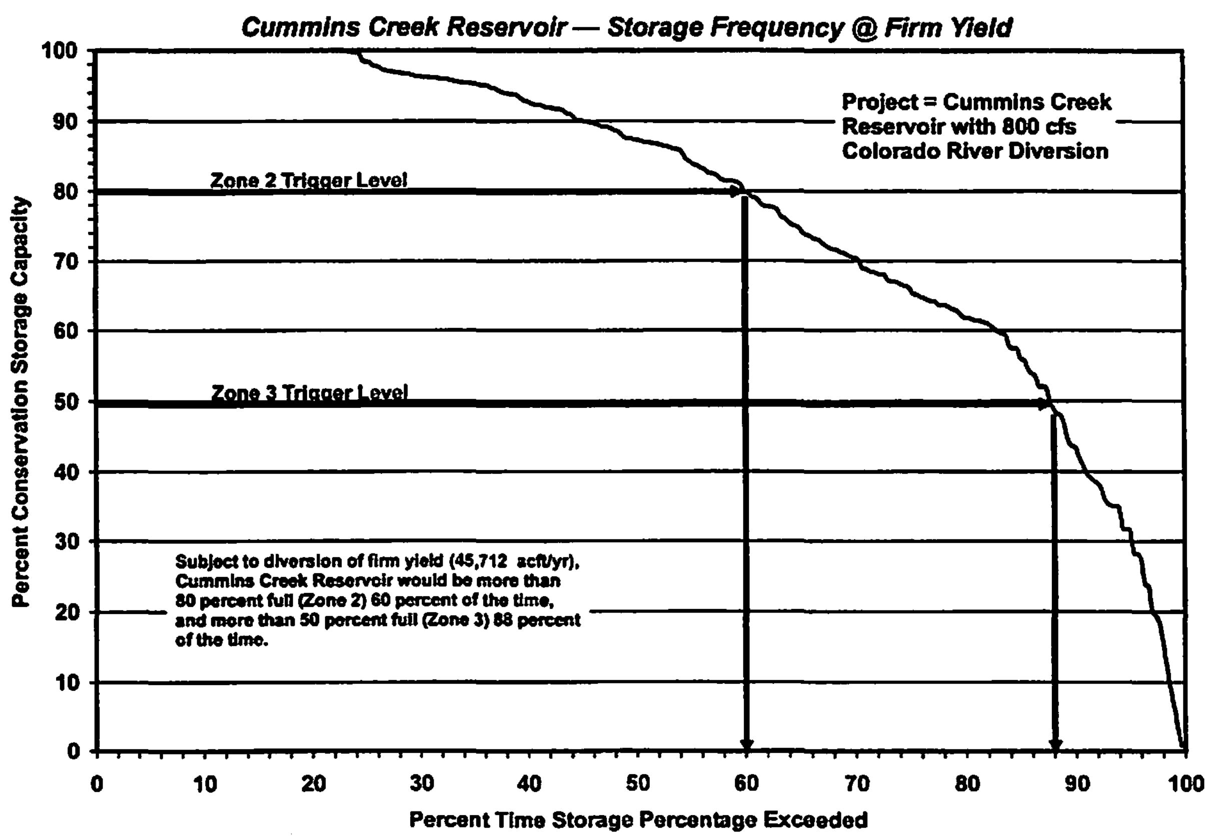
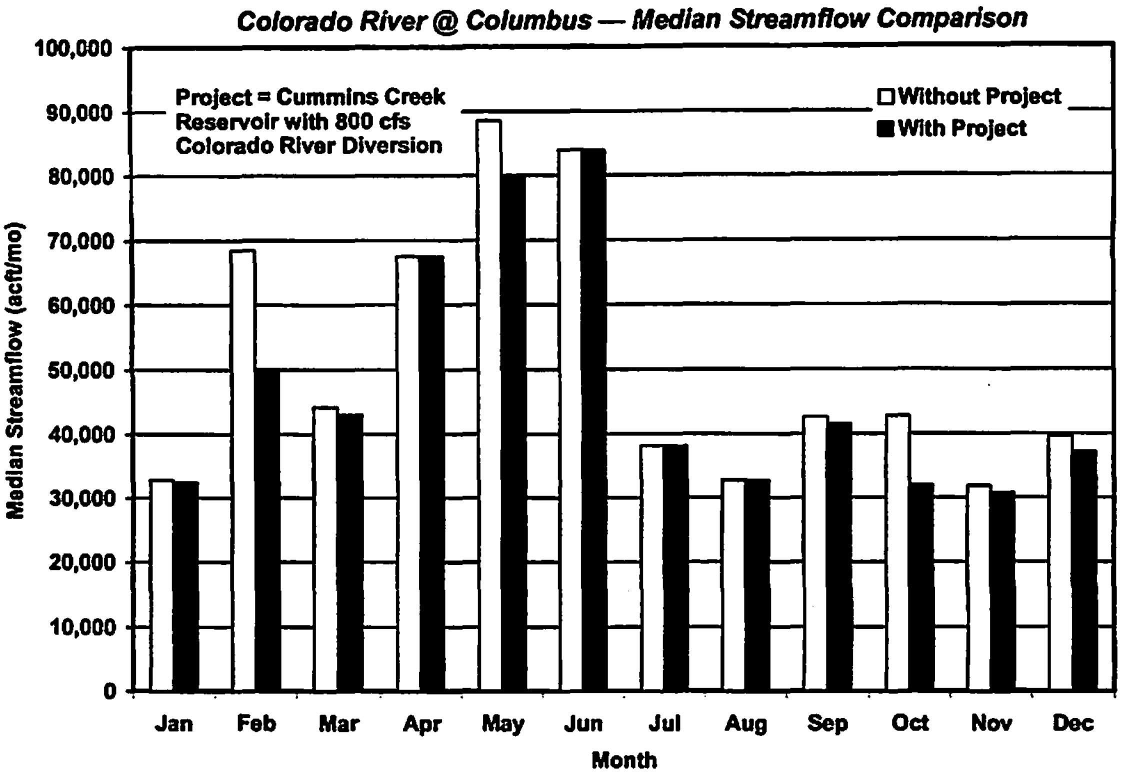


Figure 5.15-5. Cummins Creek Reservoir (Alternative B) Storage Considerations



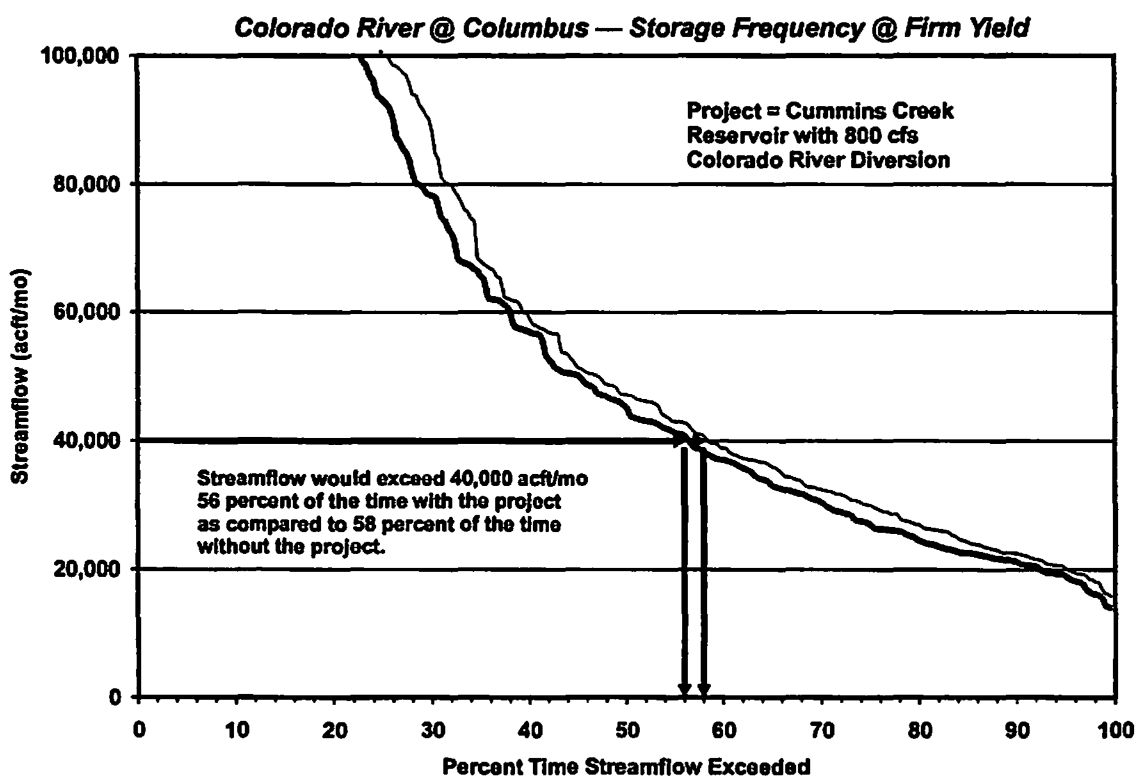


Figure 5.15-6. Colorado River at Columbus (Alternative B) Streamflow Comparisons

5.15.3 Environmental Issues

This option includes the construction of a reservoir to impound the waters of Cummins Creek near Columbus. Included is a diversion of unappropriated water from the nearby Colorado River via 3.79-mile pipelines and conveying the water to major municipal demand center of the South Central Texas Region via an approximately 132-mile transmission pipeline. Option SCTN-15 includes the construction of Cummins Creek Reservoir in Colorado County and a corresponding transmission pipeline west through Colorado, Fayette, Gonzales, Guadalupe, and Bexar Counties. The proposed reservoir and transmission pipeline lie within Omernik's[8] Texas Blackland Prairie ecoregion and East Central Texas Plains ecoregion.

The Texas Blackland Prairie ecoregion and East Central Texas Plains ecoregion lie within Blair's[9] Texan Biotic Province and reach the northern border of the Tamaulipan Biotic Province. The Texan Province is an ecotone, or ecologically transitional region between the Austroriparian Biotic Province to the northeast and the Tamaulipan Province to the southwest. The plant and animal species of the Texan Province are a mixture of species characteristic of the Austroriparian and Tamaulipan Provinces. The riparian woodlands dissecting the Texas Province provide corridors for migration and an important habitat type in this predominately grassland region. The vegetation of these counties alternates between East Central Texas Plains species, mainly tall grasses, mesquite trees, oaks, and elms, and Texas Blackland Prairie flora, typically grassland species.[10]

The Texas Blackland prairies ecoregion includes the San Antonio and Fayette Prairies. Topography is gently rolling to nearly level, well dissected with rapid surface drainage. Blackland soils are fairly uniform dark-colored calcareous clays interspersed with some gray acid sandy loams. For the most part, this fertile area has been brought under cultivation, although a few native hay meadows and ranches remain. The Texas Blackland Prairies ecoregion is a true prairie with typically grassland species.[11] The predominant vegetation of the Texas Blackland Prairie vegetation include little bluestem (*Schizachyrium scoparium* var. *frequens*) as a climax dominant, sideoats grama (*Bouteloua curtipendula*), hairy grama (*Bouteloua hirsuta*), tall dropseed (*Sporoboulus asper*), silver bluestem (*Bothriochloa*

[8] Omernik, J.M. 1987. Ecoregions of the Conterminous United States. Annals of the Association of American Geographers. 77:118-125.
[9] Blair, W. Frank. 1950. The Biotic Provinces of Texas. Texas journal of Science 2(1):93-117.
[10] Clements, J., 1988, Texas Facts, Clements Research II, Inc. Dallas, Texas.
[11] Blair, W.F., Op. Cit., 1950.

sacchariodes), and Texas wintergrass (*Stipa hirsuta*).[12] Under heavy grazing, Texas wintergrass, buffalo grass (*Buchloe dactyloides*), Texas grama (*B. rigidiseta*), smutgrass and many annuals increase or invade. Mesquite (*Prosopis glandulosa*) also has invaded hardland sites of the southern portion of the Texas Blackland Prairies. Although classed as a true prairie, the Texas Blackland prairie has much timber, especially along the streams that traverse it. Common tree species include a variety of oaks, pecan, cedar elm (*Ulmus crassifolia*), bois d'arc (*Maclura pomifera*) and mesquite. Post Oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*) increase on the medium- to light-textured soils. The soil types which support the vegetation types in this region include moderately well drained sandy to clayey soils over stream terraces or limestone.[13,14]

The East Central Texas Plains ecoregion lies immediately west of the primary forest region of Texas. The topography is also gently rolling to hilly. Soils on the uplands are light-colored, acid sandy loams or sands. Bottomland soils are light brown to dark-gray and acid, ranging in texture from sandy loams to clays. Most of the East Central Texas Plains is in native or improved pastures although small farms are common. Climax grasses include little bluestem, Indian grass, switchgrass, purpletop (*Tridens flavus*), silver bluestem, Texas wintergrass (*Stepa leucotricha*) and *Chasmanthium sessiliflorum*. The overstory is primarily post oak and blackjack oak. Many other brush and weedy species are also common. Some invading plants are red lovegrass, broomsedge, splitbeard bluestem (*Andropogon ternarius*), yankeeweed, bullnettle (*Cnidoscolus texanus*), greenbrier, yaupon (*Ilex vomitoria*), smutgrass and western ragweed.

The fauna present in areas where suitable habitat remains will be typically neotropical and grassland species.[15] On-site surveys will be necessary to determine the specific fauna of the corridor since the pipeline corridor is a mosaic of the East Central Texas Plains and the Texas Blackland Prairie ecoregions and could potentially include a wide variety of species.

The water transmission pipeline between Colorado and Bexar Counties would be about 132 miles long. A construction right-of-way 140 feet wide would affect a total area of approximately 2,240 acres. The construction of the pipeline would include the clearing and removal of woody vegetation. A 40-foot wide right-of-way corridor free of woody vegetation

[12] Gould, F. W., 1975, The Grasses of Texas, Texas A&M University Press, College Station, Texas.
[13] United States Department of Agriculture, Soil Conservation Service and Texas Agricultural Experiment Station. 1977. Soil Survey of Guadalupe County, Texas. USDA.
[14] United States Department of Agriculture, Soil Conservation Service and Texas Agricultural Experiment Station. 1991. Soil Survey of Guadalupe County, Texas. USDA.
[15] Op Cit.

maintained for the life of the project would total 640 acres. Destruction of potential habitat could be avoided by diverting the corridor through previously disturbed areas, such as croplands. Selection of a pipeline right-of-way alongside the existing habitat could also be beneficial to some wildlife by providing edge habitat; however, the majority of these areas are small and fragmented, so care should be taken to ensure minimum impacts.

Although the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Program does not report any endangered or threatened species directly along the pipeline corridor, some have been reported in the vicinity (Table 5.15-3). Many of these appear to be dependent on shrubland or riparian habitat, such as the Texas tortoise, the Reticulated collared lizard, the Texas horned lizard, and the Indigo snake. The Texas garter snake may be present in wetland habitats and the Timber rattlesnake may be found in riparian woody vegetation. For approximately the first two miles of the pipeline corridor, construction would encroach on the northern portion of what is considered to be essential habitat for the Attwater's prairie Chicken[16]; however, no Attwater's Prairie Chicken currently occupy the area, and effects of the construction on this habitat should be minimal. Implementation of this alternative is expected to require field surveys for protected species, vegetation, habitats, and cultural resources during right-of-way selection to avoid or minimize impacts.

Some species of concern which are not endangered or threatened occur within a 1-mile corridor of the transmission pipeline. Cagle's map turtle (*Graptemys caglei*), is known to exist in the San Marcos River in Gonzales County near the point of junction with the proposed pipeline route. Cagle's map turtle is listed as a candidate species by USFWS and TOES. The range of Cagle's map turtle is scattered throughout the Guadalupe and San Antonio River systems in the slow-moving pools and impoundments with exposed rocks, cypress knees, and logs. One vascular plant on the TOES watch list is known to exist within the 1-mile corridor;

[16] Attwater's Prairie Chicken Recovery Team, "Attwater's Prairie Chicken Recovery Plan," U.S. Fish and Wildlife Service, 1983.

Table 5.15-3.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Cummins Creek Reservoir (SCTN-15)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
BIRDS						
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant Resident
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant Resident
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow water for foraging	E	E	E	Nesting/Migrant Resident
Attwater's Greater Prairie-Chicken	*Tympanuchus cupido attwateri*	Coastal Prairies of Gulf Coastal Plain	E	E	E	Nesting Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E		Migrant In Resident
Wood Stork	*Mycteria americana*	forages in prairie ponds, and shallow standing water formerly nested in TX		T	T	Migrant In Resident
White-tailed Hawk	*Buteo albicaudatus*	Coastal prairies, savannahs and marshes in Gulf coastal plain		T	T	Nesting/Migrant Resident
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country, deciduous or pine-oak woodland; nests in various habitats		T	T	Nesting/Migrant Resident
Black-capped Vireo	*Vireo atricapillus*	oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces	E	E	T	Nesting/Migrant Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant Resident
Golden-cheeked Warbler	*Dendroica chrysoparia*	juniper-oak woodlands; dependent on mature Ashe juniper (cedar) for nests	E	E	E	Nesting/Migrant Resident
White-faced Ibis	*Pelagis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields		T	T	Migrant Resident
Mountain Plover	*Charadrius montanus*	Non-breeding-shortgrass plains and fields, plowed fields and sandy deserts	PT			Nesting/Migrant Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields, cut over areas; bare ground for running and walking				Nesting/Migrant Resident
REPTILES						
Cagle's Map Turtle	*Graptemys caglei*	Guadalupe River System, transition areas between riffles and pools, nests within 30 ft of water's edges	C		C	Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush		T	T	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures				Resident
Spot-tailed Lizard	*Holbrookia lacerata*	central & southern Texas; oak-juniper woodlands and mesquite-prickly pear				Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory; open grass & bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident

Table 5.15-3 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Western Smooth Green Snake	*Opheodrys vernalis blanchardi*	Coastal prairies of upper Texas coast		E	E	Resident
Timber Rattlesnake	*Crotalus horridus*	floodplains, upland pine, deciduous woodlands, riparian zones, abandoned farms, dense ground cover		T	T	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	wl	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident
AMPHIBIANS						
Houston Toad	*Bufo houstonensis*	endemic, ephemeral pools, water in pools, sandy substrate, stock tanks, associated with soils of the Recklaw, Weches, Sparta, Carrizo, Queen City, Goliad, Willis geologic formations	E	E	E	Resident
Black-spotted newt	*Notophthalmus meridionalis*	Ponds and resacas in south Texas		T	E	Resident
FISH						
Blue Sucker	*Cycleptus elongatus*	Large rivers throughout Mississippi River Basin south and west in major streams of Texas to Rio Grand River		T	wl	
Guadalupe bass	*Micropterus treculi*	Clear flowing streams			wl	Resident
INSECTS						
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	found near slow-moving water, eggs laid on objects near water; larvae are aquatic, adults prefer shady areas; feed on nectar and pollen				Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	fast erratic flight, larvae feed inside a leaf shelter, pupate in cocoon made of leaves & silk			wl	Resident
PLANTS						
Big Red Sage	*Salvia penstemonoides*	Moist Creek and stream bed edges; historic; introduced in native plant nursery trade			wl	Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			wl	Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			wl	Resident
Bracted twistflower	*Streptanthus bracteatus*	endemic, openings in juniper-oak woodlands, rocky slopes				Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Tamaulipan thorn shrublands or grasslands on shallow sandy to clayey soil over calcareous rock outcrops			wl	Resident
Correll's false dragon-head	*Physostegiacorrellii*	wet soils including roadside ditches, irrigation channels			wl	Resident
Glass Mountain coral root	*Hexalectrisnitida*	mesic woodlands in canyons, lower elevations, under oaks				Resident

Table 5.15-3 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Sandhill woolywhite	*Hymenopappuscarrizoanus*	endemic, deep loose sands of Carrizo, disturbed areas				Resident
Navasota Ladies'-tresses	*Spiranthes parksii*	margins of post oak woodlands in sandy loams along intermittent tributaries of the Brazos and Navasota; often in areas where edaphic or hydrologic factors limit competition.	E	E	E	Resident
MAMMALS						
Plains Spotted Skunk	*Spilogale putorius interrupta*	prefers wooded, brushy areas and tallgrass prairie, fields, prairies, croplands, fence rows, forest edges				Resident

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

Parks' Jointweed (*Polygonella parksii*), which has been documented to occur within the corridor in Guadalupe County. This plant prefers deep loose sands for substrate. Three other rare plants occur within the pipeline corridor in Gonzales county: Smooth Blue Star (*Amsonia glaberrima*), Texas Taushia (*Taushia texana*), and Texas Pink-root (*Spigelia texana*). These plants are considered to be rare species of concern by the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Program, but do not have federal or state status.

Several species potentially affected by the project are associated with the rivers. The blue sucker (*Cycleputs elongatus*) and Guadalupe Bass (*Micropterus treculi*) may have habitat near the proposed reservoir near the Colorado River and transmission pipeline at the Guadalupe River. The Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Program identifies the occurrence of Guadalupe bass both upstream and downstream of the proposed location of the intake on the Colorado River. The blue sucker is listed as threatened by TWPD. A recent study conducted by the LCRA[17] states that "Downstream of Columbus, the potential impact of diversions on the instream flows becomes substantial." The rock outcrops of the Colorado River between the City of Columbus and the Gulf of Mexico appear to provide significant spawning habitat for the blue sucker.[18]

[17] Mosier D. T. and Resident. T. Ray, "Instream Flows for the Lower Colorado River: Reconciling Traditional Beneficial Uses With the Ecological Requirements of the Native Aquatic Community," LCRA, Austin, Texas, 1992.
[18] Ibid.

becomes substantial." The rock outcrops of the Colorado River between the City of Columbus and the Gulf of Mexico appear to provide significant spawning habitat for the blue sucker.[18]

Stream impoundment can result in environmental changes (e.g., reduced mixing energy, increased depth) that interact to produce a cascade of effects within and downstream of a newly created reservoir. The actual nature and intensity of these effects are largely dependent on characteristics of the particular site (e.g., reservoir capacity, ratio of depth to surface area, rate of water exchange, nutrient and sediment loading, biological community type). Studies of the reaches to aid in determining the location of intake structures on the Colorado River near Columbus should be conducted in order to avoid critical habitats for spawning and early life stages of fish such as the Blue sucker and the Guadalupe bass.

The conservation pool of the Cummins Creek Reservoir would extend 12 miles upstream. The Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Program does not identify the presence of any endangered, threatened or rare species in the area of the flood pool of the Cummins Creek Reservoir which would cover approximately 9,600 acres.

When potential protected species habitat or significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use, or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, could be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

All areas to be disturbed during construction should first be surveyed by qualified professionals to determine the presence or absence of significant cultural resources. 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 (PL 96-515), and the Archaelogical and Historical Preservation Act (PL 93-291).

5.15.4 Engineering and Costing

For this option, an off-channel reservoir would be constructed on Cummins Creek in Colorado County near Columbus. The reservoir could be used to either: A) store waters derived solely from the Cummins Creek watershed; or B) store a combination of water from the

[18] Ibid.

Cummins Creek watershed and unappropriated streamflow diverted from the nearby Colorado River. The firm yield of the reservoir would then be conveyed to the major municipal demand center of the South Central Texas Region through a 132-mile transmission pipeline.

The facilities that would have to be constructed for this water supply option depend upon whether the reservoir is operated with or without the Colorado River diversion. Thus the facilities required and their associated costs are discussed in two parts. However, because the firm yield of the Cummins Creek Reservoir without the Colorado River diversion is only 15,453 acft/yr, this alternative (A) is only evaluated as a potential raw water supply at the reservoir site in Colorado County.

5.15.4.1 Alternative A — Cummins Creek Reservoir without Colorado River Diversion

The major facilities required for this alternative are itemized in Table 5.15-4. The primary capital cost item would be the off-channel reservoir itself. The dam would be a 7,800-foot rolled earthfill structure rising about 109 feet above the streambed at maximum height. The cost of this structure is estimated to be $48.86 million.

Another associated cost would be the purchase of the land inundated by the reservoir, including the flood pool. The total land area of the flood pool would be 9,567 acres. A general land cost of $2,000 per acre was used to value the land to be purchased. However, a 1000-foot-wide corridor, 15.4 miles in length, along the Cummins Creek bottom and a primary tributary was estimated to cost $5,000 per acre. The total land purchase cost, including surveying, was $25.19 million.

Engineering, contingencies, legal costs, and other studies were estimated to cost a total of $41.82 million. This brings the total project cost for the Cummins Creek Reservoir without the Colorado River diversion to $134.41 million.

Financing the reservoir and associated reservoir cost would be done with a 40-year finance period and a 6 percent annual interest rate. This results in an annual cost of $8.93 million. Operation and maintenance for the dam and reservoir would cost an estimated

Table 5.15-4.
Cost Estimate for Option SCTN-15

Item	Alternative A (without Colorado River Diversion)	Alternative B (with Colorado River Diversion)
Capital Costs		
Reservoir (132,700 acft; 6,600 ac; 256 ft-msl)	$48,863,000	$48,863,000
Channel Dam (500 ft., 15-feet high)	N/A	3,038,000
River Intake and Pump Station (800 cfs peak capacity)	N/A	10,539,000
River Diversion Pipeline (3.8 miles; two 120-inch pipes)	N/A	22,353,000
Reservoir Intake and Pump Station	N/A	6,333,000
Transmission Pump Stations (2)	N/A	9,062,000
Transmission Pipeline (54-inch dia.; 132 miles)	N/A	114,008,000
Water Treatment Plant (43.0 MGD)	N/A	30,527,000
Distribution	N/A	55,329,000
Power Connection Costs ($125/HP)	N/A	3,655,000
Total Capital Cost	**$48,863,000**	**$303,707,000**
Engineering, Contingencies, Legal Costs	$17,102,000	$98,000,000
Environment & Archaeology Studies, Mitigation, and Permitting	24,715,000	28,446,000
Land Acquisition and Surveying ([9,567] 10,241 acres)	25,193,000	31,942,000
Interest During Construction (4 years)	18,540,000	73,935,000
Total Project Cost	**$134,413,000**	**$536,030,000**
Annual Costs		
Debt Service (6 percent, 30 years)	N/A	$28,814,000
Debt Service (6 percent, 40 years)	$8,933,000	$9,265,000
Operation and Maintenance		
Intake, Pipeline, Pump Station	N/A	2,103,000
Water Treatment Plant	N/A	3,451,000
Dams and Reservoir	733,000	779,000
Distribution System	N/A	553,285
Pumping Energy Costs		
Reservoir and Pipeline (102.3 million kWh @ $0.06 per kWh)	N/A	5,325,000
Colorado River Div. (21.7 million kWh @ $0.06 per kWh)	N/A	480,000
Total Annual Cost	**$9,666,000**	**$50,770,000**
Available Project Yield (acft per year)	**15,453**	**45,712**
Annual Cost of Water ($/acft) Treated Water Distributed (Alt. B)[1]	**$626**	**$1,111**
Annual Cost of Water ($/1,000 gallons)	**$1.92**	**$3.41**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

$733,000 annually. The annual costs, including debt repayment, interest, and operation and maintenance, total $9.67 million. For an annual supply of 15,453 acft, the resulting annual cost of this raw water supply is $626 per acft at the reservoir.

5.15.4.2 Alternative B — Cummins Creek Reservoir with Colorado River Diversion

With this alternative, the addition of the Colorado River diversion increases the firm yield of the project to 45,712 acft/yr. However, several other major facilities would be required to deliver this water to the South Central Texas Region. The river intake and large pumping station are obviously necessary facilities for diverting water from the Colorado River. The river intake, pumping station, and short delivery pipelines (3.79 miles) are sized to divert up to 800 cfs from the Colorado River to the off-channel reservoir. The intake and pump station are estimated to cost a total of $10.54 million, while the short pipelines (two at 120 inches in diameter) would cost $22.35 million. Also required is a low-head channel dam for the pump intakes. The channel dam is estimated to cost $3.04 million.

The largest capital cost item would be for the approximately 132-mile pipeline that would deliver water from the Cummins Creek Reservoir at a uniform rate to the major municipal demand center of the South Central Texas Region, as shown in Figure 5.15-1. Delivery of 45,712 acft/yr would require a 54-inch diameter pipeline that costs approximately $114.01 million.

Associated with the pipeline are the initial reservoir transfer pump station and the transmission pump stations along the length of the pipeline. These pump stations are estimated to cost approximately $15.40 million. Another important capital cost is $55.33 million for distribution. Land acquisition and surveying for the pipeline right-of-way and associated pump stations would be another $6.75 million in addition to the $25.19 million for the Cummins Creek Reservoir. This brings the total land purchase and surveying cost to $31.94 million.

With engineering, contingencies, legal costs, and other studies, the total project cost for the Cummins Creek Reservoir utilizing the Colorado River diversion would be $536.03 million.

The reservoir portion of the project would be financed over 40 years at a 6 percent annual interest rate and the other portions of the project would be financed over 30 years at a 6 percent annual interest rate for an annual cost of $38.08 million. Operation and maintenance costs total $6.89 million annually. Large annual costs are associated with the pumping of Colorado River water to the off-channel reservoir and the subsequent delivery from Columbus to the South

Central Texas Region. With the necessary vertical lift and friction losses along the pipeline, the annual pumping costs are estimated to be $5.81 million.

The total annual costs, including debt repayment, interest, and operation and maintenance, total $50.77 million. For an annual supply of 45,712 acft, the resulting cost of water of would be $1,111 per acft, or $3.41 per 1,000 gallons.

5.15.5 Implementation Issues

This option includes the construction of a reservoir to impound the waters of Cummins Creek near Columbus. Also included is a diversion of unappropriated water from the nearby Colorado River. This would require obtaining new water rights for the Cummins Creek Reservoir and the Colorado River diversion. The water pumped to the South Central Texas Region would also constitute an interbasin transfer.

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

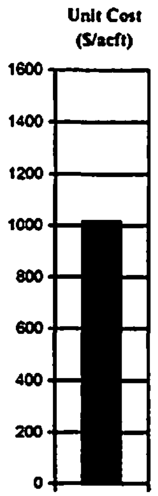
5.15.5.1 Requirements Specific to Reservoir and River Diversion

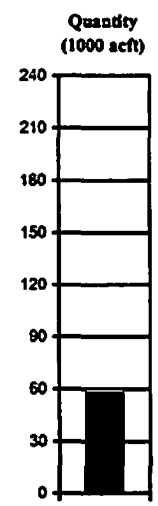
1. It will be necessary to obtain the following:
   a. TNRCC Water Right and Storage Permits.
   b. TNRCC Interbasin Transfer Approval
   c. U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for the reservoir and diversion pipelines.
   d. General Land Office (GLO) Sand and Gravel Removal review.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. TPWD Sand, Gravel, and Marl permit.
2. Permitting may require these studies:
   a. Assessment of changes in instream flow and freshwater inflows to bays and estuaries.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land must be acquired through either negotiations or condemnation.
4. Relocations for the reservoir could include:
   a. Utilities

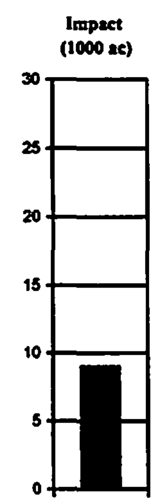
5.15.5.2 Requirements Specific to the Transmission Pipeline

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

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **B-10C**

OPTION NAME: **Allens Creek Reservoir — Firm Yield**

OPTION DESCRIPTION: *Firm yield of proposed Allens Creek Reservoir on Allens Creek, a tributary of the Brazos River in Austin County, would be diverted and pumped at a uniform rate through a transmission pipeline to a water treatment plant at the major municipal demand center of the South Central Texas Region.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	$1,016	per acft[1]	Treated Water Distributed
QUANTITY OF WATER:	57,800	acft/yr[2]	
LAND IMPACTED:	9,036	acres[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Allens Creek dam and reservoir, reservoir intake and pump station, river diversion, intake and pump station, raw water pipeline to Allens Creek Reservoir, raw water pipeline to water treatment plant, three transmission pump stations, water treatment plant, and distribution to municipal systems or recharge zone.

[2]**QUANTITY OF WATER:** Unappropriated runoff from the 58.3 square mile Allens Creek watershed, diversions of unappropriated flood flows of the Brazos River, and stored water in Allens Creek Reservoir. Instream flow requirements could affect quantities available from Allens Creek and the Brazos River.

[3]**LAND IMPACTED:** Reservoir (conservation pool), water treatment plant sites, and pipeline right-of-way. This does not include land in the floodplain above the conservation pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Terrestrial habitat effects of reservoir, pipeline and water treatment plant locations. Resource conflicts can be avoided by careful selection of water treatment plant and storage tank sites, and pipeline routes. Mitigation of the Allens Creek Reservoir site would be required. Transfer of species not presently observed in the South Central Texas Region.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, mitigation requirements, and ability to incorporated into a regional plan that realizes economies of size and benefits all participants. Implementation of this option based on a greater quantity of water or in combination with other options may reduce the unit cost of water.

ADDITIONAL FACTORS: Ability to obtain permits to transfer Brazos River Basin water to the South Central Texas Region. The 76th Texas Legislature passed SB1593 authorizing the TWDB to initiate project development and directing TNRCC to reissue abandoned permit and grant water rights to the TWDB.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: None.

5.16 Allens Creek Reservoir — Firm Yield (B-10C)

5.16.1 Description of Option

Allens Creek Reservoir is a proposed 168,000-acft off-channel reservoir located on Allens Creek, a small tributary of the Brazos River in Austin County. The reservoir site is located 2 miles north of the town of Wallis, Texas. The location of the reservoir is shown in Figure 5.16-1. The project would impound water available from the Allens Creek watershed, as well as water diverted and pumped from the Brazos River during periods of flow in excess of downstream needs. In the 76th Texas Legislative Session, SB 1593 (sponsored by Senator J.E. Brown) was passed including the following provisions:[1]

a. Authorizes the TWDB to use the state participation program to purchase up to 50 percent interest in the Allens Creek Reservoir project, including 100 percent of the reservoir site;
b. Directs the TNRCC to reissue the abandoned Allens Creek water rights permit upon application by the TWDB; and
c. Grants the TWDB additional water rights to the unappropriated flows of the Brazos River and Allens Creek.

The Allens Creek Reservoir project was originally proposed by Houston Lighting and Power Co. (HL&P) as a cooling lake for a nuclear power plant and the site was studied in 1974 by URS/Forrest and Cotton.[2] URS completed a second study in 1977 with a different dam alignment and smaller reservoir.[3] HL&P eventually abandoned plans for a power plant at the Allens Creek site and the Brazos River Authority (BRA) obtained an option to purchase the reservoir site from HL&P. In 1988, BRA retained Freese & Nichols to study the yield and cost of the proposed reservoir.[4] As part of the Trans-Texas Water Program, Freese & Nichols and Brown & Root reevaluated the firm yield of the reservoir with the application of the Trans-Texas Environmental Criteria.[5]

[1] TWDB, "76th Texas Legislative Session Wrap-up Report," June 1999.
[2] URS/Forrest and Cotton, "Allens Creek Dam and Reservoir on Allens Creek, Brazos River Basin, Austin County, Texas" (prepared for Houston Lighting and Power Company), January 1974.
[3] URS/Forrest and Cotton, "Allens Creek Dam and Reservoir on Allens Creek, Brazos River Basin, Austin County, Texas" (prepared for Houston Lighting and Power Company), July 1977.
[4] Freese & Nichols, Inc., "Yield Analysis and Cost Estimate for Allens Creek Reservoir," Brazos River Authority, February 1989.
[5] Brown & Root, Inc. and Freese & Nichols, Inc., "Trans-Texas Water Program, Southeast Area Phase I Report", March 1994.

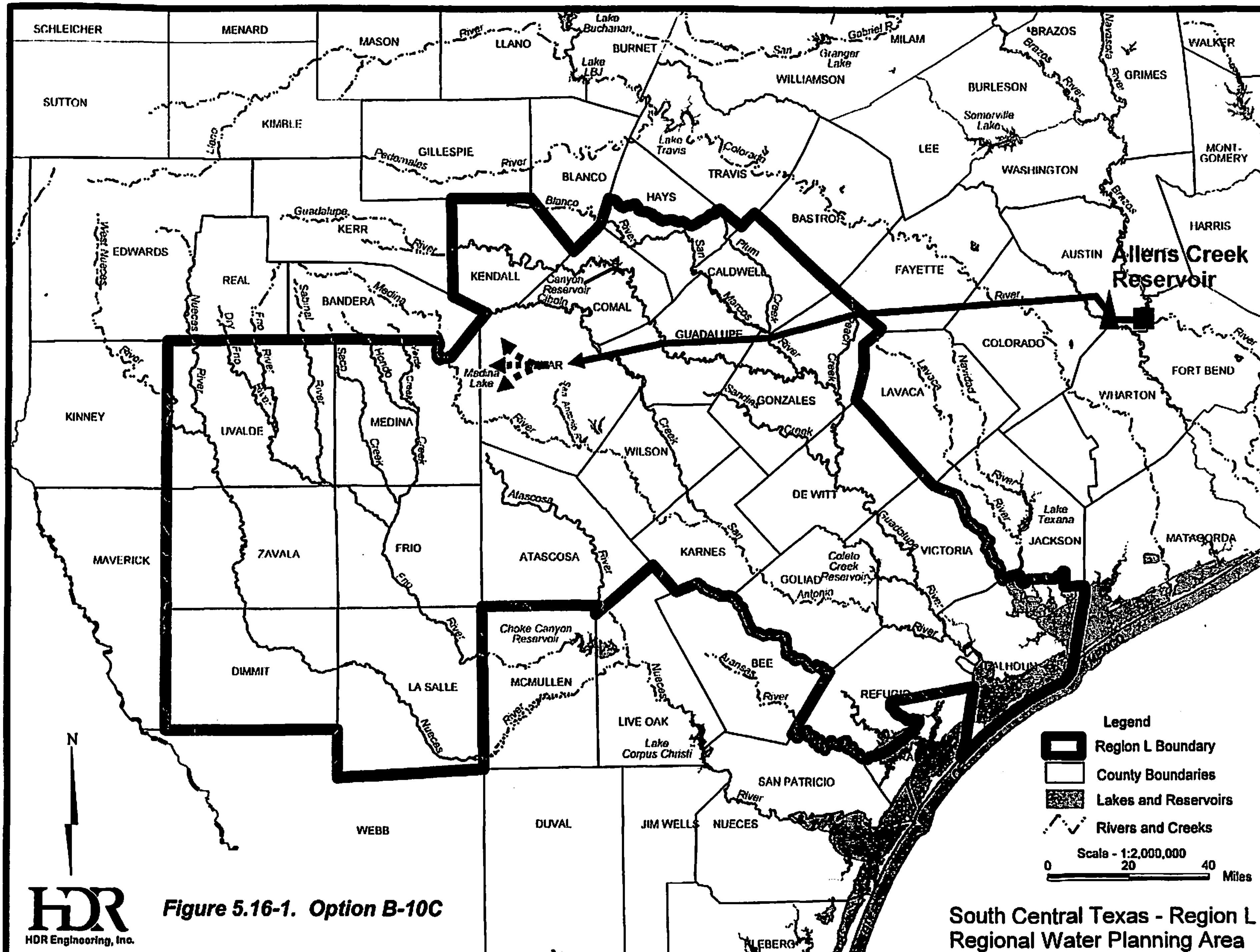


Figure 5.16-1. Option B-10C

The dam configuration studied by Freese & Nichols is the layout from the 1974 URS report, with minor changes. The dam would be a 26,200-foot earthfill embankment with a top width of 20 feet and 3-to-1 side slopes on both the upstream and downstream sides. The top of the embankment would be at elevation 136.5 ft-msl; the probable maximum flood elevation in the reservoir would be 129.2 ft-msl; and the top of the conservation pool would be at elevation 118.0 ft-msl with a surface area of 8,250 acres. Approximately 6 miles of stream channel along Allens Creek would be inundated by the reservoir.

The outlet works would consist of a 60-inch diameter pipe in the spillway and a 500-foot uncontrolled concrete ogee spillway with a crest elevation of 118.0 ft-msl. Because the Brazos River would reach the embankment under high flow conditions, slope protection would be needed to protect the downstream face of the dam below elevation 120.0 ft-msl as well as the entire upstream face. The design flood on the Brazos River exceeds the spillway elevation and the spillway would be designed to accommodate flow from the river into the reservoir. Two small dikes of compacted earthfill on the southern shore of the reservoir would be needed to raise the shoreline above the elevation of the Allens Creek probable maximum flood.

Diversion facilities on the Brazos River would include a gated intake channel, pump station, two parallel pipelines to the reservoir, and a discharge structure in the reservoir.

5.16.2 Available Yield

The Allens Creek drainage area controlled by the reservoir would be 58.3 square miles and water available for storage from the watershed during the critical drought period was estimated to be 3,407 acft/yr. To create a more significant project yield, water must be pumped into the reservoir from the Brazos River during times when flow in the river is sufficient to satisfy senior downstream water rights. Freese & Nichols[6] reports that the Texas Water Commission estimated the volume of unappropriated water in the Brazos at the proposed diversion to be an average of 3,137,000 acft/yr, with a minimum annual volume of 40,800 acft (1956), and a maximum annual volume of 8,854,000 acft (1957). During the critical drought period from March 1954 through February 1957, an average of 174,756 acft/yr would be available. These estimates were computed on a monthly basis, using historical flows between

[6] Freese & Nichols, Inc., Op. Cit., February 1989.

1947 and 1976 adjusted to reflect watershed conditions and existing water rights as of June 30, 1986; no instream or bay and estuary inflow requirements were applied.

The volume of Brazos River water that can be diverted and stored is limited by the capacity of the diversion pumps and by the daily flow distribution in the Brazos River, as well as by the reservoir storage volume. In 1994, Freese & Nichols/Brown & Root[7] updated previous yield studies of Allens Creek Reservoir for application of the Trans-Texas Environmental Criteria and recent water rights granted. They estimated that for a diversion rate of 820 cfs, the project firm yield would be 57,800 acft/yr and for a diversion rate of 1,900 cfs, the firm yield would increase to 85,000 acft/yr. Substantially greater quantities of dependable water supply could be available at this location with the purchase of stored water available in upstream reservoirs from the BRA. For purposes of this study, the river diversion rate was assumed to be 820 cfs resulting in a firm yield of 57,800 acft/yr.

Should this project become a component of an alternative regional water supply option for the South Central Texas Region, a reservoir operations study based on Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B) could be undertaken.

5.16.3 Environmental Issues

The proposed Allens Creek Reservoir will provide two benefits: 1) a uniform delivery rate regardless of Brazos River flows, allowing the transmission pipeline to be fully utilized year round, and 2) sedimentation of suspended material during storage, prior to placement in the cross-country transmission pipeline. This option includes a transmission pipeline from Allens Creek Reservoir to the crossing of IH-10 and the Colorado River, and would use the same transmission pipeline corridor from the IH-10 and Colorado River crossing to the major municipal demand center of the South Central Texas Region as that identified for Options C-17A, C-18, and SCTN-15. The transmission pipeline from the proposed Allens Creek Reservoir begins in Omernik's Western Gulf Coastal Plains Ecoregion[8] (southern Austin County). It then extends across the East Central Texas Plains (northern Austin County and

[7] Brown & Root, Inc. and Freese & Nichols, Inc., Op. Cit., March 1994.
[8] Ibid.

eastern Colorado County) and Texas Blackland Prairies Ecoregions (western Colorado County) before reaching the IH-10 and Colorado River crossing.

The proposed Allens Creek Reservoir is located in the Western Gulf Coastal Plain as described by Omernik.[9] This ecoregion is distinguished by its mosaic of bluestem and sacahuista grasses, croplands and grazing lands. Soils are primarily vertisols. Gould categorizes this area as being in the Gulf Prairies and Marshes vegetational region of Texas,[10] which is a prairie region extending inland from the Gulf of Mexico to elevations near 150 feet. It is a mosaic of grasslands and savannahs dissected by streams flowing into the Gulf. Live oak woodlands and narrow belts of low wet marsh occur immediately adjacent to the coast. Correll and Johnston described the climax vegetation as being tall grass prairie and post oak savannah, such as big bluestem, seacoast bluestem, Indian grass, eastern gama grass, gulf muhly, species of *Panicum* and others.[11] However the climax vegetation has generally been reduced to small areas and replaced with mesquite, oak, prickly pear, and several *acacias*.

Blair categorizes this area as being in the Texan Biotic Province.[12] The Texan Biotic Province as described by Blair is a broad ecotone between western grasslands and eastern forests. Blair's biogeographical listing of wildlife fauna for this province is a mix of western grassland-associated and eastern forest associated species.

The two dominant soil types found in the area to be inundated by the proposed reservoir consist mainly of Brazoria Clays. Brazoria Clay (BrA), 0 to 1 percent slopes, and the Brazoria Clay (Bs), depressional, are both deep level soils on flood plains adjacent to the Brazos River. Brazoria clays are moderately alkaline, calcareous, and poorly drained. Surface runoff and permeability are slow, the available water capacity is high and erosion hazard is slight. The BrA soil (0 to 1 percent slopes) is used mainly for pasture and crops, is well suited to corn, soybeans, and forage sorghums, and is poorly suited to urban uses. Brazoria depressional soil is slightly lower than surrounding soils and is subject to flooding for short periods. It is used mainly for pasture and range, with some areas in cropland. This soil is poorly suited to urban use because of the hazard of flooding.

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[9] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.
[10] Gould, F.W., "The Grasses of Texas," Texas A & M University Press, College Station, Texas, 1975
[11] Correll, D.S., and M.C. Johnston, "Manual of the Vascular Plants of Texas," Texas Research Foundation, Renner, Texas, 1979.
[12] Blair, W. F., "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.

The Allens Creek Reservoir site is presently used primarily for farmland and pasture, but it still supports large stands of trees and associated vegetation.[13] The riparian vegetation consists of cedar, elm, black willow, hackberry, soapberry, pecan, ash, and poison oak. The area that would be inundated by the proposed reservoir is a complex mosaic of woodlands, grasslands and croplands that have a steady water supply and together provide a high quality habitat for a wide variety of species.[14]

Direct impacts of the proposed reservoir would include construction of the dam, inundation of 8,250 acres of primarily bottomland hardwoods and croplands, the withdrawal of water from the Brazos River, and the construction of a pipeline and right-of-way maintenance from Allens Creek to the major municipal demand center of the South Central Texas Region. The construction of the 157-mile pipeline would include the clearing and removal of woody vegetation and the pipeline right-of-way (763 acres) would be maintained for the life of the project. Locating the pipeline right-of-way in previously disturbed areas, such as crop and pasturelands can minimize impacts on wildlife habitats. A cleared pipeline right-of-way through a woodland or brushy habitat could be beneficial to some wildlife by providing edge habitat, except where fragmented habitat remnants do not suffer a shortage of edges.

The Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch reports occurrences of the Attwater's Prairie Chicken (*Tympanuchus cupido attwateri*) and White-tailed Hawk (*Buteo albicaudatus*), which prefer coastal prairies, on or near the transmission pipeline. Along with the mapped bird species, the protected Houston Toad (*Bufo houstonensis*), which was reintroduced into Colorado County and prefer to live in ponds that are surrounded by forest or grass, and the Smooth Green Snake (*Liochlorophus vernalis)* are found within the corridor and reservoir site. Plant species that are confirmed and located in the study area include Flatsedge (*Cyperus grayioides*), Crown Coreopsis (*Coreopsis nuecensis*), and the Sunflower (*Helianthus occidentalis*).

The Guadalupe Bass (*Micropterus treculi*) was located up and downstream from the pipeline corridor. The upstream species will not be affected by construction, while the others might incur adverse affects. The Toothless Blindcat (*Trogloglanis pattersoni*) and Widemouth Blindcat (*Satan eurystomus*) occupy the Edwards Aquifer under the City of San Antonio and are

[13] Freese & Nichols, Inc., Op. Cit., February 1989.
[14] Ibid.

found at the west end of the pipeline route. As a result of the potential increase in recharge to the aquifer by this option, these fish species may be affected if water quality diminishes.

In addition to the Attwater's Prairie Chicken and White-tailed Hawk, a number of federally and state protected birds (American Peregrine Falcon, Arctic Peregrine Falcon, Bald Eagle, Black-capped Vireo, Golden-cheeked Warbler, Interior Least Tern, Mountain Plover, White-faced Ibis, Whooping Crane, and Wood Stork) are reported to occur within the project counties. Several protected species occurrences have been confirmed in the vicinity, such as the Texas Tortoise (*Gopherus berlandieri*), Texas Horned Lizard (*Phrynosoma cornutum*), Indigo Snake (*Drymarchon corais erebennus*), and Texas Garter Snake (*Thamnophis sirtalis annectens*). These remnant communities and the habitat of those protected species should be avoided where practical. Other species that may inhabit the site are listed in Table 5.16-1.

The pipeline corridor will be traversing what is considered to be essential habitat for the Attwater's Prairie Chicken (APC).[15] The transmission line at Allens Creek Reservoir is approximately 2 miles east of the closest confirmed observation of APC, and is within 5 miles of 12 confirmed occurrences.[16] The APC is dependent on areas that are composed of more than 50 percent tall grass prairie climax species, such as big and little bluestem, Indian grass and brownseed paspalum. The effects of construction on this habitat would be minimal if a proper corridor is chosen. If appropriate revegetation and management procedures are employed within the transmission line right-of-way, the habitat could be managed for the benefit of the APC. Implementation of this option is expected to require field surveys for protected species, vegetation, habitats, and cultural resources during right-of-way selection to avoid or minimize adverse impacts. Seasonal restrictions on construction may be imposed in APC habitat.

A 650-acre area of bottomland hardwood surrounding a pond, Alligator Hole, is located within the proposed conservation pool.[17] This bottomland hardwood community appears to be frequently inundated by flood flows and is considered to be wetland habitat (USGS, Wallis Quad) which would probably require mitigation. Wetland mapping has not been completed for this area, so a detailed inventory of wetland types is not available for this assessment. An on-site

[15] United States Fish and Wildlife Service, "Attwater's Prairie Chicken Recovery Plan," Albuquerque, NM. vii + 48 pp., 1992.
[16] Texas Parks and Wildlife Department, Resource Protection Division, Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch. 1994

Table 5.16-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Allens Creek Reservoir (B-10C)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	E			Resident
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	E			Resident
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	E	Nesting/Migrant
Attwater's Greater Prairie Chicken	*Tympanuchus cupido attwateri*	Native gulf coastal prairies of the coastal plain; 50% climax grass species composition	E	E	E	Resident
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T	E	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes				Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C			Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau				Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Crown Coreopsis	*Coreopsis nuecensis*	Endemic; sandy soils				Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau				Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Flatsedge	*Cyperus grayioides*	Pineywood regions[4]				
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodland canyons; usually under oaks				Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	E			Resident
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Helotes Mold Beetle	*Batrisodes venyivi*	Karst features in north and northwest Bexar County	E			Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident

Table 5.16-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae usually feed inside a leaf shelter and pupate in a cocoon made of leaves fastened with silk				Resident
Madla's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	E			Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer				Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT			Nesting/Migrant
Navasota Ladies'-Tresses	*Spiranthes parksii*	Margins of post oak woodlands within sandy loams	E	E	E	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies				Resident
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	E			Resident
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	E			Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations				Resident
Smooth Blue-Star	*Amsonia glaberrima*	Dense woods and low pinelands[5]				Resident
Smooth Green Snake	*Liochlorophis vernalis*	Coastal grasslands		T		Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands; shallow sandy to clay soils			WL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear				Resident
Sunflower	*Helianthus occidentalis*	Blooms late summer-fall				Resident
Texas Asaphomyian Tabanid Fly	*Asaphomyia texanus*	Near slow moving water, wait in shady areas for host			WL	Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures				Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Pink-Root	*Spigelia texana*	Wooded slopes and floodplains woods along rivers[5]				Resident
Texas Tauschia	*Tauschia texana*	Alluvial thickets or wet woods[5]				Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March through November		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident

Table 5.16-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
Veni's Cave Spider	*Cicurina venii*	Karst features in north and northwest Bexar County	E			Resident
Vesper Cave Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	E			Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
White-tailed Hawk	*Buteo albicaudatus*	Prairies, mesquite and oak savannahs, scrub-live oak, cordgrass flats		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
5 Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.
6 Checklist of Vascular Plants of Texas. Internet. Texas Parks and Wildlife Homepage. Online. www.tpwd.state.tx.us.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

survey to delineate wetlands would likely be required in future phases of implementation of this water supply option.

There are several protected and candidate species listed for Austin and some of the surrounding counties that may have habitat in the vicinity of the proposed reservoir. Species of particular concern are the Attwater's Prairie Chicken, which prefer native prairie remnants, the Timber Rattlesnake, Black-spotted Newt, White-faced Ibis, Rio Grande Lesser Siren, Sheep Frog and Texas Meadow-Rue, which prefer bottomland hardwoods, marshes and other wetland areas. The species in Table 5.16-1 would require an on-site survey and possibly require mitigation if impacted by the proposed reservoir.

The water quality of natural runoff into the proposed Allens Creek Reservoir is not known. The Brazos River Basin's overall surface water quality is relatively good, with only localized areas of concern, such as natural and man-made salt pollution, and localized problems

The water quality of natural runoff into the proposed Allens Creek Reservoir is not known. The Brazos River Basin's overall surface water quality is relatively good, with only localized areas of concern, such as natural and man-made salt pollution, and localized problems of low dissolved oxygen and elevated fecal coliform levels.[18] Specific water quality assessments will likely be completed in later phases of the implementation, if diversions from the Brazos River to the proposed Allens Creek Reservoir should continue to be considered as a viable water supply option.

The firm yield of Option B-10C was calculated without reference to the Consensus Environmental Criteria, as it is uncertain what flow criteria (if any) will be applied pursuant to the provisions of SB1593. Neither changes in instream flows nor freshwater inflows to the Gulf of Mexico are tabulated for this option. The Brazos River has already filled its Pleistocene river valley with sediments, so that its estuary consists only of the lower few miles of channel before it discharges into the Gulf of Mexico.

Cultural resources protection on public lands in Texas, or lands affected by projects regulated under Department of the Army permits, is afforded by the Antiquities Code of Texas (Title 9, Chapter 191, Texas Natural Resource Code of 1977), the National Historic Preservation Act (PL96-515), and the Archaeological and Historic Preservation Act (PL93-291). All areas to be disturbed during construction would first be surveyed by qualified professionals to determine the presence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided. Previous investigations have revealed large numbers of archaeological sites around the perimeter of the proposed reservoir.[19] It is probable that some further testing and mitigation in the reservoir pool would be needed.

5.16.4 Engineering and Costing

Pump station and transmission pipelines have been sized and costed for one annual delivery volume based on run-of-river diversions from the Brazos River and management of storage in Allens Creek Reservoir. This scenario produces a firm yield of 57,800 acft/yr.

[18] Texas Water Development Board (TWDB), "Water for Texas; Today and Tomorrow," TWDB, Austin, Texas, December 1990.
[19] Freese & Nichols, Inc., Op. Cit., February 1989.

Additional firm supply could be obtained with the purchase and delivery of water stored in upstream reservoirs operated by BRA.

For this option, the firm yield of the proposed reservoir would be diverted through an intake and pumped in a transmission line to the major municipal demand center of the South Central Texas Region (Figure 5.16-1). The diversion rate from the reservoir would be uniform throughout the year. The benefit from this project would be the addition of a new water supply source to the San Antonio distribution system, other municipal systems in the surrounding area, and/or the Edwards Aquifer (through enhancement of recharge). The major facilities required to implement this option are:

- River Diversion, Intake, and Pump Station
- Pipeline from River Pump Station to Reservoir
- Dam and Reservoir
- Reservoir Intake and Pump Station
- Raw Water Pipeline to Treatment Plant
- Raw Water Pipeline Transmission Pump Stations, 3 required
- Water Treatment Plant (Level 3)
- Distribution

The river intake and pump station are sized to deliver up to 50,000 acft/month through two 120-inch diameter pipes. The reservoir intake and pump station is sized to deliver 54.3 MGD through a 60-inch diameter transmission pipeline. The operating cost was determined for an annual raw water delivery of 57,800 acft/year. Financing the reservoir costs over 40 years and the pipeline and other costs over 30 years at a 6 percent annual interest rate results in an annual expense of $41,955,000 (Table 5.16-2). Operation and maintenance and pumping energy costs total $16,756,000 per year. Hence, the total annual cost of the project is estimated to be $58,711,000. For an annual firm yield of 57,800 acft, the resulting annual cost of water is $1,016 per acft (Table 5.16-2).

Table 5.15-2.
Cost Estimate Summary for
Allens Creek Reservoir (B-10C)
(Second Quarter 1999 Prices)

Item	*Estimated Costs for Facilities*
Capital Costs	
Dam and Reservoir (Conservation Pool: 168,000 acft; 8,250 acres; 118 ft-msl)	$54,194,000
Diversion Facilities	$14,147,000
Intake and Pump Station (54.3 MGD)	$7,458,000
Water Treatment Plant (54.3 MGD)	$37,467,000
Transmission Pump Stations (3)	$20,411,000
Transmission Pipeline (60-inch dia., 157 miles)	$154,238,000
Distribution	67,675,000
Total Capital Cost	**$355,590,000**
Engineering, Legal Costs and Contingencies	$116,657,000
Environmental & Archaeology Studies and Mitigation	$19,980,000
Land Acquisition and Surveying (10,210 acres)	$23,847,000
Interest During Construction (4 years)	82,573,000
Total Project Cost	**$598,647,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$33,605,000
Reservoir Debt Service (6 percent for 40 years)	$8,350,000
Operation and Maintenance	
Intake, Pipeline, Pump Station	$3,129,000
Dam and Reservoir	$842,000
Water Treatment Plant	$4,362,000
Pumping Energy Costs (140,386,665 kWh @ 0.06 $ per kWh)	8,423,000
Total Annual Cost	**$58,711,000**
Available Project Yield (acft/yr)	57,800
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	$1,016
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	$3.12

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated, and distributed to municipal systems or the Edwards Aquifer recharge zone.

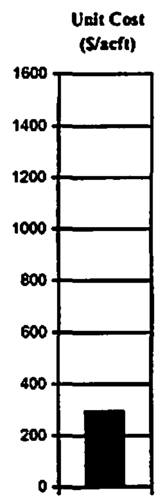
5.16.5 Implementation Issues

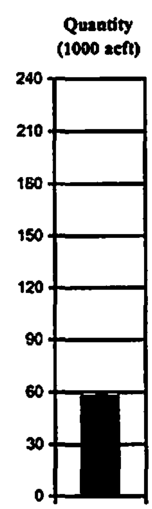
Implementation of Allens Creek Reservoir would not directly affect the feasibility of other water supply options under consideration, except to the extent that treated effluent from this imported supply may contribute to streamflow and water availability in the South Central Texas Region.

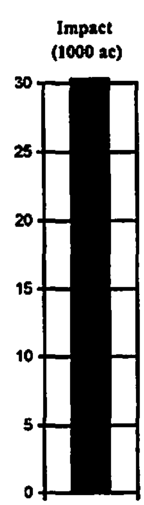
An institutional arrangement is needed to implement this project, including financing, on a regional basis.

1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits.
   b. TNRCC Interbasin Transfer Approval.
   c. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   d. GLO Sand and Gravel Removal permits.
   e. GLO Easement for use of state-owned land.
   f. Coastal Coordination Council review.
   g. TPWD Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resource studies.
3. Land will need to be acquired by negotiations or condemnation.
4. Relocations may include:
   a. Highways and railroads.
   b. Other utilities.
   b. Creeks and rivers.
   c. Other utilities.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **SCTN-18**

OPTION NAME: **Cotulla Reservoir — Raw Water at Reservoir; Firm Yield**

OPTION DESCRIPTION: *The proposed Cotulla Reservoir Site is located on the Nueces River near Cotulla in La Salle County. This reservoir was identified and evaluated in the course of studies by the U.S. Bureau of Reclamation and other consultants. Using available physical data and cost estimates from previous studies, a technical evaluation of the Cotulla Reservoir has been completed, including the computation of firm yield (subject to Consensus Environmental Criteria) and annual unit cost of raw water at the reservoir.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☐ 5-15 yr. ☒ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	$299	per acft[1]	Raw Water at Reservoir
QUANTITY OF WATER:	57,080	acft/yr[2]	
LAND IMPACTED:	31,410	acres[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Embankment and spillway, outlet works, land, relocations, reservoir clearing, diversion and care of water, grout curtain, environmental studies and mitigation, and engineering and legal services. Depending upon the location(s) and type(s) of use for water supplies associated with Cotulla Reservoir, additional facilities and costs could include raw include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems.

[2]**QUANTITY OF WATER:** Water rights and instream flow requirements.

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity. This does not include land in the floodplain above the conservation pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Inundation of approximately 31,410 acres of land, and instream flow requirements. This reservoir is contained within the Southern Texas Plain ecoregion, an area known for its mixture of Mesquite-Blackbrush Brush, Mesquite-Granjeno Parks, crops and grassland. The analyses were based upon consensus environmental criteria, which specifies conditions for storage and pass-through of flows for instream and bay and estuary needs.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and impacts on the firm yield of the Choke Canyon Reservoir/Lake Corpus Christi System.

ADDITIONAL FACTORS: Ability to obtain permits to develop the reservoir.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17a, L-17b, L-18a, L-18b, L-18c, SCTN-7b, SCTN-14a, SCTN-14b, and/or SCTN-19.

5.17 Cotulla Reservoir (SCTN-18)

5.17.1 Description of Option

The Cotulla Dam and Reservoir Project is located at river mile 250.2 on the Nueces River near the west border of La Salle County, approximately 8 miles west of the City of Cotulla. Pertinent data concerning the dam and reservoir in this option were obtained from the August 1960 report entitled "Capacity-Cost Curve for Cotulla Reservoir Site,"[1] prepared by the USCE. This report indicates that the Cotulla Reservoir was investigated in connection with the "Report on Survey of Nueces River and Tributaries, Texas," dated July 31, 1944 and also prepared by the USCE. Although the U.S. Bureau of Reclamation proposed construction of the dam, no further action was taken after a USCE study suggested the Cotulla Reservoir was not economically justified for flood control purposes.

Data obtained from the referenced report indicates that the dam would consist of an 11,600-foot rolled-earth embankment, with a top of dam elevation of 475 ft-msl, a crest width of 20 feet, and upstream and downstream slopes at a 3:1 grade. A 376-foot-long spillway would consist of a concrete, ogee-type, weir overflow section surmounted by eight tainter gates. Two 134-foot-long non-overflow sections will flank the spillway on both sides. At the normal pool elevation (454 ft-msl) the reservoir would be able to store up to 527,600 acft, and it would inundate an area of 31,410 acres. The location of the project is shown in Figure 5.17-1.

5.17.2 Water Availability

The Nueces River Basin Model[2] (Nueces Model) was used to estimate the unappropriated available streamflow in the Nueces River at the reservoir site. A modified version of the SIMDLY reservoir operation model (originally written by TWDB) was used to compute the firm yield of the Cotulla Reservoir based on the inflows and pass-through flows computed by the Nueces Model. The firm yield of the proposed Cotulla Reservoir was computed utilizing the Environmental Water Needs of the Consensus Planning Process (Consensus Criteria, Appendices B and F).

[1]U.S. Army Corps of Engineers, "Capacity-Cost Curve for Cotulla Reservoir Site – Nueces River," Fort Worth District, U.S. Study Commission, August 1960.
[2] HDR Engineering, Inc., "Regional Water Supply Planning Study – Phase I," Nueces River Authority, et al., May 1991.

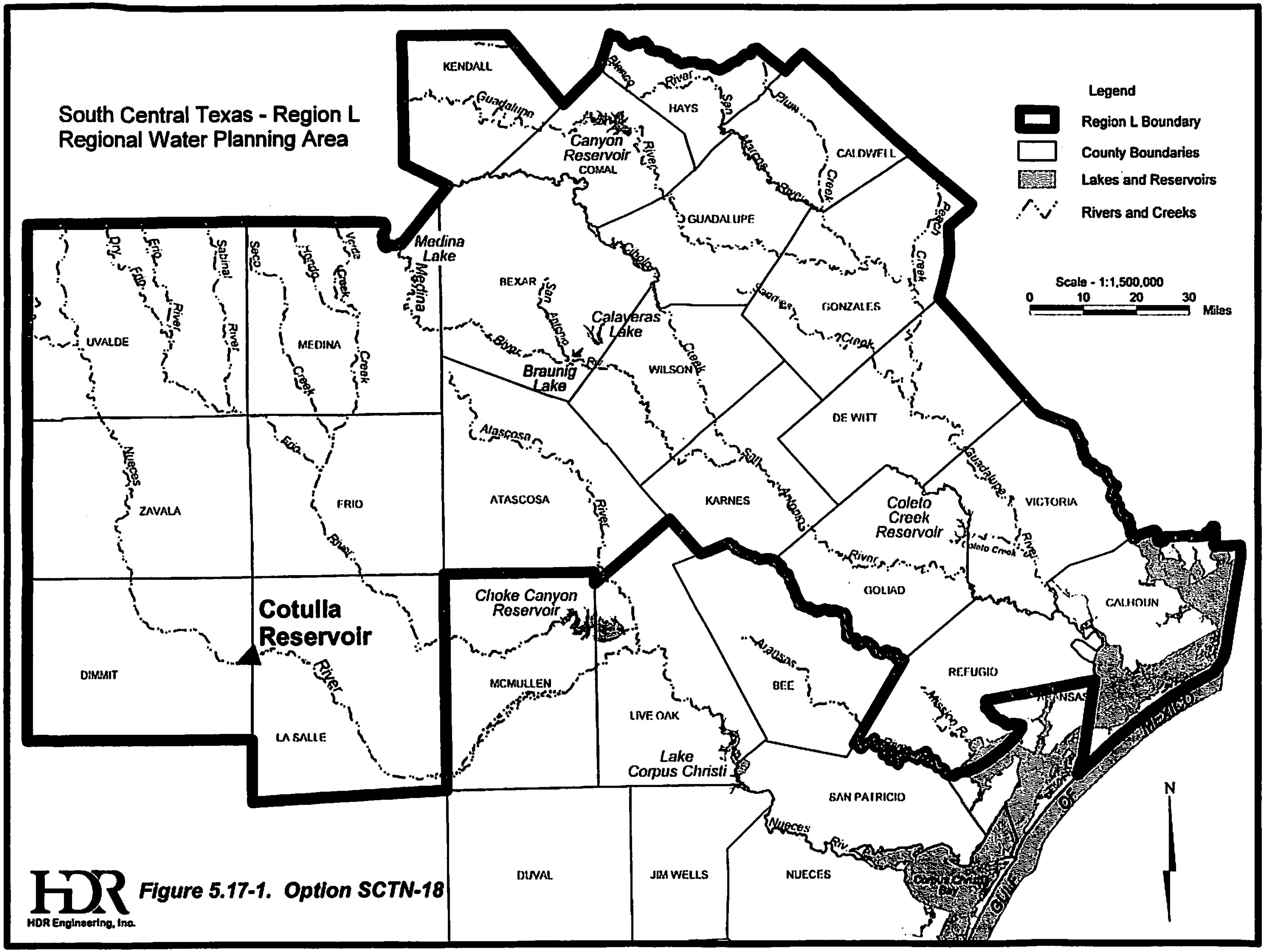


Figure 5.17-1. Option SCTN-18

For modeling purposes, streamflows for the Nueces River at Cotulla (USGS# 08194000) were assumed representative of inflows to the proposed reservoir. This gage has a drainage area of 5,171 square miles, and is located only 8 miles east of the proposed dam. Inflows are the naturalized streamflow at the reservoir site, adjusted to account for upstream water rights and return flows. The Nueces Model computes streamflow available for impoundment without causing increased shortages to downstream rights, and it allows for the option of not honoring storage rights in Lake Corpus Christi. The minimum effects of Cotulla Reservoir on the yield of the CCR/LCC System, and freshwater inflow changes at the Nueces Estuary were evaluated using the Lower Nueces River Basin and Estuary Model.[3]

The streamflow statistics used to determine the Consensus Criteria pass-through requirements are presented in Table 5.17-1. Subject to a uniform seasonal demand pattern, the firm yield of Cotulla Reservoir is 57,080 acft/yr (which represents a reliable supply based on the 1934 to 1996 historical period of hydrologic record). The associated reduction in firm yield of the CCR/LCC System is estimated to be 9,948 acft/yr.

Figure 5.17-2 illustrates the simulated Cotulla Reservoir storage fluctuations for the 1934 to 1996 historical period, subject to the firm yield of 57,080 acft/yr. Simulated reservoir storages remain above the Zone 2 trigger level (80 percent capacity) about 48 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 84 percent of the time over the 1934 to 1996 historical period. Figure 5.17-3 illustrates the changes in streamflow medians and frequencies caused by the reservoir at the project location and at the Nueces Estuary. Average annual freshwater inflows to the Nueces Estuary, would be reduced by about 7.8 percent.

5.17.3 Environmental Issues

The Cotulla Reservoir would impound the Nueces River at the dam in La Salle County, backing water past the Dimmit County line to a point near Catarina. Construction of Cotulla Reservoir will result in the inundation of approximately 32 miles of Nueces River channel, and conversion of those lotic habitats to a lentic environment. Reservoir operations will conform to the Consensus Criteria (Appendix B) to minimize impacts to stream hydrology, water quality and

[3] HDR Engineering Inc., "Water Supply Update for City of Corpus Christi Service Area," City of Corpus Christi, January 1999.

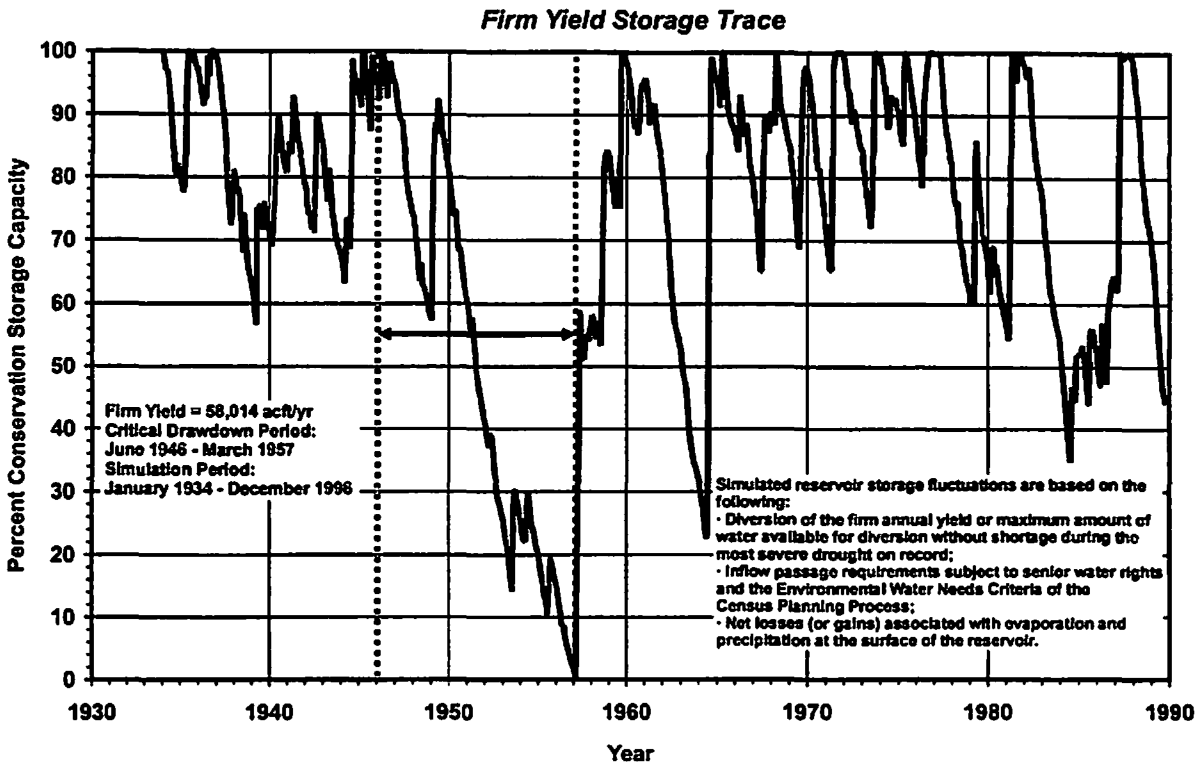
Table 5.17-1.
Daily Natural Streamflow Statistics
for the Cotulla Reservoir Site

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	38.94	14.32
February	47.49	13.39
March	42.16	7.35
April	44.94	6.74
May	51.52	6.00
June	50.51	4.00
July	43.02	0.85
August	22.74	0.20[1]
September	46.52	3.41
October	76.06	7.48
November	48.43	8.76
December	26.23	8.90
Zone 3 Pass-Through Requirement[2] (acft/day)		0.20

[1] When the Zone 3 pass-through requirement is greater than the 25th percentile flow, the 25th percentile flow is superceded by the Zone 3 pass-through requirement.
[2] Water Quality Standard (7Q2).

lotic habitats downstream of the dam. Due to the proportion of time this reservoir is expected to be in consensus Criteria Zones 2 and 3 (Figure 5.17-2), actual streamflows below the dam will be severely curtailed. Median annual streamflows are expected to decline by about 90 percent due to reservoir operation. Monthly medians in what are presently the wettest months (May, June, September and October) will be reduced by 94 to 98 percent.

However, impacts to aquatic habitats and populations will be limited because of the frequency of zero flows and a dry riverbed in the reach below the proposed Cotulla Reservoir. As indicated in Figure 5.17-3, streamflows at the project site are essentially zero approximately half of the time, with or without he project. The drying of riparian areas in the braided reach of the Nueces River that tend to be relatively mesic under the present hydrologic regime appear to be the major impact.



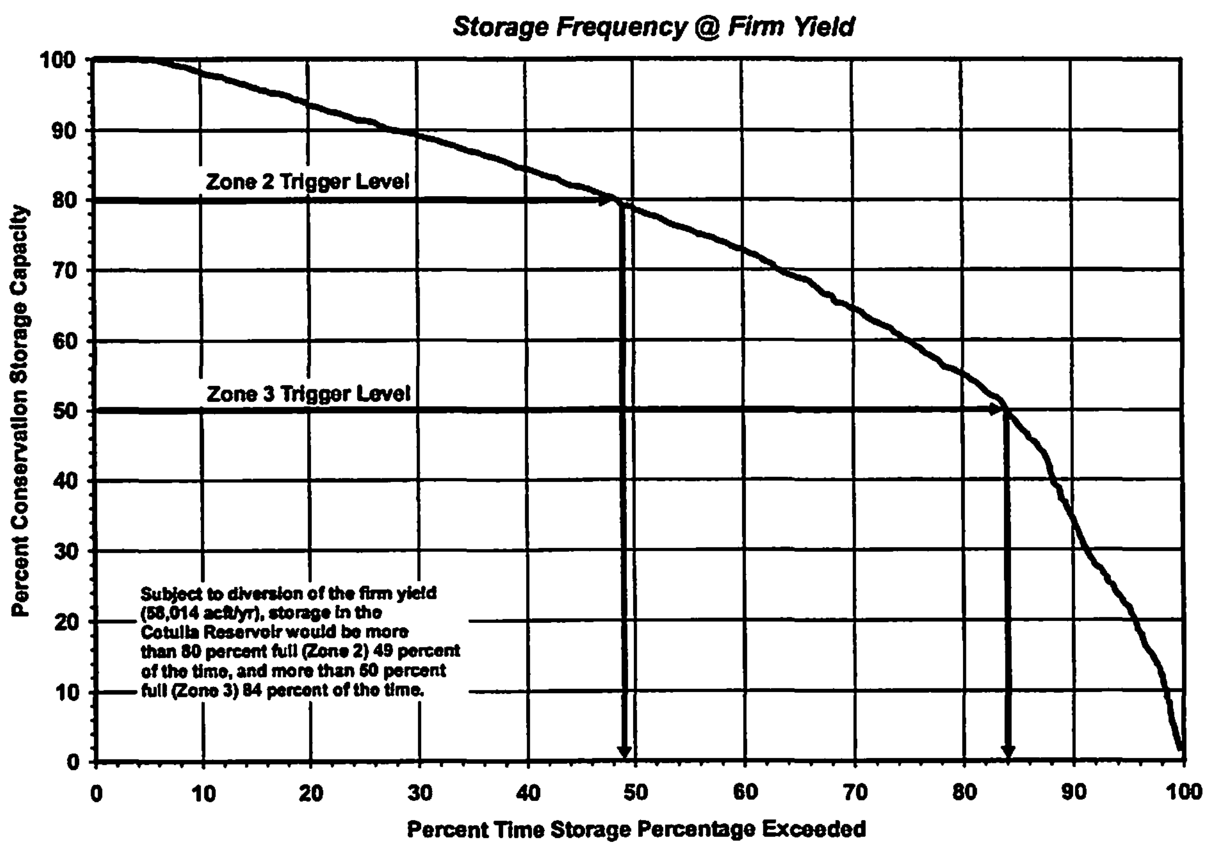


Figure 5.17-2. Cotulla Reservoir Storage Considerations

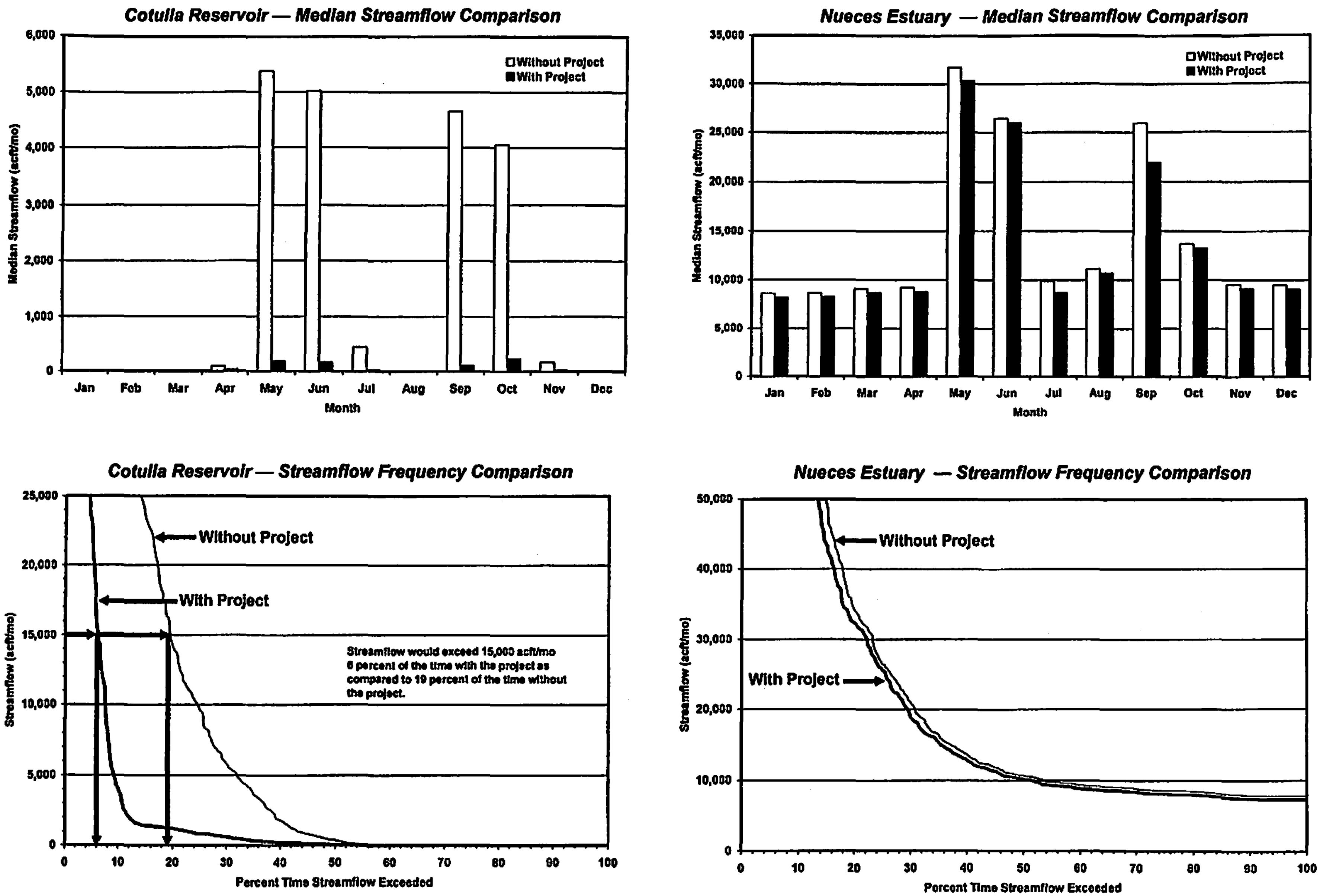


Figure 5.17-3. Cotulla Reservoir Streamflow Comparisons

This reservoir is contained within the Southern Texas Plain ecoregion,[4] an area known for its mixture of Mesquite-Blackbrush Brush, Mesquite-Granjeno Parks, crops and grassland.[5]

Mesquite-Blackbrush Brush is distributed principally on shallow, gravelly or loamy soils in the South Texas Plains. The plants most commonly associated with this type of vegetation cover are Lotebush (*Zizyphus obtusifolia*), ceniza (*Leucophyllum sp.*), guajillo (*Acacia berlandieri*), Texas pricklypear (*Opuntia* sp.), purple three-awn (*Aristida purpurea*), hairy tridens (*Erioneuron pilosum*) and two-leaved senna (*Senna roemariana*). Also distributed on sandy or loamy upland soils within the South Texas Plains are the Mesquite-Granjeno Parks. The vegetation within these areas differs in that the brush layer is fuller, and generally of a taller growth habit. Commonly associated plants within this vegetation type include Bluewood (*Condalia hookeri*), lotebush (*Zizyphus obtusifolia*), Texas colubrina (*Colubrina texensis*), hooded windmillgrass (*Chloris cucullata*), tanglehead (*Heteropogon contortus*) and firewheel (*Gaillardia* sp.). Remaining vegetation types within the proposed reservoir area include cultivated cover crops or row crops providing food and/or fiber for either man or domestic animals. This vegetation type may also represent grassland associated with crop rotation. In addition, relatively small portions of the proposed reservoir area contain native or introduced grasses. The distribution of this vegetative type is principally within the southern part of the proposed reservoir site. This vegetative type includes mixed native or introduced grasses and forbs on grassland sites, or mixed herbaceous communities resulting from the clearing of the woody vegetation within an area. Within the South Texas Plains, this type of vegetation generally results in areas where the brush has been cleared. These areas are particularly subject to change, as regrowth of the original brush vegetation can be rapid. The reservoir site appears to cover an area principally composed of brushy areas, with some grassland produced by brush clearing, and cropland alternating with native grassland.

The reservoir site lies within an area described by Omernik[6] as the Southern Texas Plains. This area is composed of smooth or irregular plains, vegetated with mesquite/acacia savanna (bluestem, bristlegrass). Land use of this area is generally open woodland grazed,

[4] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[5] McMahan, Craig A., Roy G. Frye, and Kirby L. Brown, "The Vegetation Types of Texas Including Cropland," Texas Parks and Wildlife Department, 1984.
[6] Omernik, J. M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77:118-125, 1987.

subhumid grassland, and semiarid grazing land. In addition, Blair[7] describes this area as being located within the Tamaulipan biotic province. This biotic province extends into southern Texas from eastern Mexico and encompasses only the southern tip of Texas. The climate of this province is semiarid, and there is marked deficiency of moisture for plant growth resulting in thorny brush as the predominant vegetation type.

Important species with habitats within Dimmit and La Salle counties are listed in Table 5.17-2. In accordance with the TPWD Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, no listed species were located within the reservoir site, however there are numerous species found within the two counties which should be considered in terms of habitat modification or destruction by the reservoir project. Several protected plant and animal species have habitat requirements or preferences that indicate that they could be present within the project area.

Within the reservoir site substantial acres of brush, grassland and crops would be inundated. These types of habitat are utilized by many protected species. The endangered jaguarundi (*Felis yagouaroundi*) prefers thick brushlands especially in areas near water, while the Texas tortoise (*Gopherus berlandieri*) inhabits the open brush with a grass understory. The endangered ocelot (*Felis pardalis*) lives within mesquite-thorn scrubland, dense chaparral thickets and live oak mottes. A sighting of the ocelot was reported near the proposed reservoir site. Grass prairies and sand hills, thornbrush woodland and mesquite savannah harbor the indigo snake (*Drymarchon corais erebennus*). The Carrizo Springs pocket gopher (*Geomys personatus streckeri*) inhabits deep sandy soils which may be found within the reservoir area.

Other important species, which may inhabit the project area, include the Texas horned lizard (*Phrynosoma cornutum*), found in grass, cactus and brush, and the interior least tern (*Sterna antillarum athalassos*) a nesting/migrant species which prefers inland river sandbars for nesting and shallow water for foraging. Three lizard species might possibly occur within the proposed reservoir site. Two are species of concern, the keeled earless lizard (*Holbrookia propinqua*) and spot-tailed earless lizard (*Holbrookia lacerata*), and one, the reticulate collared lizard (*Crotaphytus reticulatus*) is listed as threatened. The reticulate collared lizard requires open brush-grassland, prickly pear and mesquite within its habitat.

[7] Blair, W. Frank, "The Biotic Provinces of Texas," Texas Journal of Science 2(1):93-117, 1950..

Table 5.17-2
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option[1]
Cotulla Reservoir (SCTN-18)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWD	Listing Entity TPWD	Listing Entity TOES	Potential Occurrence in County
Birds						
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs	E	E	E	Nesting/Migrant Resident
Arctic Peregrine Falcon	*Falco peregrinus tundrus*	Open country; cliffs	E	T	T	Nesting/Migrant Resident
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow water for foraging	E	E	E	Nesting/Migrant Resident
Reptiles						
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands, grass, cactus, brush		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush w/ grass understory; open grass/bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Requires open brush-grasslands, prickly pear and mesquite.		T	WL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear				Resident
Plants						
Dimmit Sunflower	*Helianthus praecox ssp. hirtus*	Well drained sandy soils in open shrublands.				Resident
Silvery wild-mercury	*Argythamnia argyraea*	Among shortgrasses on whitish clay soils in shrub-invaded grasslands, particularly over the Yegua Formation.			WL	Resident
Kleberg Saltbush	*Atriplex klebergorum*	Light sandy to clayey loams, usually saline, sparsely vegetated, usually with other halophytes.			WL	Resident
Crown tickseed	*Coreopsis nuecens*	Open, sandy areas				Resident
Mexican mud-plantain	*Heteranthera mexicana*	Plants creeping in mud or floating in shallow water.				Resident
Mammals						
Ocelot	*Felis pardalis*	dense chaparral thickets; mesquite-thorn scrub and live oak mottes	E	E	E	Resident
Carrizo Springs Pocket Gopher	*Geomys personatus streckeri*	Deep sandy soils.			WL	Resident
Jaguarundi	*Felis yagouaroudi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered; T = Threatened; C = Candidate Category, Substantial Information; E/PT = Proposed Endangered or Threatened; Blank = Rare, but no regulatory listing status; WL = Conservation Watch List

Plants listed as species of concern within the reservoir site include the Dimmit sunflower (*Helianthus praecox* ssp. Hirtus), a species found in well-drained sandy soils in open shrublands. Among shortgrasses in shrub-invaded grasslands is the silvery wild-mercury (*Argythamnia argyracea*). Mexican mud-plantain (*Heteranthera mexicana*) is found creeping in mud or floating in shallow water along the river. Kleberg saltbrush (*Atriplex klebergorum*) is usually found in light sandy to clayey loams, sparsely vegetated. Crown tickseed (*Coreopsis nuecens*) is noted as occurring within La Salle County.

There are no cultural resources sites listed by the Texas Historical Commission within the proposed reservoir site.

5.17.4 Engineering and Costing

The cost estimate for this option is shown in Table 5.17-3. The portion of the estimate pertaining to the dam and reservoir (capital cost) is based on a previous cost estimate prepared by the USCE in 1960. All other costs, including inundated land and mitigation land acquisition, and operation and maintenance costs were developed in accordance with the standard cost estimating procedures summarized in Appendix A. Costs include land acquisition up to the maximum water surface elevation (elevation 459 ft-msl; 37,470 acres). Water rights mitigation costs account for the 9,948-acft/yr firm yield reduction at the CCR/LCC System, and 37,180-acft/yr mean estuarine inflow reduction. Financing the project under the Senate Bill 1 assumptions (40 years at a 6 percent annual interest rate) results in an annual expense of $11,734,000. Annual operation and maintenance costs total $913,000. The annual cost, including debt service, water rights mitigation, and operation and maintenance, totals $17,074,000. For an annual firm yield of 57,080 acft, the resulting cost of raw water at the reservoir is $299 per acft (Table 5.17-3). Depending upon the location(s) and type(s) of use for water supplies associated with Cotulla Reservoir, additional facilities and costs could include raw water intake, pump station(s), transmission pipeline, water treatment plant, and distribution to municipal systems.

Table 5.17-3. Cost Estimate Summary for Cotulla Reservoir (SCTN-18) (Second Quarter 1999 Prices)

Item	*Estimated Costs for Facilities*
Capital Costs	
Dam and Reservoir (Conservation Pool: 527,500 acft; 31,410 acres; 454 ft-msl)	
Relocations	$4,039,000
Diversion and Care of Water	412,000
Dam, Spillway, and Reservoir Area Clearing & Grubbing	19,523,000
Embankment	12,157,000
Spillway	23,597,000
General Items	1,154,000
Total Capital Cost	**$60,882,000**
Engineering, Legal Costs and Contingencies	$21,309,000
Environmental & Archaeology Studies and Mitigation	34,218,000
Land Acquisition and Surveying (37,470 acres)	35,789,000
Interest During Construction (4 years)	24,352,000
Total Project Cost	**$176,550,000**
Annual Costs	
Debt Service (6 percent for 40 years)	$11,734,000
Operation and Maintenance	913,000
Water Rights Mitigation	4,427,000
Total Annual Cost	**$17,074,000**
Available Project Yield (acft/yr)	57,080
Annual Cost of Water ($ per acft) Raw Water at Reservoir	$299
Annual Cost of Water ($ per 1,000 gallons) Raw Water at Reservoir	$0.92

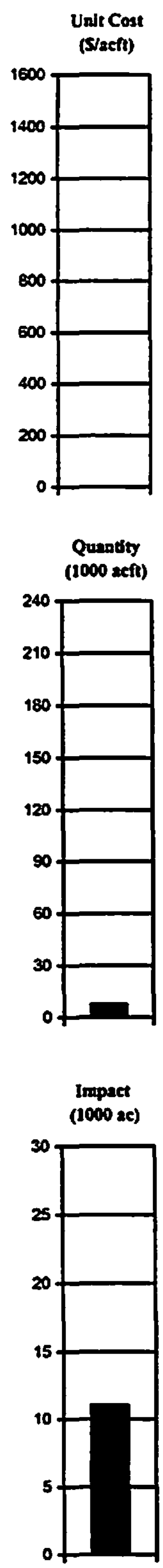
5.17.5 Implementation Issues

Implementation of Cotulla Reservoir could directly affect the feasibility of other water supply options under consideration, including L-17a, L-17b, L-18a, L-18b, L-18c, SCTN-7b, SCTN-14a, SCTN-14b, and/or SCTN-19.

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

1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits.
   b. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. GLO Sand and Gravel Removal permits.
   d. GLO Easement for use of state-owned land.
   e. Coastal Coordination Council review.
   f. TPWD Sand, Gravel, and Marl permit.
2. Permitting, at a minimum, will require these studies:
   a. Assessment of instream flow and bay and estuary inflow changes.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.
3. Land will need to be acquired through either negotiations or condemnation.
4. Relocations for the reservoir may include:
   a. County roads.
   b. Other utilities.
   c. Structures of historical significance.
   d. Cemeteries.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001



OPTION NUMBER: SCTN-19
OPTION NAME: Nueces Reservoir — Smyth Crossing Site

OPTION DESCRIPTION: *Evaluation of the potential firm yield which could be developed through construction of the Smyth Crossing Reservoir located on the Nueces River below U.S. Highway 90 between Uvalde and La Pryor. This reservoir might serve as a surface water supply for Uvalde and/or other water users along the Nueces River in Zavala or Dimmit Counties.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☐ 5-15 yr. ☒ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	N/A	per acft[1]
QUANTITY OF WATER:	7,507	acft/yr[2]
LAND IMPACTED:	11,300	acres[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Not evaluated at this time.

[2]**QUANTITY OF WATER:** Water rights and instream flow requirements. Firm yield based on total storage capacity (including flood control storage).

[3]**LAND IMPACTED:** Area inundated by the reservoir at full conservation pool capacity. This does not include land in the floodplain above the conservation pool at the reservoir or land purchased for mitigation.

ENVIRONMENTAL ISSUES: Not evaluated at this time.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water, environmental mitigation, and impacts on the firm yield of the CCR/LCC System.

ADDITIONAL FACTORS: Ability to obtain permits to develop the reservoir.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-17a, L-17b, L-18a, L-18b, L-18c, SCTN-7a, SCTN-14a, SCTN-14b, and/or SCTN-18.

5.18 Nueces Reservoir/Smyth Crossing Site (SCTN-19)

5.18.1 Description of Option

The Smyth Crossing Dam and Reservoir Project is located on the Nueces River in Uvalde County, approximately 8 miles southwest of the City of Uvalde, and 2 miles north of the Zavala County line (Figure 5.18-1). Pertinent data concerning the dam and reservoir in this option were obtained from a June 1964 report entitled "Feasibility Report on Nueces River Reservoir."[1] The report indicates that the Smyth Crossing Site provides the best alternative for a reservoir in the area as compared to the Tom Nunn Hill Dam Site, which has similar drainage area, capacity, and yield characteristics, and is located only a few miles upstream.

Data obtained from the referenced report indicates that the dam would consist of a 31,900-foot rolled-earth embankment, with a top of dam elevation of 914 ft-msl, a crest width of 20 feet, and upstream and downstream slopes at a 3:1 grade. The 4,600-foot-long emergency spillway would be located at the right abutment at an elevation of 888.1 ft-msl. At the top of the flood control pool (888.1 ft-msl), the reservoir would be able to store up to 315,000 acft, and it would inundate an area of 11,300 acres. As described in the referenced report, the Smyth Crossing Reservoir might have an original conservation storage capacity of about 65,000 acft and a flood control capacity of about 250,000 acft. The location of the project is shown in Figure 5.18-1.

5.17.2 Water Availability

The Nueces River Basin Model[2] (Nueces Model) was used to estimate the unappropriated streamflow available in the Nueces River at the reservoir site. A modified version of the SIMDLY reservoir operation model (originally written by TWDB) was used to compute firm yields of the Smyth Crossing Reservoir based on inflows and water rights requirements computed by the Nueces Model. Firm yield estimates for a range of potential storage capacities for the proposed Smyth Crossing Reservoir were computed utilizing the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendices B and F).

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[1]Freese, Nichols and Endress Consulting Engineers, "Feasibility Report on Nueces River Reservoir," Zavala-Dimmit Counties Water Improvement District Number One, June 1964.

[2] HDR Engineering, Inc., "Nueces River Basin Regional Water Supply Planning Study – Phase I," Nueces River Authority, et al., May 1991.

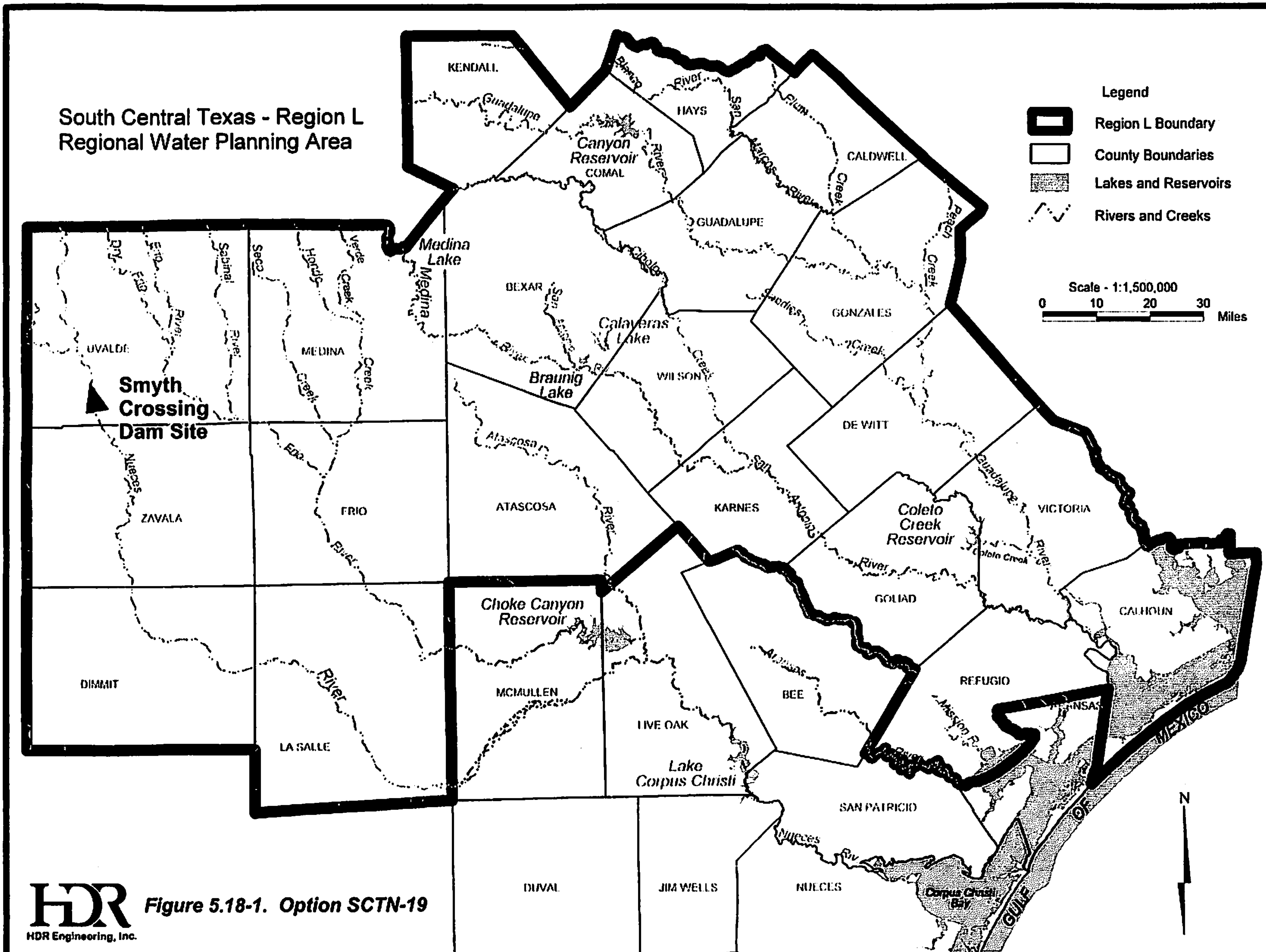


Figure 5.18-1. Option SCTN-19

For modeling purposes, streamflows for the Nueces River below Uvalde (USGS# 08192000) were assumed representative of inflows to the proposed reservoir. This gage has a drainage area of 1,861 square miles, and is located approximately one mile upstream of the proposed Smyth Crossing Dam. The drainage area above the dam is 1,954 square miles, or 93 square miles more than USGS gage # 08192000 drainage area. Inflows are the naturalized streamflow at the reservoir site, adjusted to account for upstream water rights. The Nueces Model computes streamflow available for impoundment without causing increased shortages to downstream rights, and it allows for the options of not honoring storage rights in Lake Corpus Christi and/or the Zavala-Dimmit Counties WID No. 1 water rights.

Streamflow statistics used to define the Consensus Criteria pass-through requirements are presented in Table 5.18-1. Subject to a uniform seasonal demand pattern, firm yields for the Smyth Crossing Reservoir were evaluated for the alternatives of honoring, and not honoring, diversion rights for the Zavala-Dimmit Counties WID No. 1. No inflows were passed for storage rights at Lake Corpus Christi assuming that any impacts to the firm yield of the Choke Canyon Reservoir/Lake Corpus Christi System would be mitigated financially or by delivery of water from other sources. In each case, firm yield associated with each of five reservoir capacities was evaluated based on the 1934 to 1996 historical period of hydrologic record. As Figure 5.18-2 illustrates, when storage rights for the Zavala-Dimmit Counties WID No. 1 are honored, yields in the range of 4,475 to 14,983 acft/yr are obtained for capacities ranging from 86,050 to 683,790 acft. On the other hand, when storage rights for the Zavala-Dimmit Counties WID No. 1 are not honored, yields for the same range of capacities vary from 4,798 to 15,619 acft/yr. The firm yield at the total storage capacity for the Smyth Crossing Reservoir (315,000 acft) is 7,507 acft/yr when storage rights for the Zavala-Dimmit Counties WID No. 1 are honored, and 8,072 acft/yr when they are not honored. These estimates of firm yield appear consistent with estimates of "average yield" reported by Freese, Nichols and Endress in 1964.

Figure 5.18-3 illustrates simulated Smyth Crossing Reservoir storage fluctuations for the 1934 to 1996 historical period, subject to diversion of the firm yield of 7,507 acft/yr, and honoring storage rights for the Zavala-Dimmit Counties WID No. 1. As depicted in the figure, the critical drought (drawdown) period for this reservoir is lengthy (16.5 years) in duration. Simulated reservoir storages remain above the Zone 2 trigger level (80 percent capacity) about 54 percent of the time and above the Zone 3 trigger level (50 percent capacity) about 73 percent of the time over the 1934 to 1996 historical period.

Table 5.18-1.
Daily Natural Streamflow Statistics for the Smyth Crossing Reservoir Site

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	49.95	23.87
February	47.06	23.90
March	43.89	23.94
April	46.59	21.97
May	53.61	29.65
June	57.17	26.33
July	56.64	26.87
August	53.81	21.69
September	51.90	24.00
October	64.57	26.35
November	61.79	23.97
December	55.59	21.86
Zone 3 Pass-Through Requirement[1] (acft/day)		17.14

[1] 7Q2 based on natural streamflows for the Nueces River at Uvalde (USGS #08192000) for the 1934 to 1996 historical period.

5.18.3 Implementation Issues

Implementation of Smyth Crossing Reservoir could directly affect the feasibility of other water supply options under consideration, including L-17a, L-17b, L-18a, L-18b, L-18c, SCTN-7a, SCTN-14a, SCTN-14b, and/or SCTN-18.

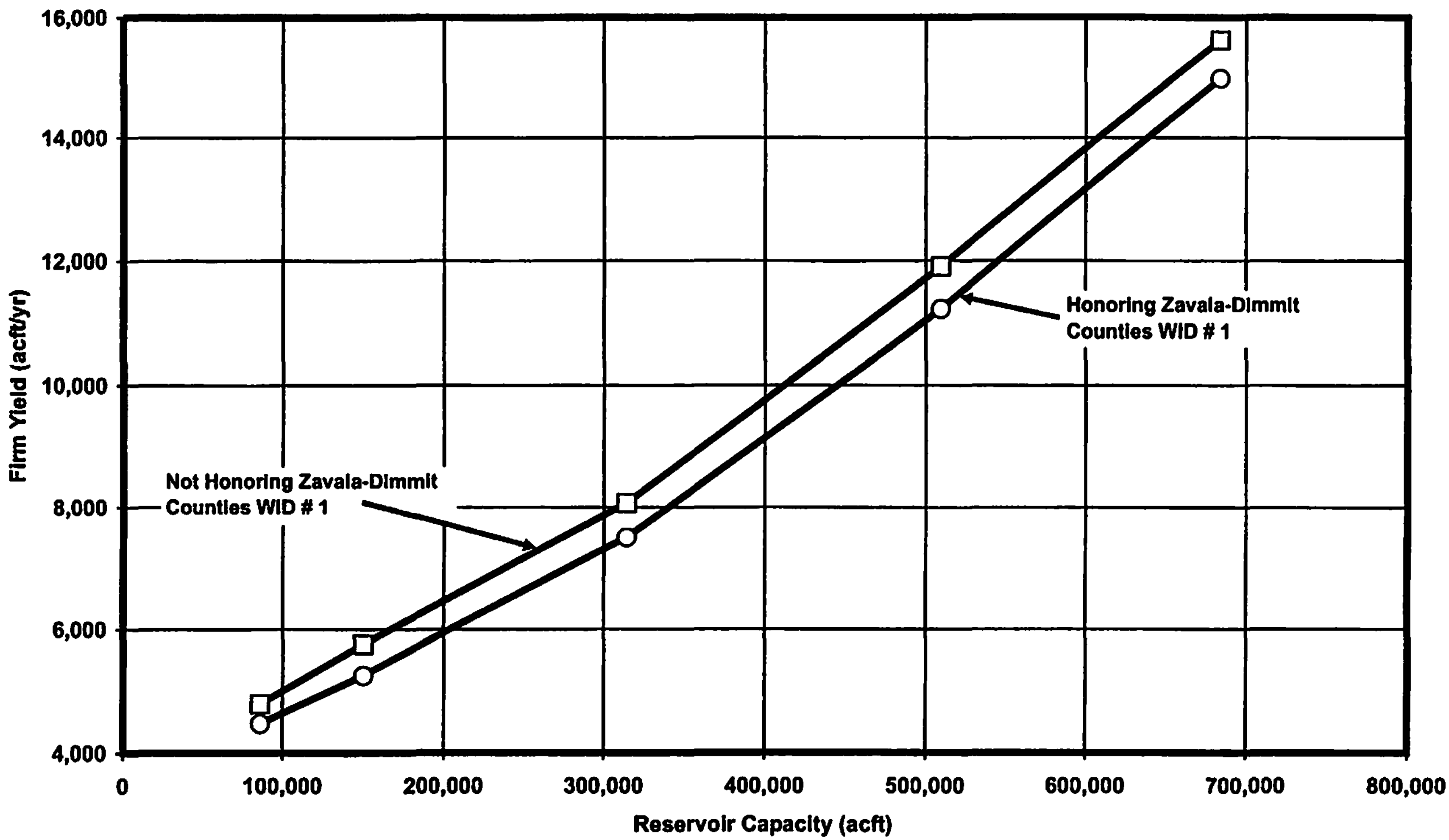
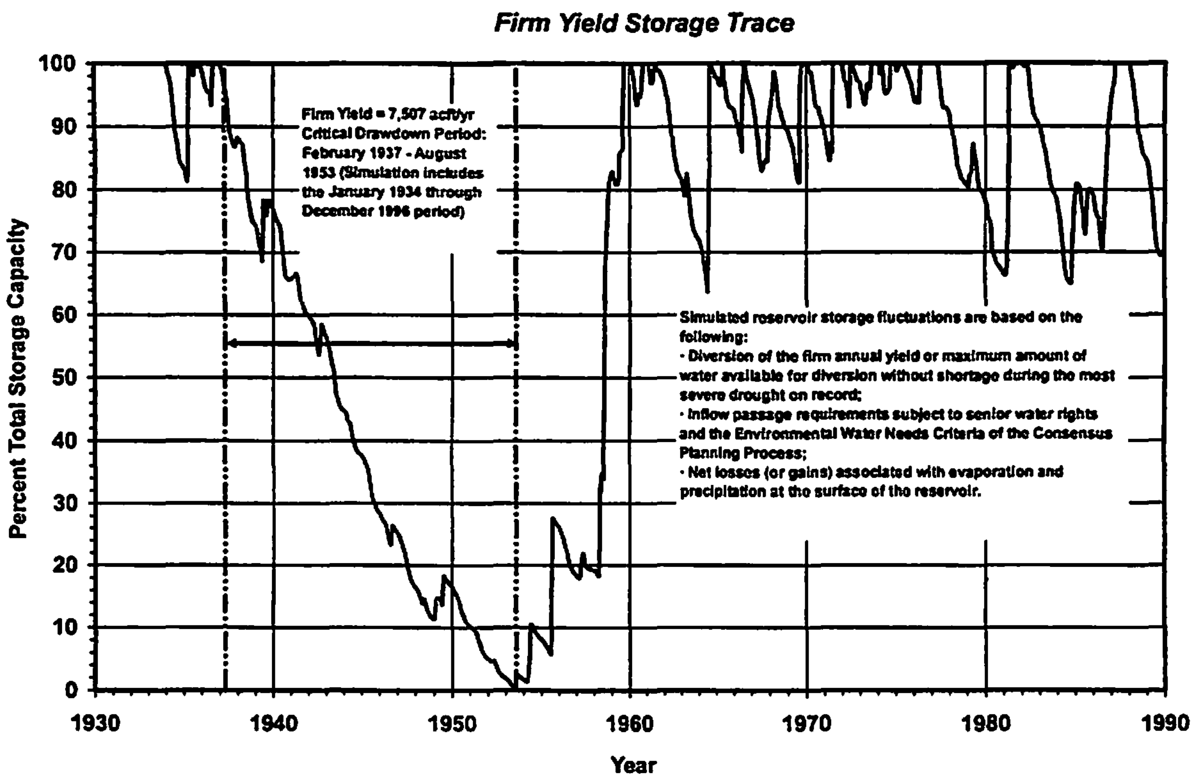


Figure 5.18-2. Nueces Reservoir above La Pryor (Smyth Crossing Site)



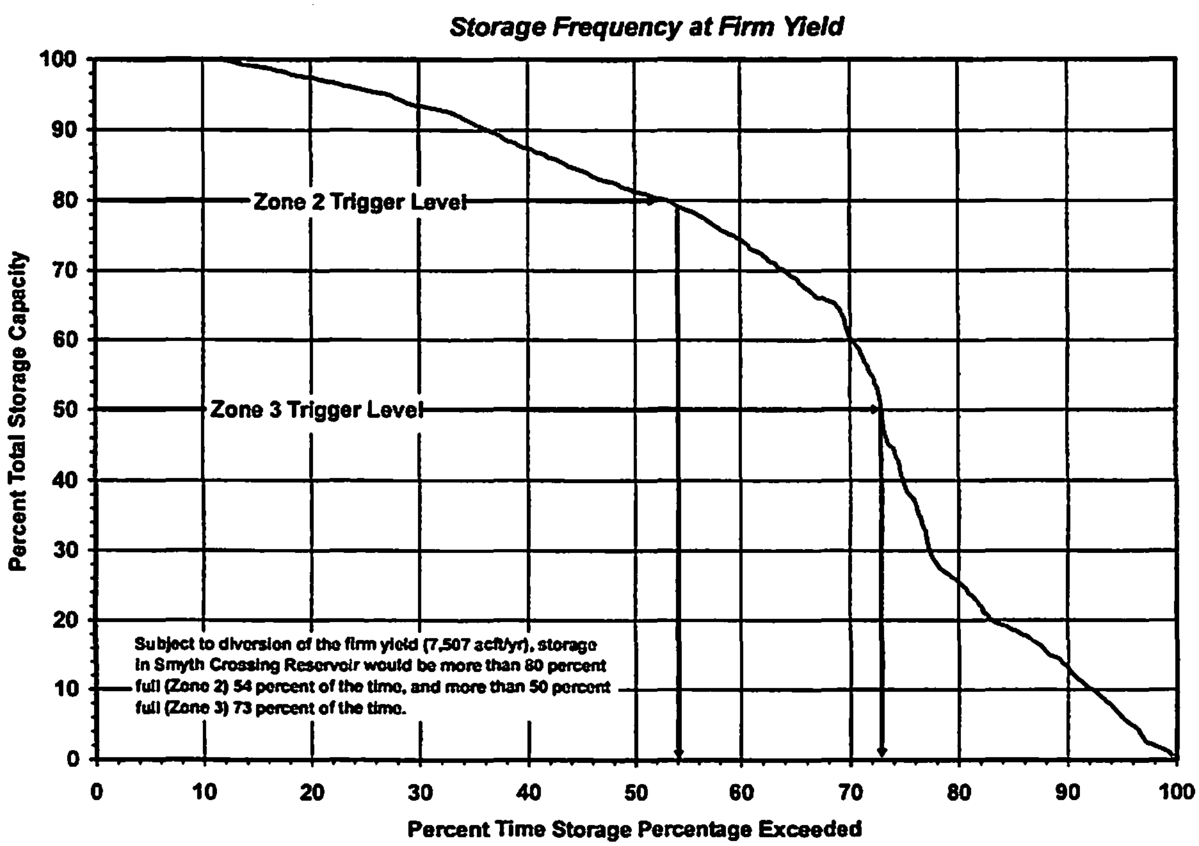
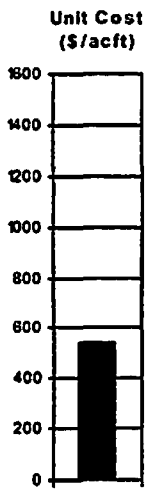
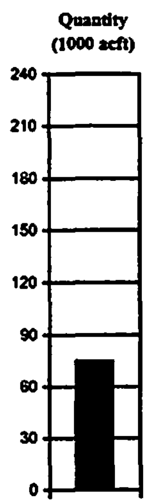
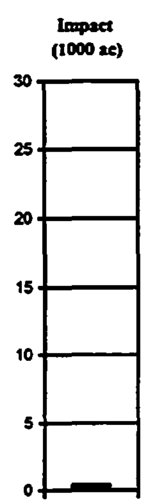


Figure 5.18-3. Nueces Reservoir/Smyth Crossing Site, Storage Considerations

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: CZ-10C

OPTION NAME: Carrizo-Wilcox Aquifer between San Marcos and Frio Rivers (75,000 acft/yr))

OPTION DESCRIPTION: *Under this option, the development of a 75,000 acft/yr supply of groundwater from the Carrizo-Wilcox Aquifer between southwestern Wilson County to a few miles southwest of the City of Gonzales in Gonzales County was evaluated for major municipal and industrial demands in the major municipal demand center of the South Central Texas Region. The assessment takes into account the development of groundwater from the aquifer in the area to meet local needs first, plus the Schertz-Seguin draft contract for a 20,000-acft/yr water supply from the same area. The evaluation included: (1) selecting a suitable area for large municipal well fields, (2) computing the water level drawdowns in the vicinity of the well field, (3) computing the effects on streamflow in the Guadalupe and San Antonio Rivers, and (4) estimating costs.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER	$590	per acft[1]	Treated Water Distributed
QUANTITY OF WATER:	75,000	acft/yr[2]	
LAND IMPACTED:	429	acres[3]	

POSITION RELATIVE TO ALL OPTIONS			
UNIT COST OF WATER:	of		(1=lowest unit)
QUANTITY OF WATER:	of		(1=highest volume)
LAND IMPACTED:	of		(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Land for groundwater rights and facilities, wells, pipelines, booster stations, and water treatment (Level 2) to remove excessive levels of iron and manganese,, and connection to regional water distribution system.

[2]**QUANTITY OF WATER:** The facilities would be designed to supply 75,000 acft/yr and the analyses show that this quantity would be available through 2050.

[3]**LAND IMPACTED:** Impacted land is related to wells, pipelines, pump stations, and water treatment plants and totals 429 acres. However, about 64,000 acres would need to be purchased or leased for groundwater rights.

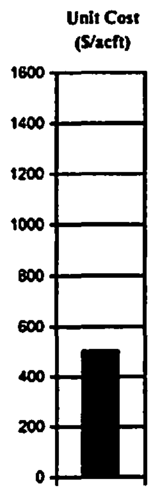
ENVIRONMENTAL ISSUES: Most of the concern relates to possible reduction of baseflow to streams.

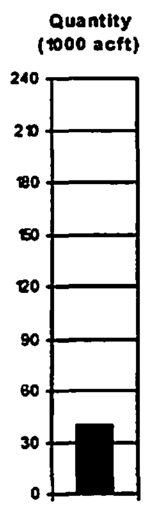
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing property or leases from landowners, and permits from local underground water conservation districts for groundwater rights, sufficient technical data, and determining the effect of long-term pumping of the aquifer.

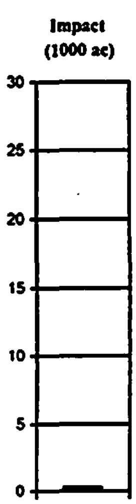
ADDITIONAL FACTORS: Competition with others for groundwater. Total pumpage may be in excess of effective recharge.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: CZ-10D and SCTN-1a.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: CZ-10C
OPTION NAME: Carrizo-Wilcox Aquifer between San Marcos and Frio Rivers (40,000 acft/yr))

OPTION DESCRIPTION: *Under this option, the development of a 40,000 acft/yr supply of groundwater from the Carrizo-Wilcox Aquifer between southwestern Wilson County to a few miles southwest of the City of Gonzales in Gonzales County was evaluated for municipal and industrial demands in the major municipal demand center of the South Central Texas Region. The assessment takes into account the development of groundwater from the aquifer in the area to meet local needs first, plus the Schertz-Seguin draft contract for a 20,000-acft/yr water supply from the same area. The evaluation included: (1) selecting a suitable area for municipal well fields, (2) computing the water level drawdowns in the vicinity of the well field, (3) computing the effects on streamflow in the Guadalupe and San Antonio Rivers, and (4) estimating costs.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	**$640**	**per acft[1]**	**Treated Water Distributed**
QUANTITY OF WATER:	**40,000**	**acft/yr[2]**	
LAND IMPACTED:	**302**	**acres[3]**	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Land for groundwater rights and facilities, wells, pipelines, booster stations, and water treatment (Level 2) to remove excessive levels of iron and manganese, and connection to regional water distribution systems.

[2]**QUANTITY OF WATER:** The facilities are designed to supply 40,000 acft/yr and the analyses show that this quantity would be available through 2050.

[3]**LAND IMPACTED:** The impacted land for wells, pipelines, pump stations, and a water treatment plant is about 302 acres. However, about 36,000 acres would need to be purchased or leased for groundwater rights.

ENVIRONMENTAL ISSUES: Most of the concern relates to possible reduction of baseflow to streams.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing property or leases from landowners, and permits from local underground water conservation districts for groundwater rights, sufficient technical data, and determining the effect of long-term pumping of the aquifer.

ADDITIONAL FACTORS: Competition with others for groundwater. Total pumpage may be in excess of effective recharge.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: CZ-10D and SCTN-1a.

6.1 Carrizo-Wilcox Aquifer between San Marcos and Frio Rivers (CZ-10C)

6.1.1 Description of Option

The Carrizo-Wilcox Aquifer is one of four major aquifers in the South Central Texas Water Planning Region. In the Wintergarden area, which is generally considered to be west of the Atascosa River, the aquifer has been extensively developed for many decades. East of the Atascosa River, the aquifer has had a moderate amount of development in Atascosa County and very limited development in Caldwell, Gonzales, Guadalupe, and Wilson Counties. Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply, except for elevated concentrations of iron and manganese in many areas.

The Evergreen Underground Water Conservation District (UWCD) includes Atascosa, Frio, Karnes, and Wilson Counties; the Gonzales County UWCD covers Gonzales County; the Wintergarden Groundwater Conservation District includes Dimmit, La Salle, and Zavala Counties; and the Live Oak UWCD covers Live Oak County. Each district has developed a water management plan and district rules and regulations that affect the export of groundwater.

Under this option, the development of a 40,000 and a 75,000 acft/yr supply of groundwater from the Carrizo-Wilcox Aquifer between the San Marcos and Frio Rivers (Figure 6.1-1) was evaluated for municipal and industrial demands in the major municipal demand center of the South Central Texas Region. The assessment takes into account the development of groundwater from the aquifer in the area to meet local needs first, plus the Schertz/Seguin draft contract for a 20,000-acft/yr water supply from the same area. The evaluation included: (1) selecting a suitable area for a large municipal well field, (2) computing the water level drawdowns in the vicinity of the well field, (3) computing the effects on streamflow in the Guadalupe and San Antonio Rivers, and (4) estimating costs.

6.1.2 Available Yield

A review of existing reports,[1,2,3] the extent of other groundwater users in the area, and hydrogeologic data indicate that a well field(s) could be developed in a section of the Carrizo-

[1] Klemt, W.B., et al., "Ground-Water Resources of the Carrizo Aquifer in the Winter Garden Area of Texas," Texas Water Development Board (TWDB) Report 210, Vols. 1 and 2, 1976.
[2] HDR Engineering, Inc. (HDR) and LBG-Guyton Associates (LBG), "Interaction Between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," TWDB, August 1998.
[3] Ryder, P.D. and Ardis, A.F., "Hydrology of the Texas Gulf Coast Aquifer System." U.S. Geological Survey Open-File Report 91-64, 1991.

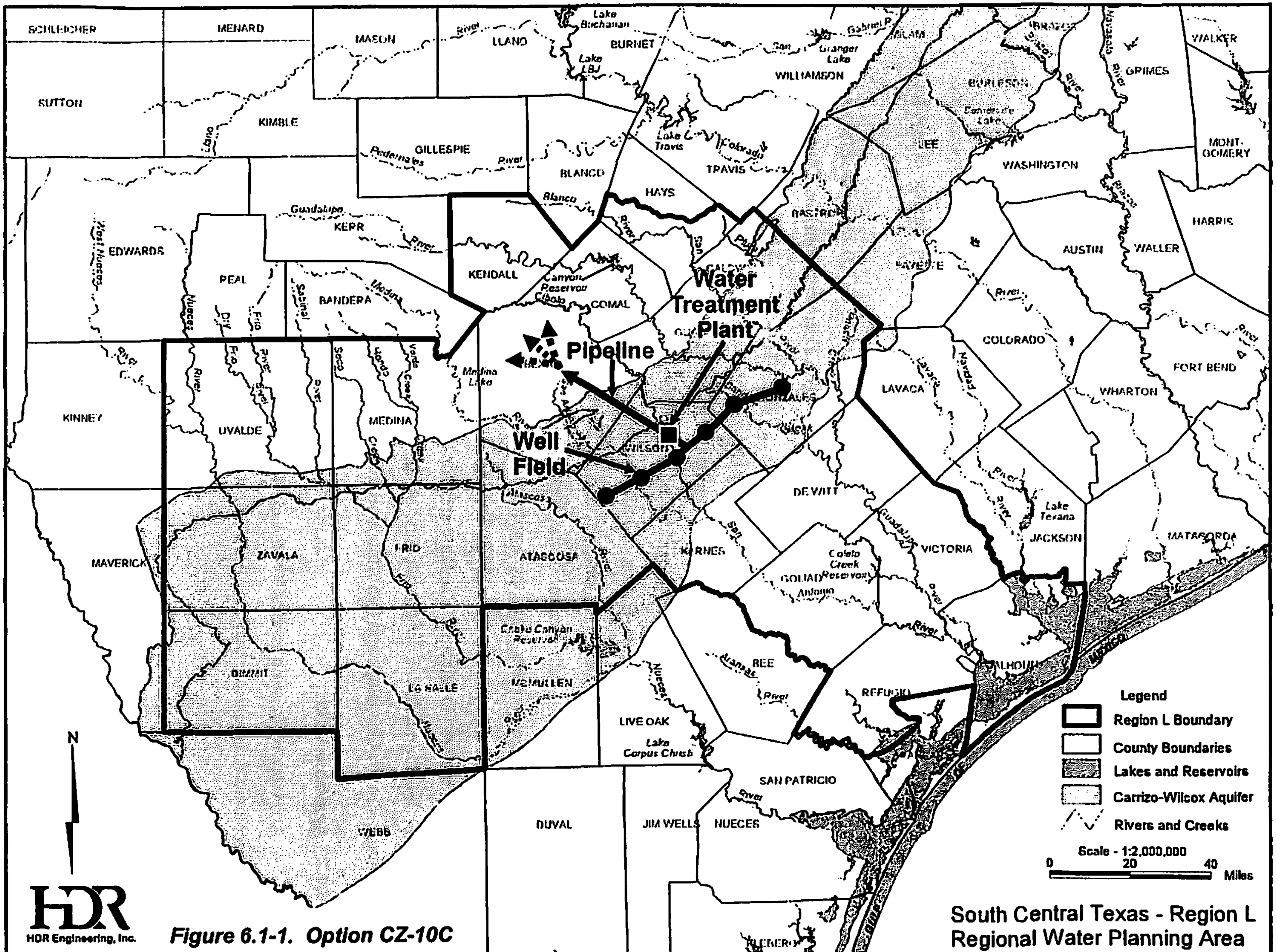


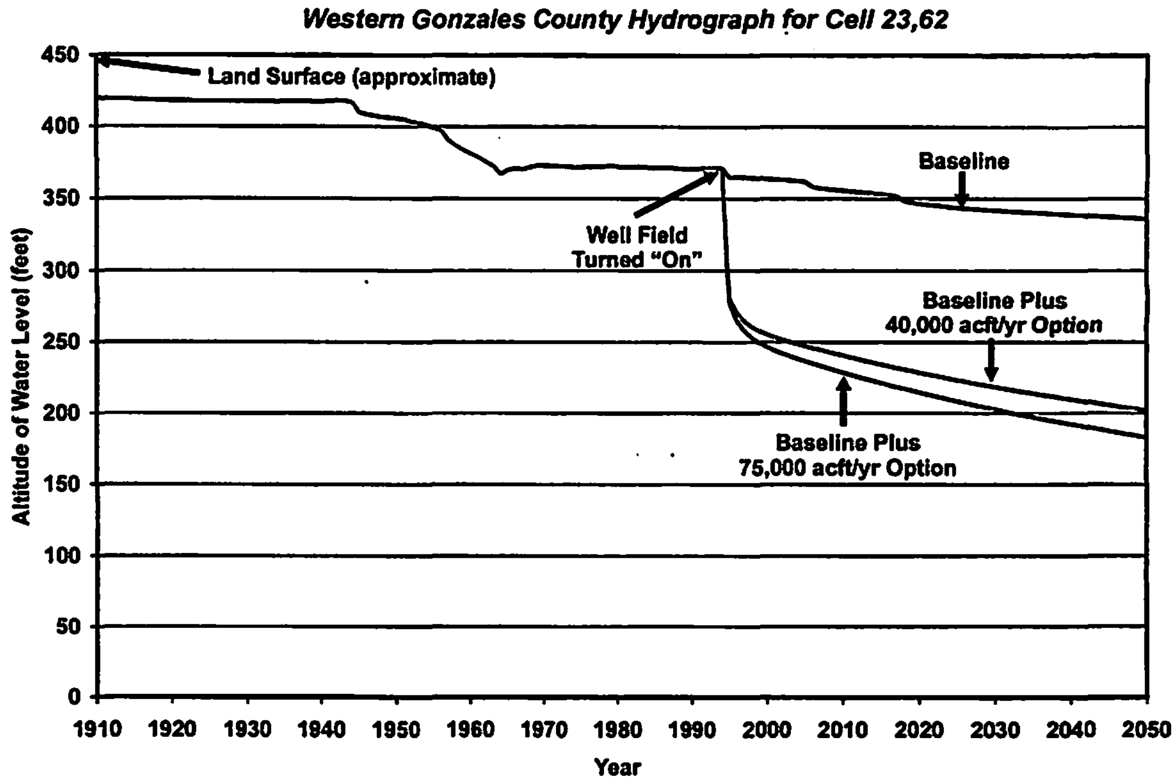
Figure 6.1-1. Option CZ-10C

Wilcox Aquifer that extends from southwestern Wilson County to a few miles southwest of the City of Gonzales in Gonzales County (Figure 6.1-1). This well field(s) would be separated at or "skip over" wells of the cities of Floresville and Stockdale. The projected needs of local entities and planned pumpages by Schertz and Seguin are included in the well field(s) being evaluated for this option.

Large capacity wells in the area typically produce 1,000 gallons per minute or more. With a contingency of 10 percent of the wells being out of service, the required number of wells would be 28 for the 40,000-acft/yr option and 52 for the 75,000-acft/yr option. Well spacings are planned to be about 1 mile.

To estimate the effects of the pumpage to meet projected local demands through 2050, planned pumpage by Schertz and Seguin, and Option CZ-10C pumpage (40,000 and 75,000 acft/yr), the "Interaction Between Groundwater and Surface Water in the Carrizo-Wilcox Aquifer" model was applied. The computer simulations indicate that pumpage to meet local needs to 2050 would result in water levels being drawn down between 30 and 40 feet in southwestern Gonzales and eastern Wilson Counties. With the additional pumpage of 20,000 acft/yr for Schertz/Seguin and 40,000 acft/yr for Option CZ-10C, water levels of the area would be drawn down an additional 120 feet for a total drawdown for local needs, Schertz/Seguin, and CZ-10C at 40,000 acft/yr of 150 to 160 feet. For the CZ-10C case of 75,000 acft/yr, water levels would be drawn down an additional 20 feet, for a drawdown of 170 to 180 feet when local, Schertz/Seguin, and CZ-10C (75,000 acft/yr) demands are considered. Southwest of the well field (Atascosa County), the drawdown would be about 120 feet and reflects the projected local Atascosa County pumpage, as well as the effect of the simulated pumpage in Wilson and Gonzales Counties.

To show the long-term change in water levels in the Carrizo Aquifer as a result of pumpage for historic conditions and CZ-10C options, water level hydrographs are shown for simulations from years 1910 to 2050 in Figure 6.1-2. Monitoring locations are cell 23,62 in western Gonzales County and cell 24,53 in west central Wilson County. These cell locations are in the well fields as outlined for this option. For the Gonzales County cell, the total drawdown from predeveloped conditions (1910) to end of the assessment (2050) is about 220 feet for the 40,000 acft/yr option and 245 feet for the 75,000 acft/yr option. The drawdowns are slightly less for the cell in Wilson County. For the Carrizo-Wilcox Aquifer, the TWDB calculated



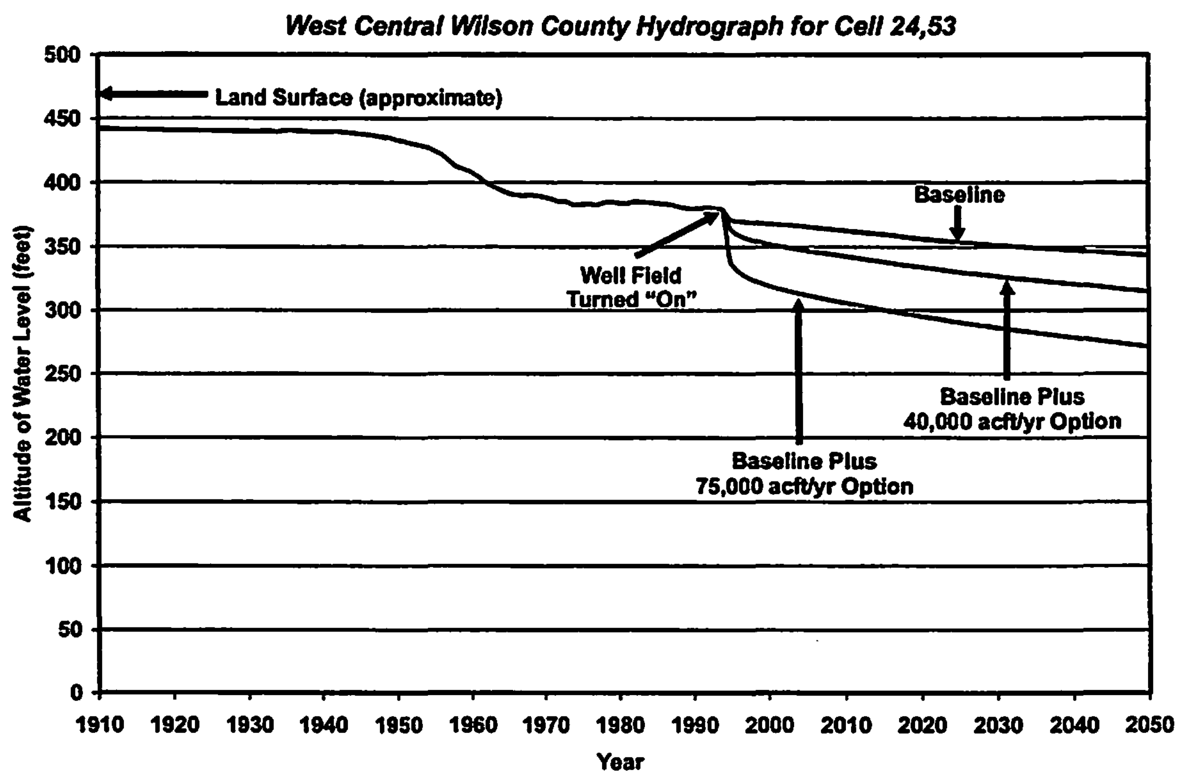


Figure 6.1-2. Hydrographs of Groundwater Levels

groundwater availability has two components, as follows. When water levels are less than 400 feet below land surface, groundwater availability is considered to be depletion from storage plus effective recharge. In Gonzales and Wilson Counties, the groundwater availability for the Carrizo-Wilcox Aquifer for both components is 47,033 and 43,391 acft/yr, respectively. For both projects, maximum depth of water levels below land surface is less than 400 feet in year 2050. As shown in Figure 6.1-2, the water levels are continuing to decline at a rate of about 1-foot per year in year 2050.

The combined effects of the development of groundwater under Option CZ-10C, the Schertz/Seguin plan, and local pumpage to meet projected local demands, are of importance at several locations on the Guadalupe and San Antonio Rivers. For comparative purposes, the streamflows at selected locations in the Guadalupe and San Antonio Rivers are computed by the Guadalupe-San Antonio River Basin Model (GSA Model)[4] for baseline and full development scenarios. The results are presented below.

As was done in previous studies,[5] to evaluate the impact of specified pumpage scenarios on surface water flows in the Guadalupe-San Antonio River Basin, changes in streamflows were extracted from the groundwater model runs and incorporated into the GSA River Basin Model based on comparison with historical streamflow. For this analysis, streamflows were compared at two locations: the San Antonio River at Falls City and the Guadalupe River at the Saltwater Barrier. As a baseline, the impacts due to expected local pumpage to meet local needs projected to 2050 on historical streamflows were computed and used as the baseline flow set for computing streamflow impacts due to additional pumpage scenarios.

As shown in Table 6.1-1, simulated average annual streamflows for the period of record simulated (1934 to 1989) on the San Antonio River at Falls city assuming baseline Carrizo-Wilcox Aquifer pumpage was computed to be 252,838 acft/yr. When the Schertz/Seguin pumpage of 20,000 acft/yr and the CZ-10C pumpage of 40,000 acft/yr are evaluated, average annual flows at Falls City would be reduced to 246,610 acft/yr (or a 2.5 percent reduction) (Table 6.1-1). Decreases in average annual flows during the historical drought of record (1947 to 1956) were computed to be 4,857 acft/yr (5.7 percent) with the additional (20,000 plus

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[4] HDR, "Guadalupe-San Antonio River Basin Model Modifications and Enhancements," Trans-Texas Water Program, West Central Study Area, Phase II, San Antonio River Authority, et al., March 1998.
[5] HDR and LBG, Op. Cit., August 1998.

Table 6.1-1
Impacts to Streamflow Due to Additional Carrizo-Wilcox Pumpage
20,000 acft/yr for Schertz/Seguin plus 40,000 acft/yr for CZ-10C

Stream Location	Average Annual Streamflow (1934 to 1989) in acft With Baseline 2050 Carrizo-Wilcox Pumpage[1]	With Additional 60,000 acft/year Pumpage[2]	Change	Percent Change
San Antonio River at Falls City	252,838	246,610	-6,228	-2.5%
Guadalupe River at SWB[3]	1,591,727	1,575,249	-16,478	-1.0%
	Drought Average Annual Streamflow (1947 to 1956) in acft			
San Antonio River at Falls City	85,675	80,818	-4,857	-5.7%
Guadalupe River at SWB[3]	507,563	496,796	-10,767	-2.1%

[1] Average Annual Streamflows assuming 2050 local pumpage were used as a baseline in order to access only the impacts attributable to the 20,000 acft/yr of Schertz/Seguin and the 40,000 acft/yr of additional pumpage (CZ-10C).
[2] Additional pumpage taken from a well field in Wilson, and Gonzales Counties (20,000 acft/yr plus 40,000 acft/yr.)
[3] Does not include ungaged runoff to the estuary below the Saltwater Barrier.

40,000 acft/yr) Carrizo-Wilcox pumpage. Likewise, the simulated annual average streamflows at the Saltwater Barrier under baseline Carrizo-Wilcox Aquifer pumpage were computed to be 1,591,727 acft/yr and would be reduced to 1,575,249 acft/yr (or a 1.0 percent reduction) with additional 60,000 acft/yr pumpage of the aquifer (Table 6.1-1). Average annual flows during the historical drought of record (1947 to 1956) at the Saltwater Barrier would be reduced by 10,767 acft/yr (2.1 percent) with the additional pumpage (Table 6.1-1).

Figure 6.1-3 shows the impact of the additional 60,000 acft/yr (20,000 plus 40,000) pumpage on median monthly streamflows and streamflow frequencies at the two streamflow locations analyzed. The changes in monthly median streamflows for the San Antonio River at Falls City range from a minimum impact of 275 acft in January to a maximum of 717 acft in November. On an annual basis, annual median streamflows at Falls City would be reduced by 2.9 percent (5,667 acft/yr). Similarly, for the Guadalupe River at the Saltwater Barrier, the minimum impact to median monthly streamflows was computed to be 969 acft in September and the maximum impact was 1,953 acft in December. On an annual basis, median streamflows at the Saltwater Barrier were reduced by 1.2 percent (16,699 acft/yr).

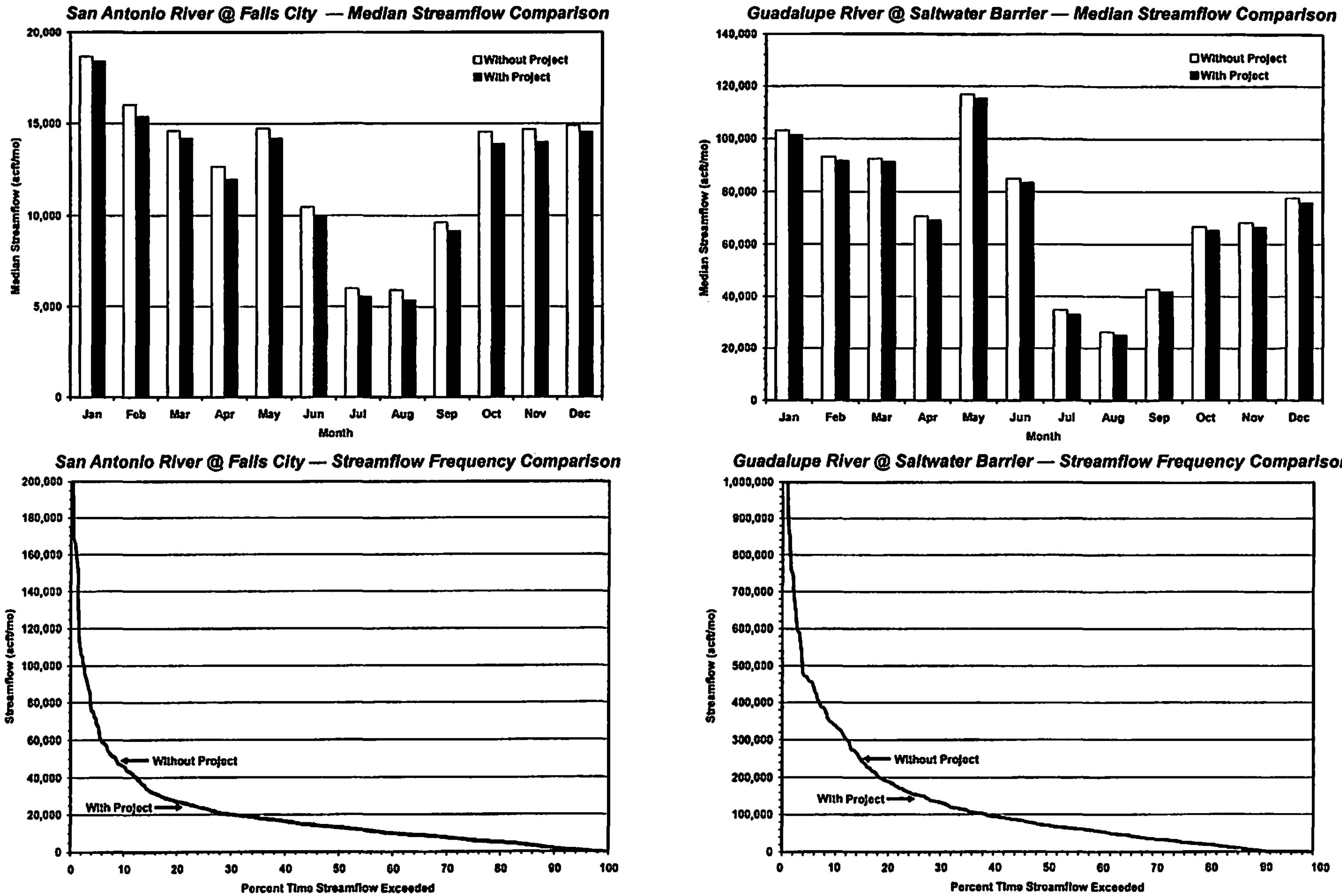


Figure 6.1-3. Changes in Streamflow for 40,000 acft/yr Option

Table 6.1-2 shows the impacts of additional pumpage of 95,000 acft/yr (20,000 plus 75,000) from the Carrizo-Wilcox Aquifer on average annual flows at Falls City (1934 to 1989). Under this pumpage scenario, average annual flows at Falls City would be reduced to 235,203 acft/yr, or a 7.0 percent reduction (Table 6.1-2). Decreases in average annual flows during the historical drought of record (1947 to 1956) were computed to be 14,225 acft/yr (16.6 percent) with the additional 95,000 acft/yr of Carrizo-Wilcox pumpage (Table 6.1-2). The simulated annual average streamflows at the Saltwater Barrier under this additional Carrizo-Wilcox Aquifer pumpage scenario were computed to be 1,565,848 acft/yr, or a 1.6-percent reduction over baseline flows (Table 6.1-2). Average annual flows during the historical drought of record (1947 to 1956) at the Saltwater Barrier would be reduced by 17,233 acft/yr (3.4 percent) with the additional pumpage. (Table 6.1-2)

Table 6.1-2
Impacts to Streamflow Due to Additional Carrizo-Wilcox Pumpage
20,000 acft/yr for Schertz/Seguin and 75,000 acft/yr for CZ-10C

Stream Location	Average Annual Streamflow (1934 to 1989) in acft			
	With Baseline 2050 Carrizo-Wilcox Pumpage[1]	With Additional 95,000 acft/year Pumpage[2]	Change	Percent Change
San Antonio River at Falls City	252,838	235,203	-17,635	-7.0%
Guadalupe River at SWB[3]	1,591,727	1,565,848	-25,879	-1.6%
	Drought Average Annual Streamflow (1947 to 1956) in acft			
San Antonio River at Falls City	85,675	71,450	-14,225	-16.6%
Guadalupe River at SWB[3]	507,563	490,330	-17,233	-3.4%

[1] Average Annual Streamflows assuming 2050 local pumpage were used as a baseline in order to access only the impacts attributable to the 20,000 acft/yr of Schertz/Seguin and the 75,000 acft/yr of additional pumpage (CZ-10C).
[2] Additional pumpage taken from a well field in Wilson and Gonzales Counties (20,000 acft/yr plus 75,000 acft/yr.)
[3] Does not include ungaged runoff to the estuary below the Saltwater Barrier.

Figure 6.1-4 shows the impact of the additional 95,000 acft/yr (20,000 plus 75,000) pumpage on median monthly streamflows and streamflow frequencies at the two streamflow locations analyzed. The changes in monthly median streamflows for the San Antonio River at Falls City range from a minimum impact of 976 acft in September to a maximum of 1,964 acft in November. On an annual basis, annual median streamflows at Falls City would be reduced by 8.5 percent (16,611 acft/yr) (Figure 6.1-4). Similarly, for the Guadalupe River at the Saltwater

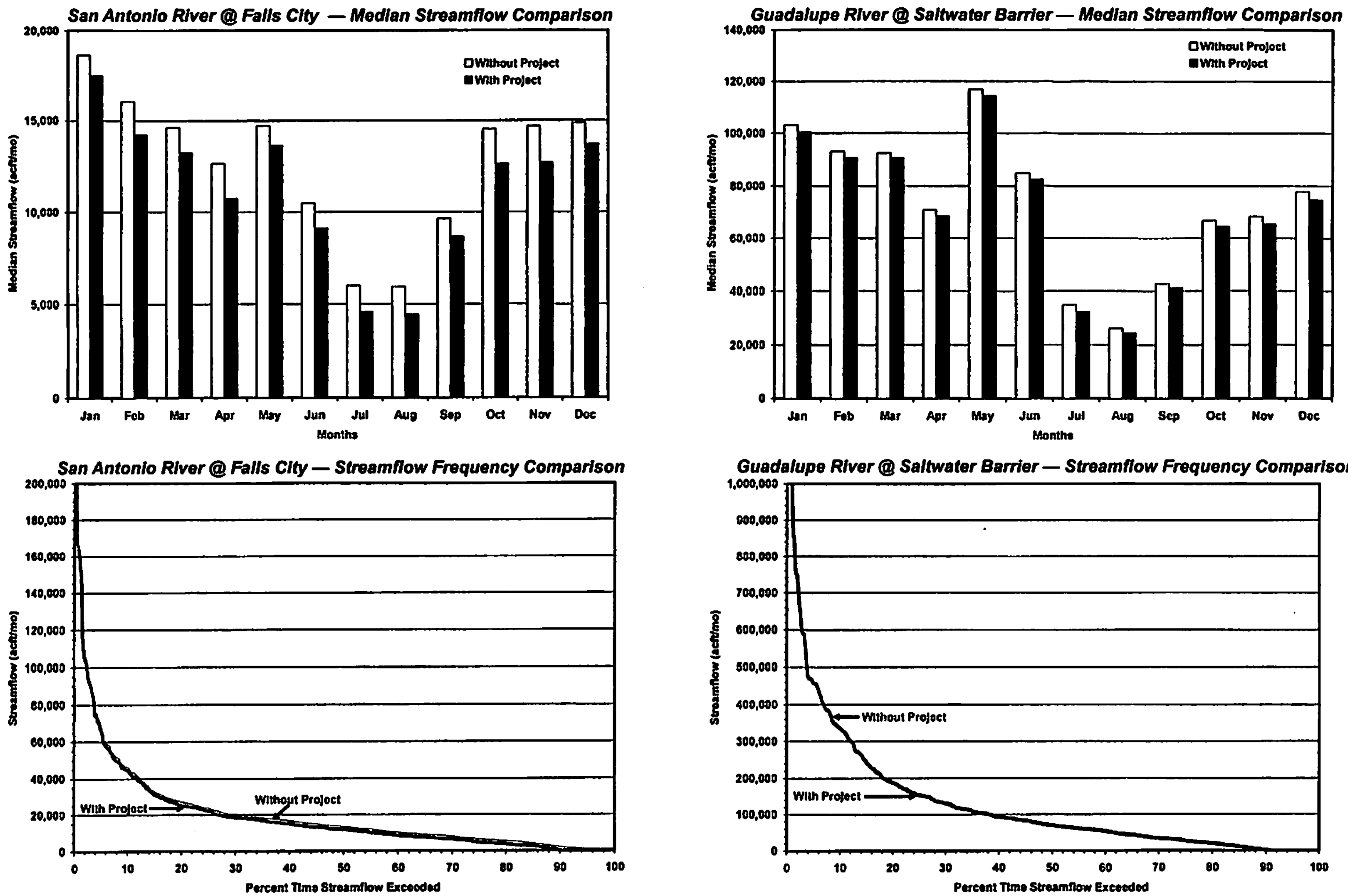


Figure 6.1-4. Changes in Streamflow for 75,000 acft/yr Option

Barrier, the minimum impact to median monthly streamflows was computed to be 1,625 acft in September and the maximum impact was 3,102 acft in December. On an annual basis, median streamflows at the Saltwater Barrier would be reduced by 1.9 percent (26,436 acft/yr) (Figure 6.1-4).

6.1.3 Environmental Issues

The Carrizo-Wilcox Aquifer encompasses several formations of hydrologically connected cross-bedded sands interspersed with clay, sandstone, silt, and lignites (Wilcox Group) and overlying massive sands of the Carrizo formation. These formations outcrop in a southwest-northeast trending crescent near the inland margin of the Gulf Coastal Plain (Figure 6.1-1), and dip downward toward the coast. Aquifer recharge occurs over the general surface of the outcrop area.[6] The thickness of the Carrizo in the downdip artesian areas at the study site ranges from about 400 feet in Gonzales and Caldwell Counties to more than 1,000 feet in Atascosa County. The maximum thickness of the Carrizo Aquifer in this area is about 2,500 feet.

The project area for CZ-10C extends from southwestern Wilson County northeast to Gonzales County. It consists of all or parts of Wilson, Bexar and Gonzales Counties. The larger municipalities of the study area are: Floresville, Stockdale, Nixon and Gonzales. The project area includes land in the Blackland Prairies vegetational area in the northeast, and the south Texas Plains vegetational area in the south. The Blackland Prairies soils are fairly uniform, dark-colored calcareous clays interspersed with some gray acid sandy loams. Most of this fertile area has been cultivated, although a few native hay meadows and ranches remain. Little bluestem is the dominant grass of the native assemblage with other important grasses present including big bluestem, Indian grass, switchgrass, tall dropseed, silver bluestem and Texas wintergrass. Under heavy grazing, buffalo grass, Texas grama, smutgrass and many annuals increase or invade native pastures. Mesquite, post oak and blackjack oak also invade or increase under these conditions.

The South Texas Plains is dissected by streams flowing into the Rio Grande and the Gulf of Mexico. Soils in this area range from clays to sandy loams, and vary in reaction from very

[6] LBG, "Phase I Evaluation Carrizo-Wilcox Aquifer West-Central Study Area Trans-Texas Water Program," prepared for HDR Engineering, Inc., Austin, Texas, 1994.

basic to slightly acid. This wide range of soil types is responsible for great differences in soil drainage and moisture holding capacities within this region.[7,8] Wetlands in the project area consist of riverine habitats of Cibolo Creek, the San Antonio and Guadalupe Rivers and their tributaries, as well as associated palustrine habitats which are generally composed of narrow bands of wetlands along these watercourses.

Vertebrate fauna typifying these regions include the opossum, raccoon, weasel, skunk, white-tailed deer, and bobcat. The coyote and javelina are found mainly in brush/shrub areas and the red and gray fox in woodlands.[9] A wide variety of species of amphibians, reptiles and birds are also found throughout the region.[10,11]

The 70-mile well field/pipeline and the 25-mile transfer pipeline and water treatment plant in CZ-10C (Figure 6.1-1) would encompass approximately 1,762 acres. Cropland, together with shrub and brushland dominate the landscapes in which this option would lie.

The potential environmental effects resulting from the construction and operation of well pads and water transport pipelines depend to a large extent on the exact placement of the construction corridor. In general, habitats critical to the survival of important and protected species are locally restricted so that adverse impacts can often be avoided or minimized by site and alignment selection. More generally distributed habitats, although perhaps important to regional wildlife populations in some areas, may not be so easy to avoid, but the limited area affected by these corridors allows for insignificant impacts.

Plant and animal species listed by the U.S. Fish and Wildlife Service (USFWS) and Texas Parks and Wildlife Department (TPWD) as endangered or threatened in the project area, and those with candidate status for listing are presented in Table 6.1-3. Because this option would extend through two ecoregions in three counties, all the species listed in Table 6.1-3 have habitat requirements or preferences that suggest they could be present within the project area.

[7] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1962
[8] McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas," Texas Parks and Wildlife Department, Austin, Texas, 1984.
[9] Jones, K.J., et al., "Annotated Checklist of Recent Land Mammals of Texas," Occasional Papers, The Museum, Texas Tech University No. 119. May 1988
[10] McMahan, C.A., R.G. Frye, K.L. Brown, Op. Cit., 1984.
[11] Jones, K.J., et al, May 1988, "Annotated Checklist of Recent Land Mammals of Texas," Occasional Papers, the Museum, Texas Tech. Univ. No. 119.

Table 6.1-3.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Carrizo-Wilcox Aquifer between San Marcos and Frio Rivers (CZ-10C)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS[1]	TPWD[1]	TOES[2,3]	Potential Occurrence in County
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T		Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C			Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau				Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau				Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks				Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer				Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT			Nesting/Migrant

Table 6.1-3 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies				Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations				Resident
Siren, Lesser, Rio Grande	*Siren intermedia texana*	Wet or temporarily wet areas, arroyos, canals, ditches and shallow depressions; requires moisture to remain		E	E	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear				Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures				Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
5 Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

Surveys for protected species or other biological resources of restricted distribution, or other importance, would need to be conducted within the proposed construction corridors where preliminary studies have indicated that habitat may be present.

The primary impacts that would result from construction and operation of Option CZ-10C include temporary disturbance to soils and habitat during construction of wells, pipelines and other facilities; permanent conversion of existing habitats or land uses to maintained pipeline rights-of-way; disturbance of minor acreages for construction of water treatment plants, storage stations and well injection fields and mixing of treated aquifer water with waters of the Edwards Aquifer, if this water is to be used to recharge the Edwards Aquifer. Indirect effects of construction may include mitigation areas converted to alternate uses to compensate for losses of terrestrial habitat.

The Texas Texas Boilogical and Conservation Data System maintained by TPWD Wildlife Diversity Branch maps several plant species of concern directly on the pipeline route for CZ-10C: Elmendorf's onion (*Allium elmendorfii*), Big Red Sage (*Salvia penstemonoides*), and Parks' jointweed (*Polygonella parksii*). Both Elmendorf's onion and Parks' jointweed are found in deep sands. The Big Red Sage usually grows along creek beds and seepage slopes of limestone canyons.

Because there are no known metazoan inhabitants present, withdrawing water from the Carrizo Aquifer would not impact an endemic fauna. These withdrawals may, however, lower the water table to some extent in the outcrop area, potentially affecting the water budgets of streams and ponds in the area (Section 6.1.2). Northeast of Atascosa County, the Carrizo Aquifer appears to be full and is discharging water to streams and rivers that cross the outcrop. It is expected that the proposed well field would lower water levels in outcrop areas and thereby additional storage space would be created in the aquifer, increasing infiltration of surface-water runoff[12]. As a result, it is expected that the base flows of streams crossing the recharge zone would be reduced, and that channel losses could increase on the outcrop. The rates of water loss from permanent ephemeral ponds could also increase. Because of limited groundwater storage capacity, the potential for significant losses of stream baseflow is probably not a major concern. Enhancement of seepage losses, however, may prove to be of more concern.

[12] Ibid.

Lowering the Carrizo Aquifer water table could possibly impact Houston toad habitat and the Texas garter snake, timber/canebrake rattlesnake, black-spotted newt, lesser siren and bracted twistflower populations, since the species inhabit wet areas in the project area (Table 6.1-3).

The transfer of Carrizo-Wilcox water could adversely affect two protected fish species within the Edwards Aquifer if the Carrizo water is used to recharge the Edwards Aquifer. The toothless blindcat (*Trogloglanis pattersoni*) and widemouth blindcat (*Satan eurystomus*) both inhabit the aquifer under the city of San Antonio. Both of these threatened species may incur negative impacts if the water quality of the aquifer is not maintained.

The endangered golden-cheeked warbler (*Dendroica chrysoparia*) and black-capped vireo (*Vireo atricapillus*) may have habitat within the study area. The golden-cheeked warbler inhabits mature oak-Ashe juniper woods for nesting. It requires strips of Ashe juniper bark for nest material. The black-capped vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories.

It should be noted that the range of the golden-cheeked warbler and black-capped vireo only extend into Bexar County and not the other counties in this project area, while the two fishes mentioned above are endemic to the Edwards Aquifer. These species and others in Table 6.1-3, which are endemic to the Edwards Plateau region, would only be affected by the delivery pipeline of CZ-10C and not the well field.

Construction in brush/shrub habitat and maintenance activities would potentially impact populations of the Texas tortoise, Texas horned lizard, indigo snake, spot-tailed earless lizard, plains spotted skunk, jaguarundi, and ocelot. Since over half of the proposed well field corridor in Option CZ-10C consists of cropland, wildlife habitats tend to be small and fragmented, and may be disproportionately valuable to regional wildlife populations. Construction impact can generally be minimized or avoided, however, by locating project features in less sensitive cropland, pasture or upland woodland whenever possible. Construction across rivers and streams should be minimized, as riparian zones support wetlands and are valuable to wildlife. Mitigation may be required for impacts associated with the pump stations, water treatment plant, and pipelines identified for CZ-10C, and injection wells, and recharge structures, if any, if sensitive ecological or cultural resources are identified in the plan formulation phase of this study.

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 (PL 96-515), and the Archaeological and Historic Preservation Act (PL 93-291). All areas to be disturbed during construction would need to be surveyed by qualified professionals for the presence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided.

6.1.4 Engineering and Costing

For the 75,000 acft/yr scenario, groundwater would be developed by constructing wells along a line that extends from southwestern Wilson County to a few miles southwest of the City of Gonzales in Gonzales County, except for gaps for the cities of Floresville and Stockdale. (Figure 6.1-1). The well field for the 40,000 acft/yr scenario would be shortened by eliminating some of the wells at each end of the line. The wells would be connected by a collector pipeline, with pump station(s), a water treatment plant, and terminal storage near the center of the well field (Figure 6.1-1). The water would be treated for high iron and manganese concentrations and pumped through a pipeline to the major municipal demand center in the South Central Texas Region. The major facilities required for these options are:

- Water Collection and Conveyance System
  - Wells
  - Pipelines
  - Pump Station
  - Transmission System
- Storage
- Pipeline
- Pump Stations
- Water Treatment Plant (Iron and Manganese removal)

The approximate locations of these facilities were shown earlier in Figure 6.1-1.

Cost estimates were computed for capital and project expenses, annual debt service, operation and maintenance, power, land, and environmental mitigation. These costs are summarized in Tables 6.1-4 and 6.1-5 for the 40,000 and 75,000 acft/yr options, respectively. Because of the uncertainty in the acquisition of groundwater rights, estimates are based on land purchases to meet groundwater development requirements of the Evergreen and Gonzales underground water conservation districts. The annual costs, including debt service for a 30-year loan at 6 percent interest and operation and maintenance costs, including power, is estimated to

Table 6.1-4.
Cost Estimate Summary
Option CZ-10C — 40,000 acft/yr Scenario
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Well Costs (150 HP to 250 HP)	$15,147,000
Pipeline (12", 18", 24", 30", 36", 42", 48", & 54"; 422,000' total)	44,994,000
Transmission Pump Station (3,800 HP)	5,497,000
Water Treatment Plant (38 MGD) (Iron and Manganese Removal)	14,207,000
Distribution	48,944,000
Total Capital Cost	**$128,789,000**
Engineering, Legal Costs and Contingencies (32% of capital costs)	$42,826,000
Environmental & Archaeology Studies and Mitigation	2,125,000
Land Acquisition and Surveying (36,302 acres) ($1,120/acre)	40,673,000
Interest During Construction (4 years)	34,307,000
Total Project Cost	**$248,720,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$18,069,000
Operation and Maintenance:	
Wells, Pipeline, Transmission Pump Station	723,000
Water Treatment Plant	2,725,000
Pumping Energy Costs (49,616,667kWh @ $0.06 per kWh)	2,977,000
Water Export Fee - Wilson County 20,000 acft ($0.17 per 1,000 gallons)	1,108,000
Total Annual Cost	**$25,602,000**
Available Project Yield (acft/yr)	**40,000**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$640**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$1.96**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

be $640 and $590 per acft/yr for the 40,000 and 75,000 acft/yr scenarios, respectively (Tables 6.1-4 and 6.1-5).

Table 6.1-5.
Cost Estimate Summary
Option CZ-10C — 75,000 acft/yr Scenario
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Well Costs (150 HP to 250 HP)	$29,807,000
Pipeline (12", 18", 24", 30", 36", 42", 48", 54" and 64"; 422,000' total)	70,675,000
Transmission Pump Station (8,800 HP)	8,298,000
Water Treatment Plant (71 MGD) (Iron and Manganese Removal)	22,334,000
Distribution	80,318,000
Total Capital Cost	**$211,432,000**
Engineering, Legal Costs and Contingencies (32% of capital costs)	$70,467,000
Environmental & Archaeology Studies and Mitigation	3,215,000
Land Acquisition and Surveying (64,429 acres) ($1,106/acre)	71,296,000
Interest During Construction (4 years)	57,026,000
Total Project Cost	**$413,436,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$30,036,000
Operation and Maintenance:	
Wells, Pipeline, Transmission Pump Station	1,188,000
Water Treatment Plant	4,467,000
Pumping Energy Costs (912,666,667 kWh @ $0.06 per kWh)	5,476,000
Water Export Fee - Wilson County 55,000 acft ($0.17 per 1,000 gallons)	3,047,000
Total Annual Cost	**$44,214,000**
Available Project Yield (acft/yr)	**75,000**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$590**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$1.81**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

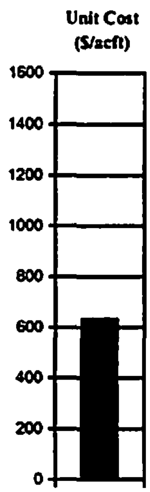
6.1.5 Implementation Issues

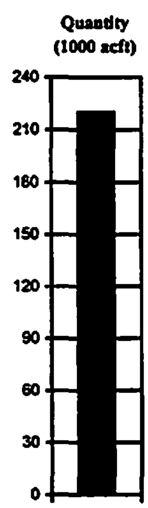
Implementation of Carrizo-Wilcox Aquifer between San Marcos and Frio Rivers option could directly affect the feasibility of other water supply options under consideration, including CZ-10D and/or SCTN-1a.

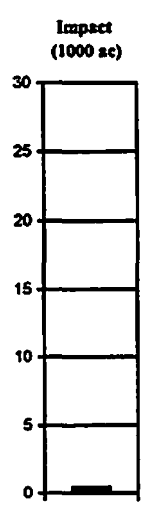
The development of groundwater in the Carrizo-Wilcox Aquifer in Wilson and Gonzales Counties for the South Texas Water Planning Region must address several issues. Major issues include:

- Detailed feasibility evaluation, including test drilling and aquifer and water quality testing of prospective well fields, followed with more detailed groundwater modeling to confirm results of this preliminary evaluation.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Competition with others for groundwater in the area.
- Regulations by the Evergreen and Gonzales County UWCDs, including the renewal of pumping permits at 5-year intervals in the Evergreen district.
- Water levels did not stabilize during the computer simulation of pumping for a period of 50 years, thereby indicating that the simulated withdrawals may be in excess of the effective recharge rates.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **CZ-10D**

OPTION NAME: **Carrizo-Wilcox Aquifer between Colorado and Frio Rivers**

OPTION DESCRIPTION: *Under this option, the development of a 220,000 acft/yr supply of groundwater from the Carrizo-Wilcox Aquifer between the Colorado River in Bastrop County to the Frio River in Frio County was evaluated for municipal and industrial demands in the major municipal demand center of the South Central Texas Region. The assessment takes into account the development of groundwater from the aquifer in the area to meet local needs first, plus the 20,000 acft/yr of the Schertz/Seguin plan. The evaluation includes: (1) selecting a suitable area for large municipal well fields, (2) computing the water level drawdowns in the vicinity of the well field, (3) computing the effects on streamflow in the Guadalupe and San Antonio Rivers, and (4) estimating costs.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yr. ☐ 5-15 yr. ☐ > 15yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	$632	per acft[1]
QUANTITY OF WATER:	220,000	acft/yr[2]
LAND IMPACTED:	1,437	acres[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Land for groundwater rights, facilities, wells, pipelines, booster stations, and water treatment (Level 2) to remove excessive levels of iron and manganese, and connection to regional water distribution systems.

[2]**QUANTITY OF WATER:** The facilities are designed to supply 220,000 acft/yr, and the analyses show that this quantity would be available through 2050.

[3]**LAND IMPACTED:** About 1,437 acres of land would be needed for wells, pipelines, pump stations, and water treatment plants. However, about 131,000 acres would need to be purchased or leased for groundwater rights.

ENVIRONMENTAL ISSUES: Most of the concern relates to possible reduction of baseflow to streams.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing property or leases from landowners, and permits from local underground water conservation districts for groundwater rights, sufficient technical data, and determining the effect of long-term pumping of the aquifer.

ADDITIONAL FACTORS: Competition with others for groundwater. Total pumpage may be in excess of effective recharge.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-21, CZ-10C, and/or SCTN-1a.

6.2 Carrizo-Wilcox Aquifer between Colorado and Frio Rivers (CZ-10D)

6.2.1 Description of Option

The Carrizo-Wilcox Aquifer is one of four major aquifers in the South Central Texas Water Planning Region. In the Wintergarden area, which is generally considered to be west of the Atascosa-Frio county line, the aquifer has been extensively developed for many decades. Between this county line and the Colorado River, the aquifer has had limited development in Atascosa County and very limited development in Bastrop, Caldwell, Gonzales, Guadalupe, and Wilson Counties. Overall, the water quality of the Carrizo-Wilcox Aquifer is suitable for use as a water supply except for elevated concentrations of iron and manganese in many areas.

The Evergreen UWCD includes Atascosa, Frio, Karnes, and Wilson Counties, the Gonzales County UWCD includes Gonzales County, the Wintergarden Groundwater Conservation District includes Dimmit, La Salle, and Zavala Counties, and Live Oak UWCD covers Live Oak County. Each district has developed a water management plan and district rules and regulations that affect the export of groundwater. The Lost Pines Groundwater Conservation District, which covers Bastrop County, was created in the 76th Texas Legislature, but requires ratification or authorization in the next legislative session before becoming permanent. Regulations on the export of groundwater from the new district have not been established.

Under this option, the development of a 220,000 acft/yr supply of groundwater from the Carrizo-Wilcox Aquifer between the Frio and Colorado Rivers (Figure 6.2-1) was evaluated for municipal and industrial demands in the major municipal demand center of the South Central Texas Region. The assessment takes into account the projected local demands plus the 20,000 acft/yr demands of the Schertz/Seguin plan. The evaluation included: (1) selecting a suitable area for large municipal well fields, (2) computing the water level drawdowns in the vicinity of the well fields, (3) computing the effects on streamflow in the Guadalupe and San Antonio Rivers, and (4) estimating costs.

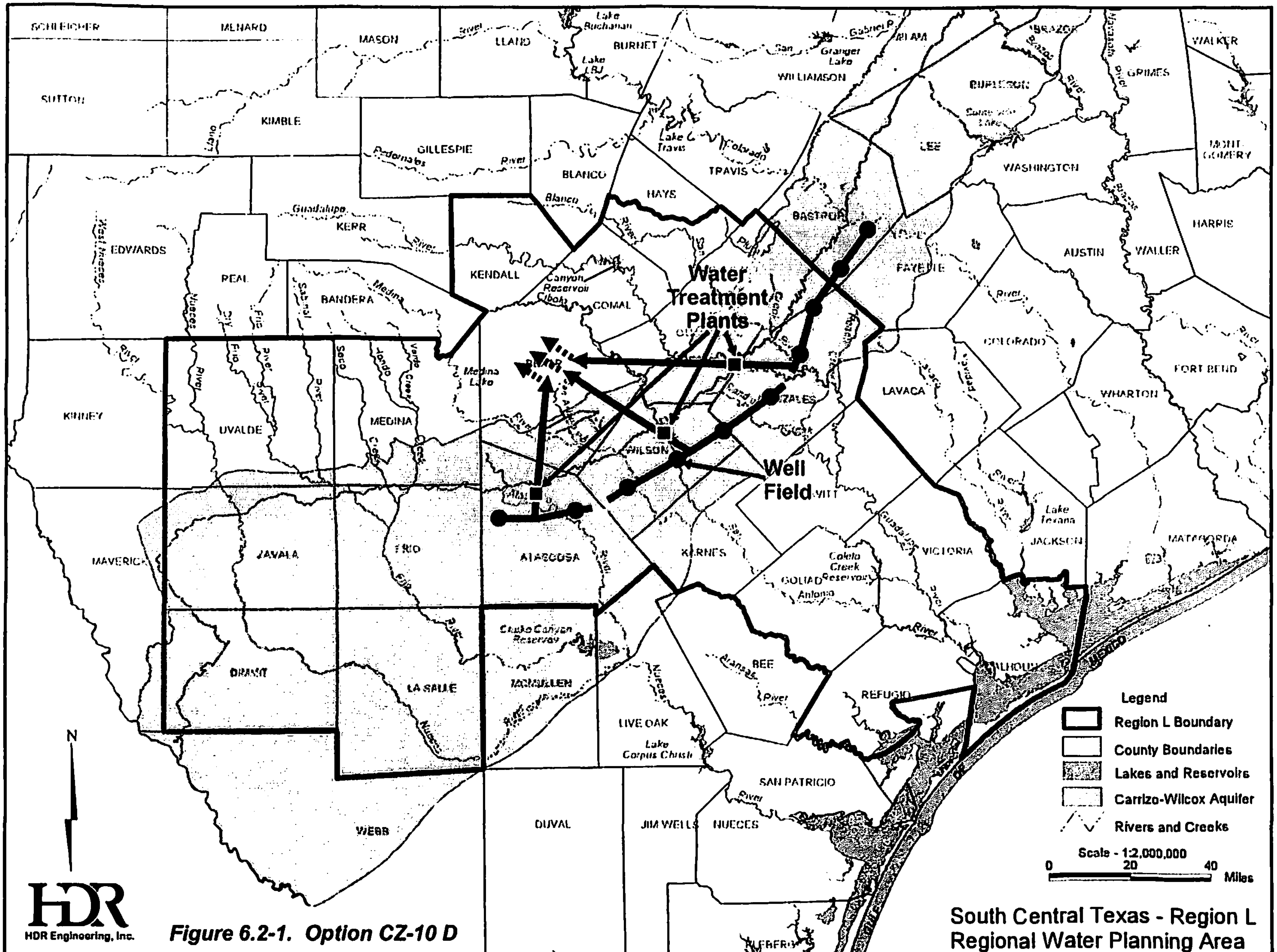


Figure 6.2-1. Option CZ-10 D

6.2.2 Available Yield

A review of existing reports,[1,2,3] the extent of other groundwater users in the area, and hydrogeologic data indicates that well fields can be developed in a section of the Carrizo-Wilcox Aquifer that extends from the Frio-Atascosa County line to a few miles south of the Colorado River in Bastrop County. These well fields would be separated or would "skip" across existing well fields for the cities of Jourdanton, Pleasanton, Floresville, Stockdale, and Gonzales.

Large capacity wells in the area typically produce 1,000 gallons per minute or more. With a contingency of 10 percent of the wells being out-of-service, about 150 wells would be required. Well spacings are planned to be about one mile.

To estimate the effects of the projected pumpage to meet local demands and the Schertz/Seguin plan through the year 2050, and Option CZ-10D pumpage (220,000 acft/yr), the "Interaction Between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer" model and a well image model for the well field north of the San Marcos River were applied. The computer simulations indicate drawdown in the well field in the year 2050 for pumping to meet local needs plus 20,000 acft/yr for Schertz/Seguin and an additional 220,000 acft/yr would be about 250 feet in Bastrop County, about 170 to 180 feet in Gonzales and Wilson Counties, and 120 to 150 feet in Atascosa County.

To show the long-term change in water levels in the Carrizo Aquifer as a result of pumpage to meet local demands plus the Schertz/Seguin and CZ-10D option, water level hydrographs are shown in Figure 6.2-2 for aquifer simulations from years 1910 to 2050. Monitoring locations are cell 23,62 in western Gonzales County, cell 24,53 in west-central Wilson County, and cell 20,43 in northwest Atascosa County. These cell locations are in the well fields as outlined for this option. For the Gonzales, Wilson, and Atascosa County cells, the total drawdown from predevelopment conditions (1910) to end of the assessment (2050) is about 245, 210 and 270 feet, respectively. For the Carrizo-Wilcox Aquifer, the TWDB calculated groundwater availability as having two components, as follows. When water levels are less than

[1] Klemt, W.B., et al., "Ground-Water Resources of the Carrizo Aquifer in the Winter Garden Area of Texas," Texas Water Development Board (TWDB) Report 210, Vols. 1 and 2, 1976.
[2] HDR Engineering, Inc (HDR) and LBG-Guyton Associates (LBG), "Interaction Between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," TWDB, August 1998.
[3] Ryder, P.D. and Ardis, A.F., "Hydrology of the Texas Gulf Coast Aquifer System." U.S. Geological Survey Open-File Report 91-64, 1991.

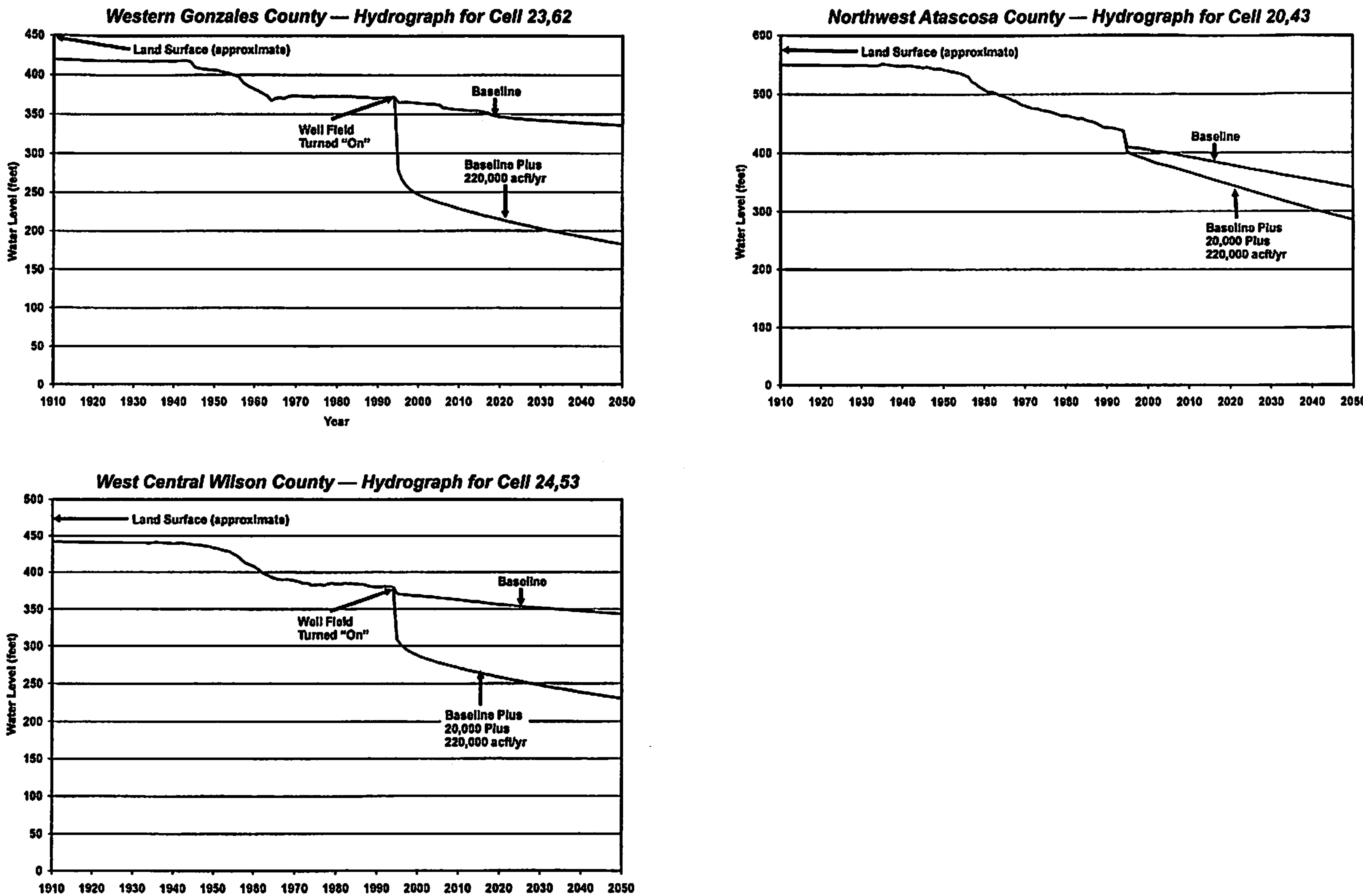


Figure 6.2-2. Hydrographs of Groundwater Levels

400 feet below land surface, groundwater availability is considered to be depletion from storage plus effective recharge. In Gonzales, Wilson, and Atascosa Counties, the groundwater availability for the Carrizo-Wilcox Aquifer for both components is 47,033, 43,391, and 30,824 acft/yr, respectively. For both projects, maximum depth of water levels below land surface is less than 400 feet in year 2050. As shown in Figure 6.2-2, the water levels are continuing to decline at a rate of about 1 foot per year in year 2050 in Gonzales County and about 2 feet per year in Atascosa County.

The combined effects of the development of groundwater under the Option CZ-10D and pumping to meet projected local demands are of importance at several locations on the Guadalupe and San Antonio rivers. For comparative purposes, the streamflow at several locations in these rivers are computed by using the GSA Model[4] for baseline and full development scenarios.

As was done in previous studies,[5] to evaluate the impact of specified pumpage scenarios on surface water flows in the Guadalupe–San Antonio River Basin, changes in streamflows were extracted from the groundwater model runs and incorporated into the GSA Model based on comparison with historical streamflow. For this analysis, streamflows were compared at two locations: the San Antonio River at Falls City and the Guadalupe River at the Saltwater Barrier. The impacts due to expected local pumpage to meet local needs projected to 2050 on historical streamflows were computed and used as the baseline flow set for computing streamflow impacts due to additional pumpage scenarios.

As shown in Table 6.2-1, simulated average annual streamflows for the period of record simulated (1934 to 1989) on the San Antonio River at Falls City assuming baseline Carrizo-Wilcox Aquifer pumpage was computed to be 252,838 acft/yr. Under an additional pumpage of 20,000 plus 220,000 acft/yr, average annual flows at Falls City would be reduced to 224,696 acft/yr, or a reduction of 11.1 percent (Table 6.2-1). Decreases in average annual flows during the historical drought of record (1947 to 1956) were computed to be 22,831 acft/yr (26.6 percent) with additional Carrizo-Wilcox pumpage of 240,000 acft/yr (Table 6.2-1).

[4] HDR, "Guadalupe-San Antonio River Basin Model Modifications and Enhancements," Trans-Texas Water Program, West Central Study Area, Phase II, San Antonio River Authority, et al., March 1998.
[5] HDR and LBG, Op. Cit., August 1998.

Table 6.2-1.
Impacts to Streamflow Due to
20,000 Plus 220,000 acft/year of Additional Carrizo-Wilcox Pumpage

Stream Location	Average Annual Streamflow (1934 to 1989) in acft			
	With Baseline 2050 Carrizo-Wilcox Pumpage[1]	With Additional 240,000 acft/year Pumpage[2]	Change	Percent Change
San Antonio River at Falls City	252,838	224,696	-28,147	-11.1%
Guadalupe River at SWB[3]	1,591,727	1,551,940	-39,787	-2.5%
	Drought Average Annual Streamflow (1947 to 1956) in acft			
San Antonio River at Falls City	85,675	62,844	-22,831	-26.6%
Guadalupe River at SWB[3]	507,563	480,826	-26,737	-5.3%

[1] Average Annual Streamflows assuming 2050 local pumpage were used as a baseline in order to access only the impacts attributable to the 20,000 acft/yr plus 220,000 acft/yr of additional pumpage (CZ-10D).
[2] Additional pumpage taken from a well field in Wilson, Atascosa, Gonzales, Caldwell, and/or Bastrop Counties.
[3] Does not include ungaged runoff to the estuary below the Saltwater Barrier.

Likewise, the simulated annual average streamflows at the Saltwater Barrier under baseline Carrizo-Wilcox Aquifer pumpage were computed to be 1,591,727 acft/yr and were reduced to 1,551,940 acft/yr (or a 2.5 percent reduction) with 240,000 acft/yr additional pumpage of the aquifer (Table 6.2-1). Average annual flows during the historical drought of record (1947 to 1956) at the Saltwater Barrier were reduced by 26,737 acft/yr (5.3 percent) with the additional 240,000-acft/yr pumpage (Table 6.2-1).

Figure 6.2-3 shows the impact of the additional 20,000 plus 220,000 acft/yr pumpage on median monthly streamflows and streamflow frequencies at the two streamflow locations analyzed. The changes in monthly median streamflows for the San Antonio River at Falls City range from a minimum impact of 1,544 acft in September to a maximum of 2,879 acft in November. On an annual basis, annual median streamflows at Falls City were reduced by 12.6 percent, or 24,593 acft/yr (Figure 6.2-3). Similarly, for the Guadalupe River at the Saltwater Barrier, the minimum impact to median monthly streamflows was computed to be 2,265 acft in September and the maximum impact was 4,216 acft in December. On an annual basis, median streamflows at the Saltwater Barrier were reduced by 2.7 percent, or 36,792 acft/yr (Figure 6.2-3).

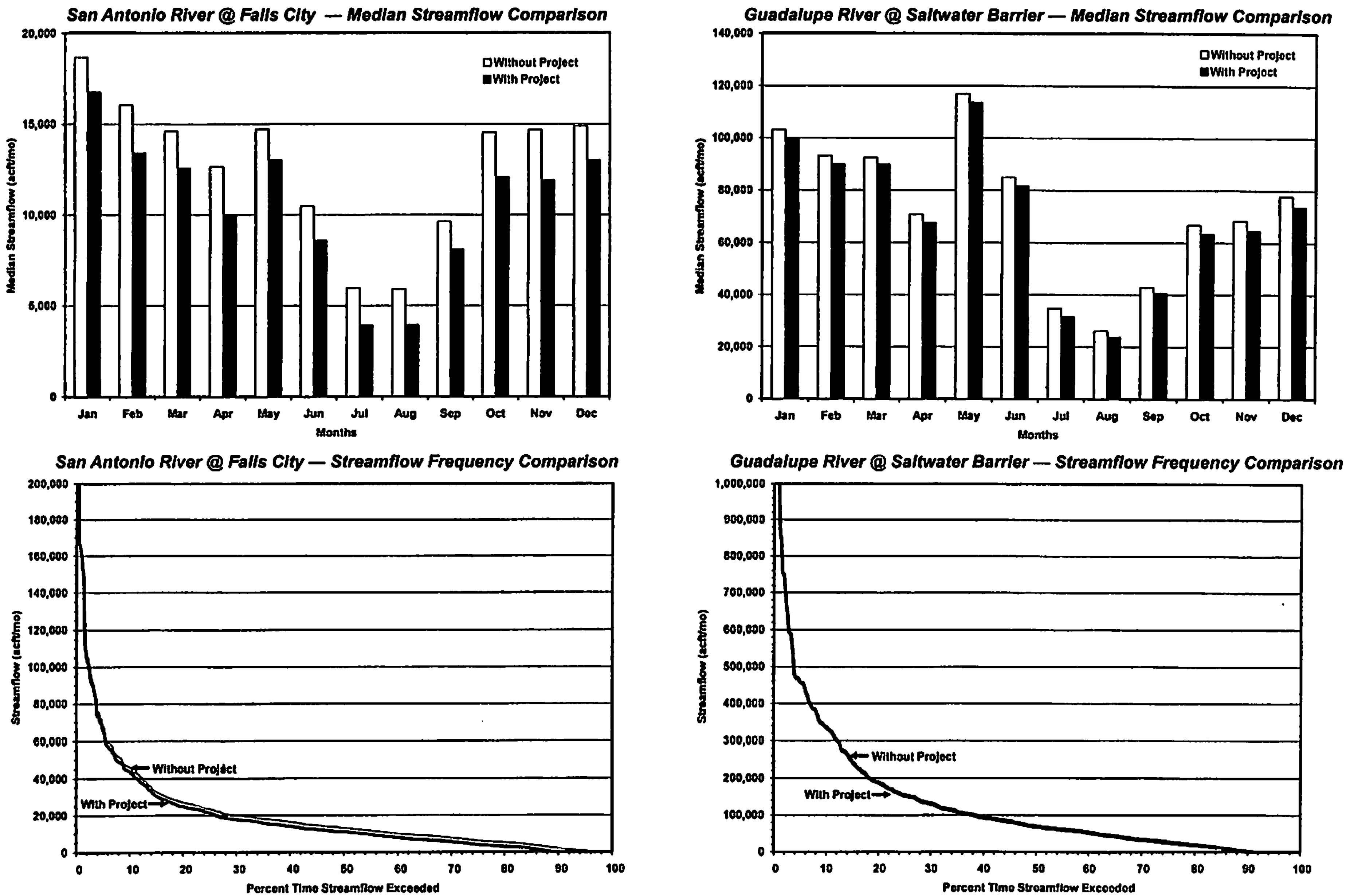


Figure 6.2-3. Changes in Streamflow for 20,000 Plus 220,000 acft/yr Option

6.2.3 Environmental Issues

The Carrizo-Wilcox Aquifer encompasses several formations of hydrologically connected cross-bedded sands interspersed with clay, sandstone, silt, and lignites (Wilcox Group) and overlying massive sands of the Carrizo formation. These formations outcrop in a southwest-northeast trending crescent near the inland margin of the Gulf Coastal Plain (Figure 6.2-1), and dip downward toward the coast. Aquifer recharge occurs over the general surface of the outcrop area.[6] The thickness of the Carrizo in the downdip artesian areas at the study site ranges from about 400 feet in Gonzales and Caldwell Counties to more than 1,000 feet in Atascosa County. The maximum thickness of the Carrizo Aquifer in this area is about 2,500 feet.

The project area for CZ-10D extends from Atascosa County northeast to Bastrop County. It consists of all or parts of Atascosa, Wilson, Bexar, Guadalupe, Gonzales, Caldwell, Bastrop, and Fayette Counties. The larger municipalities of the study area are Pleasanton, Floresville, Seguin, Gonzales, Luling, Lockhart, Smithville and Bastrop. The project area includes land primarily in the Post Oak Savannah vegetational area in the northeast, and the Blackland Prairies vegetational area in the south. Only a portion of the study area (Atascosa County) lies within the South Texas Plains vegetational area.[7] The Blackland Prairies soils are fairly uniform, dark-colored calcareous clays interspersed with some gray acid sandy loams. Most of this fertile area has been cultivated, although a few native hay meadows and ranches remain. Little bluestem is the dominant grass of the native assemblage with other important grasses present including big bluestem, Indian grass, switchgrass, tall dropseed, silver bluestem and Texas wintergrass. Under heavy grazing, buffalo grass, Texas grama, smutgrass and many annuals increase or invade native pastures. Mesquite, post oak and blackjack oak also invade or increase under these conditions.

The Post Oak Savannah upland soils are light-colored, acid sandy loams or sands. Bottomland soils are light brown to dark-gray and acid, ranging in texture from sandy loams to clays. Most of the Post Oak Savannah is still in native or improved pastures although small farms are common.

[6] LBG, "Phase I Evaluation Carrizo-Wilcox Aquifer West-Central Study Area Trans-Texas Water Program," prepared for HDR Engineering, Inc., Austin, Texas (also Appendix to this report), 1994.
[7] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, Texas Agricultural Experiment Station, College Station, Texas, 1962.

The South Texas Plains is dissected by streams flowing into the Rio Grande and the Gulf of Mexico. Soils in this area range from clays to sandy loams, and vary in reaction from very basic to slightly acid. This wide range of soil types is responsible for great differences in soil drainage and moisture holding capacities within this region.[8,9] Wetlands in the project area consist of riverine habitats of Cibolo Creek, the San Antonio, Guadalupe and Colorado Rivers and their tributaries, as well as associated palustrine habitats that are generally composed of narrow bands of wetlands along these watercourses.

Vertebrate fauna typifying these regions include the opossum, raccoon, weasel, skunk, white-tailed deer, and bobcat. The coyote and javelina are found mainly in brush/shrub areas and the red and gray fox in woodlands.[10] A wide variety of species of amphibians, reptiles and birds are also found throughout the region.[11,12]

The estimated area required for construction of Option CZ-10D encompasses 5,376 acres. Cropland, together with shrub and brushland dominates the landscape of the south Texas Plains and Blackland Prairies in which Option CZ-10D would lie, but Option CZ-10D also extends into the Post Oak Savannah in an area less impacted by ongoing agricultural activity.

The potential environmental effects resulting from the construction and operation of well pads and water transport pipelines depend to a large extent on the exact placement of the construction corridor. In general, habitats critical to the survival of important and protected species are locally restricted so that adverse impacts can often be avoided or minimized by site and alignment selection. More generally distributed habitats, although perhaps important to regional wildlife populations in some areas, may not be so easy to avoid, but the limited area affected by these corridors allows for insignificant impacts.

Plant and animal species listed by the USFWS and TPWD as endangered or threatened in the project area and those with candidate status for listing are presented in Table 6.2-2. Because this option would extend through three ecoregions in seven counties, all the species listed in Table 6.2-2 have habitat requirements or preferences that suggest they could be present within

[8] Ibid.
[9] McMahan, C.A., R.G. Frye, K.L. Brown, "The Vegetation Types of Texas," Texas Parks and Wildlife Department, Austin, Texas, 1984.
[10] Jones, K.J., et al., "Annotated Checklist of Recent Land Mammals of Texas," Occasional Papers, The Museum, Texas Tech University No. 119, May 1988.
[11] McMahan, C.A., R.G. Frye, K.L. Brown, Op. Cit., 1984.
[12] Jones, K.J., et al, Op. Cit., May 1988.

Table 6.2-2.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Carrizo-Wilcox Aquifer between Colorado and Frio Rivers (CZ-10D)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods	E	T		Resident
Blue Sucker	*Cycleptus elongatus*	Channels and flowing pools with exposed bedrock		T	WL	Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C			Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau				Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau				Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks				Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Jaguarundi	*Felis yagouaroudi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer				Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT			Nesting/Migrant
Navasota Ladies'-Tresses	*Spiranthes parksii*	Margins of post oak woodlands within sandy loams	E	E	E	Resident
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident

Table 6.2-2 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
Palmetto Pill Snail	*Euchemotrema Cheatumi*					Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies				Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations				Resident
Siren, Lesser, Rio Grande	*Siren intermedia texana*	Wet or temporarily wet areas, arroyos, canals, ditches and shallow depressions; requires moisture to remain		E	E	Resident
Smooth Blue-Star	*Amsonia glaberrima*	Dense woods and low pinelands[5]				Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Spikerush	*Eleocharis austrotexana*	Fresh and moderately alkali marshes; along coasts in fresh and water marshes[6]				Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear				Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures				Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Meadow-rue	*Thalictrum texanum*	Coastal plains and savannah			WL	Resident
Texas Pink-Root	*Spigelia texana*	Wooded slopes and floodplains woods along rivers[5]				Resident
Texas Tauschia	*Tauschia texana*	Alluvial thickets or wet woods[5]				Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, undergound burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
[5] Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.
[6] Hotchkiss, Neil. 1972. Common Marsh, Underwater & Floating-leaved Plants of the United States and Canada. Dover Publications, Inc., New York.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

the project area. Surveys for protected species or other biological resources of restricted distribution, or other importance, would need to be conducted within the proposed construction corridors where preliminary studies have indicated that habitat may be present.

The primary impacts that would result from construction and operation of Option CZ-10D include temporary disturbance to soils and habitat during construction of wells, pipelines and other facilities; permanent conversion of existing habitats or land uses to maintained pipeline rights-of-way; disturbance of minor acreages for construction of water treatment plants and storage stations; and well injection fields, and mixing of treated aquifer water with waters of the Edwards Aquifer, if this water is to be used to recharge the Edwards Aquifer. Indirect effects of construction may include mitigation areas converted to alternate uses to compensate for losses of terrestrial habitat.

The Texas Texas Biological and Conservation Data System maintained by TPWS Wildlife Diversity Branch maps several plant species on or in the vicinity of the pipeline route for CZ-10D; Elmendorf's onion (*Allium elmendorfii*), Parks' jointweed (*Polygonella parksii*), Sandhill Woolywhite (*Hymenopappus carrizoanus*), spikerush (*Eleocharis texana*), Texas Tauschia (*Tauschia texana*), smooth blue-star (*Amsonia glaberrima*), and Texas pink-root (*Spigelia texana*). Elmendorf's onion, Parks' jointweed, and Sandhill Woolywhite are found in deep sands usually derived from Eocene formations. The Texas Tauschia, smooth blue-star, and Texas pink-root grow in alluvial thickets or other wooded areas near water, while the spikerush thrives in fresh to moderately alkaline marshes. The aforementioned species are rare but not under regulatory status by TPWD or USFWS.

The Guadalupe Bass (*Micropterus treculi)*), which resides within streams of the Edwards Plateau, and Cagle's Map Turtle, which inhabits waters of the Guadalupe River Basin, were mapped near the pipeline corridor. Construction across streams and rivers might impact these two species of concern. The transfer of Carrizo-Wilcox water could also adversely affect two protected fish species within the Edwards Aquifer. The toothless Blindcat (*Trogloglanis pattersoni*) and Widemouth Blindcat (*Satan eurystomus*) both inhabit the aquifer under the City of San Antonio. Both of these threatened species may incur negative impacts if the water quality of the aquifer is not maintained.

The mountain plover (*Charadrius montanus*), designated a species of concern by TPWD, was mapped within 2 miles of the project area and may have essential habitat along the pipeline corridor. The mountain plover inhabits shortgrass plains, sandy deserts, and plowed fields.

Because there are no known metazoan inhabitants present, withdrawing water from the Carrizo Aquifer would not impact an endemic fauna. These withdrawals may, however, lower the water table to some extent in the outcrop area, potentially affecting the water budgets of streams and ponds in the area. Northeast of Atascosa County, the Carrizo Aquifer appears to be full and is discharging water to streams and rivers that cross the outcrop.[13] It is expected that the proposed well field would lower water levels in outcrop areas and thereby additional storage space would be created in the aquifer, increasing infiltration of surface-water runoff.[14] As a result, it is expected that the base flows of streams crossing the recharge zone would be reduced, and that channel losses could increase on the outcrop. The rates of water loss from permanent ephemeral ponds could also increase. Because of limited groundwater storage capacity, the potential for significant losses of stream baseflow is probably not a major concern. Enhancement of seepage losses, however, may prove to be of more concern.

Lowering the Carrizo Aquifer water table in Bastrop County could possibly impact Houston toad habitat (Table 6.2-2). The Houston toad uses the vernal pools (temporary ponds that typically contain water during the spring and dry completely during the summer) provided by the saturated sands of the Carrizo Aquifer as their breeding habitat.[15] The Texas garter snake, timber/canebrake rattlesnake, black-spotted newt, lesser siren and Bracted Twistflower populations could also be impacted as they inhabit wet areas in the project area (Table 6.2-2).

The endangered Golden-Cheeked Warbler (*Dendroica chrysoparia*) and Black-Capped Vireo (*Vireo atricapillus*) may have habitat within the study area. The Golden-Cheeked Warbler inhabits mature oak-Ashe juniper woods for nesting. It requires strips of Ashe juniper bark for nest material. The Black-Capped Vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories.

Construction in brush/shrub habitat and maintenance activities would potentially impact populations of the Texas tortoise, indigo snake, spot-tailed earless lizard, plains spotted skunk, jaguarundi, ocelot and Texas horned lizard. Construction impact can generally be minimized or

[13] LBG, Op. Cit., 1994.
[14] Ibid.

avoided, however, by locating project features in less sensitive cropland, pasture or upland woodland whenever possible. Construction across rivers and streams should be minimized, as riparian zones support wetlands and are valuable to wildlife. Mitigation may be required for impacts associated with the pump stations, injection wells, recharge structures, water treatment plants, and pipelines identified for CZ-10D option if sensitive ecological or cultural resources are identified in the plan formulation phase of this study.

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 (PL 96-515), and the Archaeological and Historic Preservation Act (PL 93-291). All areas to be disturbed during construction would need to be surveyed by qualified professionals for the presence of significant cultural resources. Additional measures to mitigate impacts may be required by the presence of significant cultural deposits that cannot be avoided.

6.2.4 Engineering and Costing

Groundwater would be developed by constructing a line of wells in a section of the Carrizo-Wilcox Aquifer that extends from the Frio-Atascosa County line to a few miles south of the Colorado River in Bastrop County. These well fields would be separated in areas where well fields are located for the cities of Jourdanton, Pleasanton, Floresville, Stockdale, and Gonzales.

The well field is divided into three sections with each section being independent of the other. Each section would have a well field, collector pipeline, pump station(s), and terminal storage and Level 2 water treatment (iron and manganese removal) near the center of the well field. From there, the water would be pumped through a pipeline to the major municipal demand center in the South Central Texas Region.

The Atascosa, Wilson-Gonzales, and Gonzales-Bastrop segments are designed to supply 55,000, 75,000 and 90,000 acft/yr, respectively. The major facilities required for these options are:

- Water Collection and Conveyance System
    - Wells
    - Pipelines
    - Pump Station
    - Transmission System

[15] Andrew H. Price, Personal Communication, Resource Protection Division, Texas Parks and Wildlife Department, Austin, Texas, 1994.

- Storage
- Pipeline
- Pump Stations
- Water Treatment Plant (Iron and Manganese removal).

The approximate locations of these facilities were shown earlier in Figure 6.2-1.

Cost estimates were computed for capital and project expenses, annual debt service, operation and maintenance, power, land, and environmental mitigation. These costs are summarized in Table 6.2-3. Because of the uncertainty in the acquisition of groundwater rights, estimates are based on land purchases to meet groundwater development requirements of the Evergreen and Gonzales groundwater districts. The costs are estimated for the annual costs, including debt service for a 30-year loan at 6 percent interest and operation and maintenance costs, including power. The cost of water is estimated to be $632 per acft/yr (Table 6.2-3).

6.2.5 Implementation Issues

Implementation of Carrizo-Wilcox Aquifer between Colorado and Frio Rivers option could directly affect the feasibility of other water supply options under consideration, including G-21, CZ-10C, and/or SCTN-10.

The development of groundwater in the Carrizo-Wilcox Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

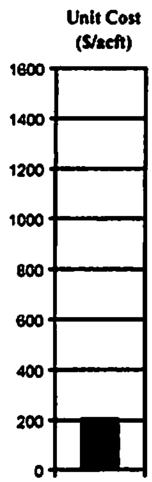
- Detailed feasibility evaluation including test drilling and aquifer and water quality testing, followed with more detailed groundwater modeling to confirm results of this preliminary evaluation.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Competition with others in the area for groundwater.
- Regulations by the Evergreen and Gonzales County UWCDs, including the renewal of pumping permits at 5-year intervals in the Evergreen District.
- Water levels did not stabilize during the 50-year evaluation and simulated pumping may be in excess of effective recharge.

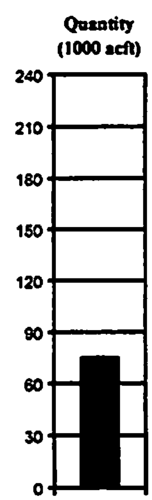
Table 6.2-3.
Cost Estimate Summary
Option CZ-10D — 220,000 acft/yr Scenario
(Second Quarter 1999 Prices)

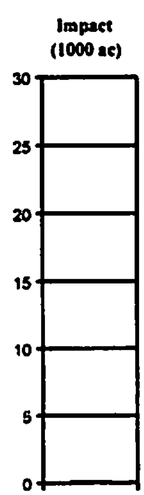
Item	Estimated Costs for Facilities
Capital Costs	
Well Costs	$86,890,000
Pipeline	255,681,000
Transmission Pump Station	33,108,000
Water Treatment Plants (Iron and Manganese Removal) (208 MGD)	70,177,000
Distribution	237,467,000
Total Capital Cost	**$683,323,00**
Engineering, Legal Costs and Contingencies (33% of capital costs)	$226,379,000
Environmental & Archaeology Studies and Mitigation	9,037,000
Land Acquisition and Surveying (132,437 acres @ $1,300-$1,600/acre)	205,714,000
Interest During Construction (4 years)	179,921,000
Total Project Cost	**$1,304,374,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$94,512,000
Operation and Maintenance:	
Wells, Pipeline, Transmission Pump Station	6,528,000
Water Treatment Plant	14,610,000
Pumping Energy Costs (286,550,000 kWh @$0.06/KW hr)	17,193,000
Water Export Fee ($0.17/1,000 gallons (Wilson & Atascosa Counties only)	6,094,000
Total Annual Cost	**$138,937,000**
Available Project Yield (acft/yr)	**220,000**
Annual Cost of Water ($ per acft) Treated Water Distributed[1]	**$632**
Annual Cost of Water ($ per 1,000 gallons) Treated Water Distributed[1]	**$1.94**

[1] Water delivered from source to major municipal demand center of the South Central Texas Region, treated and distributed to municipal systems or the Edwards Aquifer recharge zone.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **SCTN-3a**

OPTION NAME: **Simsboro Aquifer—Bastrop, Lee, and Milam Counties with Delivery to Colorado River**

OPTION DESCRIPTION: *The Simsboro Aquifer in Central Texas is part of the Carrizo-Wilcox Aquifer System and is capable of producing large quantities of freshwater. In fact, lignite mine operators of Milam County have had to pump about 30,000 acft/yr from the Simsboro and have disposed of much of the water by discharging it to East Yegua Creek. Over the next few decades, the mining operations are expected to advance southwestward. A potential well field in the mining area to support the mining effort would extend from U.S. Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, a distance of about 32 miles.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yrs. ☐ 5-15 yrs. ☐ > 15yrs.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	$203	per acft[1]	Raw Water Delivered
QUANTITY OF WATER:	75,000	acft/yr[2]	
LAND IMPACTED:	78	acres[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Wells, pumps, water collection and conveyance system, pipelines and pump stations, water purchase, land acquisition, and mitigation.

[2]**QUANTITY OF WATER:** Groundwater availability in the mining area is estimated to be somewhat larger than 75,000 acft/yr.

[3]**LAND IMPACTED:** Wells would be sited on property owned by the mining company and near the areas that have been or will be disturbed by mining. Pipelines and pump stations would disturb corridors along roads. Mine property and well field are excluded.

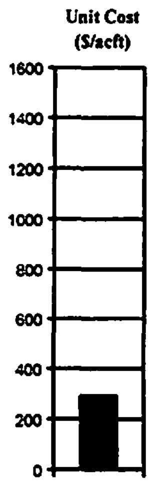
ENVIRONMENTAL ISSUES: Concern exists about the potential reduction in baseflow in small streams in the area and potential reduction of wetland areas.

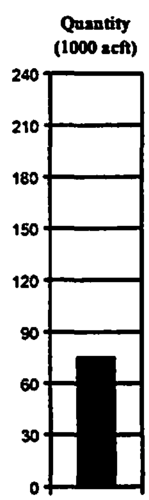
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: The transfer of groundwater from Bastrop and Lee Counties may be regulated in the future by a new groundwater conservation district. Transfer of groundwater from one river basin to another and one planning region to another. Lowering groundwater levels and impact to existing wells and water supplies. Losses of water in 'bed and banks' transport.

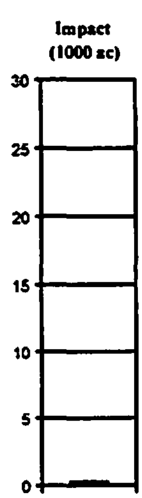
ADDITIONAL FACTORS: Negotiation of contracts with Lower Colorado River Authority for an exchange of water. Compliance with regulatory requirements in 'bed and banks' transport and water quality in Colorado River.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: None, except to the extent that this source of supply increases return flow from which reclaimed water might be obtained.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **SCTN-3b**

OPTION NAME: **Simsboro Aquifer—Bastrop, Lee, and Milam Counties with Delivery to Plum Creek**

OPTION DESCRIPTION: *The Simsboro Aquifer in Central Texas is part of the Carrizo-Wilcox Aquifer System and is capable of producing large quantities of freshwater. In fact, lignite mine operators of Milam County have had to pump about 30,000 acft/yr from the Simsboro and have disposed of much of the water by discharging it to East Yegua Creek. Over the next few decades, the mining operations are expected to advance southwestward. A potential well field in the mining area to support the mining effort would extend from U.S. Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, a distance of about 32 miles.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yrs. ☐ 5-15 yrs. ☐ > 15yrs.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	$290	per acft[1]	Raw Water Delivered
QUANTITY OF WATER:	75,000	acft/yr[2]	
LAND IMPACTED:	269	acres[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

<u>*FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED*</u>

[1]**COST:** Wells, pumps, water collection and conveyance system, pipelines and pump stations, water purchase, land acquisition, and mitigation.

[2]**QUANTITY OF WATER:** Groundwater availability in the mining area is estimated to be somewhat larger than 75,000 acft/yr.

[3]**LAND IMPACTED:** Wells would be sited on property owned by the mining company and near the areas that have been or will be disturbed by mining. Pipelines and pump stations would disturb corridors along roads. Mine property and well field are excluded.

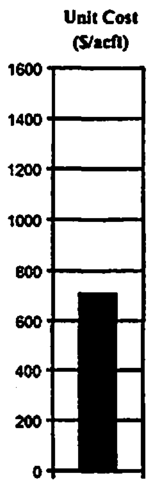
ENVIRONMENTAL ISSUES: Concern exists about the potential reduction in baseflow in small streams in the area and potential reduction of wetland areas.

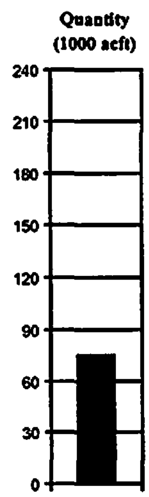
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: The transfer of groundwater from Bastrop and Lee Counties may be regulated in the future by a new groundwater conservation district. Transfer of groundwater from one river basin to another and one planning region to another. Lowering groundwater levels and impact to existing wells and water supplies. Losses of water in 'bed and banks' transport.

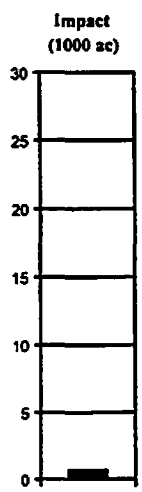
ADDITIONAL FACTORS: Negotiation of contracts with Guadalupe-Blanco River Authority for an exchange of water. Compliance with regulatory requirements in 'bed and banks' transport and water quality in streams in the Guadalupe River Basin.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: None, except to the extent that this source of supply increases return flow from which reclaimed water might be obtained.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **SCTN-3c**

OPTION NAME: **Simsboro Aquifer—Bastrop, Lee, and Milam Counties with Delivery to a Major Municipal Demand Center**

OPTION DESCRIPTION: *The Simsboro Aquifer in Central Texas is part of the Carrizo-Wilcox Aquifer System and is capable of producing large quantities of freshwater. In fact, lignite mine operators of Milam County have had to pump about 30,000 acft/yr from the Simsboro and have disposed of much of the water by discharging it to East Yegua Creek. Over the next few decades, the mining operations are expected to advance southwestward. A potential well field in the mining area to support the mining effort would extend from U.S. Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, a distance of about 32 miles.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yrs. ☐ 5-15 yrs. ☐ > 15yrs.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	**$707**	**per acft[1]**	**Treated Water Distributed**
QUANTITY OF WATER:	**75,000**	**acft/yr[2]**	
LAND IMPACTED:	**671**	**acres[3]**	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Wells, pumps, water collection and conveyance system, pipelines and pump stations, water purchase, mitigation, land acquisition, and water treatment

[2]**QUANTITY OF WATER:** Groundwater availability in the mining area is estimated to be somewhat larger than 75,000 acft/yr.

[3]**LAND IMPACTED:** Wells would be sited on property owned by the mining company and near the areas that have been or will be disturbed by mining. Pipelines and pump stations would disturb corridors along roads. Mine property and well field are excluded.

ENVIRONMENTAL ISSUES: Concern exists on the potential reduction in baseflow in small streams in the area and potential reduction of wetland areas.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: The transfer of groundwater from Bastrop and Lee Counties may be regulated in the future by a new groundwater conservation district. Transfer of groundwater from one river basin to another and one planning region to another. Lowering groundwater levels and impact to existing wells and water supplies.

ADDITIONAL FACTORS: Water customer acceptability of Simsboro Aquifer water.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: None, except to the extent that this source of supply increases return flow from which reclaimed water might be obtained.

6.3 Simsboro Aquifer – Bastrop, Lee, and Milam Counties (SCTN-3)

6.3.1 Description of Option

The Simsboro Aquifer in Central Texas is part of the Carrizo-Wilcox Aquifer System and is capable of producing large quantities of freshwater. The aquifer has primarily been used for domestic, livestock, and public supplies, except in southwestern Milam County where an ongoing lignite mining operation has found it to be necessary to depressurize the aquifer for mining operations in the overlying Calvert Bluff Formation. Since 1988, the mine operators have pumped about 30,000 acft/yr from the Simsboro Aquifer and have disposed of much of the water by discharging it to East Yegua Creek. Over the next few decades, the mining operators are planning to advance southwestward into western Lee and northern Bastrop Counties. A well field intended for depressurization purposes in these expanded mining operations, as well as additional water being pumped from wells in the vicinity of the present mining operations would result in a well field that extends from U.S. Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, a distance of about 32 miles (Figure 6.3-1).

Under this option, the placement and operation of wells for supplies to be used in the South Central Texas Water Planning Region would be coordinated with mining operations, and would result in the water that is pumped to depressurize the mines being used for municipal and industrial purposes as opposed to being discharged into local streams for disposal. The water quality of the Simsboro Aquifer is suitable for use as a public water supply, except for elevated concentrations of iron and manganese.

Even though some of the supply wells may have to be abandoned and replaced at another location from time-to-time, for planning purposes, only one well field development scenario is studied. With a proposed transfer of 75,000 acft/yr to the South Central Texas Water Planning Region and average well yields from the Simsboro Aquifer of about 300 gpm in the proposed well field, 170 wells would be required, including a contingency of 10 percent for wells being out-of-service. The supply wells would be spaced about 1,000 feet apart and parallel the outcrop.

The delivery options for the water supply include transporting the water at a uniform rate for: (1) release into the Colorado River west of Bastrop, (2) release into Plum Creek east of Lockhart, and (3) use in the major municipal and industrial demand center of the South Central Texas Region. The first two options would only be considered in conjunction with an exchange

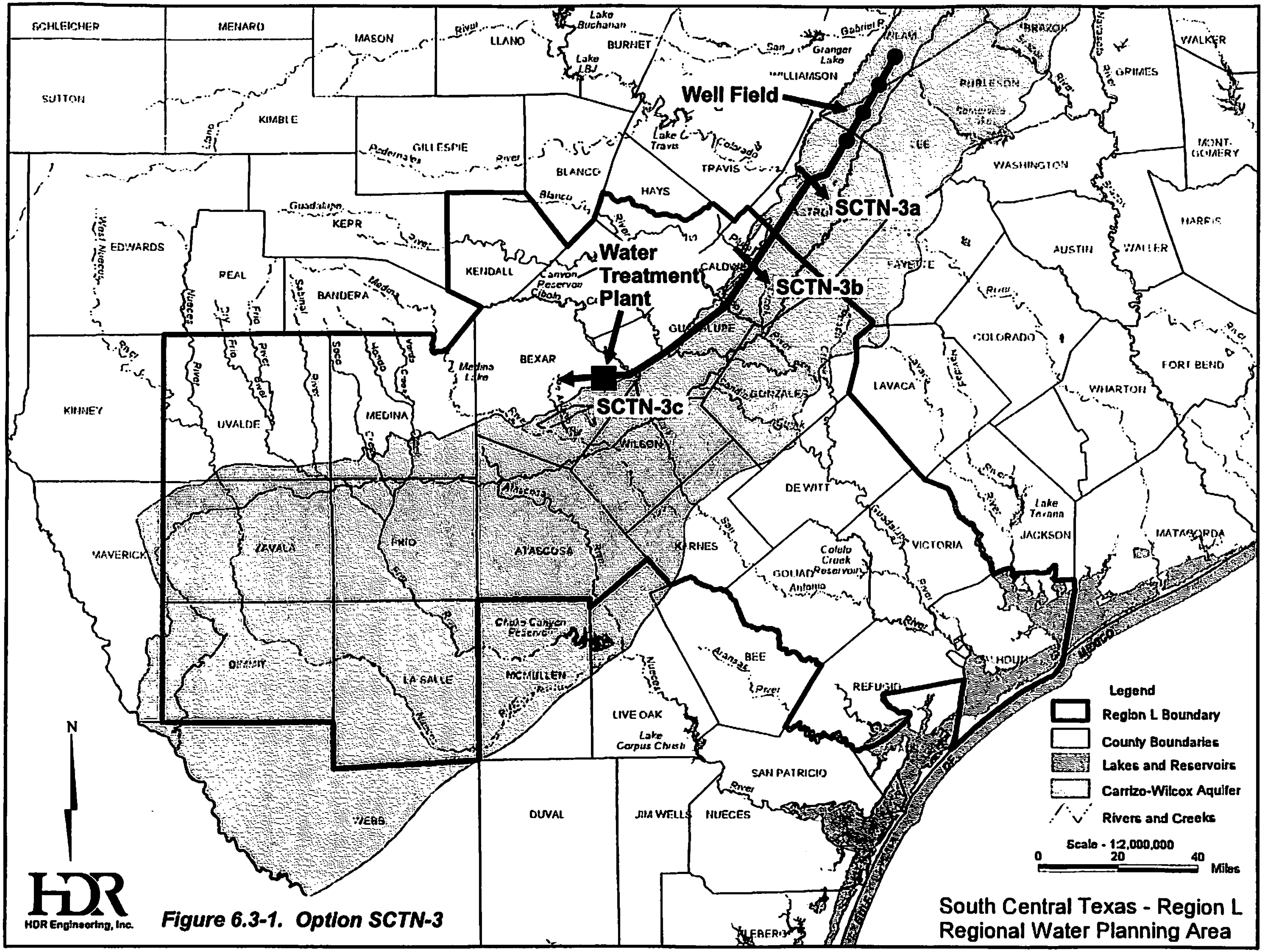


Figure 6.3-1. Option SCTN-3

for water in the Colorado and Guadalupe River Basins, which would then be transferred to the major municipal and industrial demand center of the South Central Texas Region. The third option would be to transport potable water to the major municipal and industrial demand center of the South Central Texas Region for direct use. The required facilities for all options include a Well Field and Conveyance System of pipelines, pump stations, and storage facilities. The third option requires a water treatment plant for removal of iron and manganese. Figure 6.3-1 indicates the location of the pipeline route, water treatment plant, and delivery points.

6.3.2 Available Yield

For an evaluation of this option, two recent groundwater availability studies[1,2] were reviewed. These studies indicate that in the project area, about 2,500 acft/yr of groundwater can be developed per mile along the outcrop of the Simsboro Aquifer. Considering a 32-mile section of the Carrizo-Wilcox Aquifer from U.S. Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, about 80,000 acft/yr could be developed. After making an allowance for local groundwater use in the area, 75,000 acft/yr could be developed and transported to the South Central Texas Water Planning Region. Model simulations of the aquifer system indicate that drawdowns in the well field would be 100 to 150 feet in addition to drawdowns that are estimated to occur as a result of development for local use as reported in the TWDB's 1997 Water Plan.

6.3.3 Environmental Issues

Option SCTN-3 involves the construction of a 32-mile well field in Milam, Lee, and Bastrop Counties and a small portion of Williamson County, with three alternative extensions of a transmission pipeline that would deliver water to:

- (3a) The Colorado River west of Bastrop,
- (3b) Plum Creek east of Lockhart, or
- (3c) A major municipal demand center in the Edwards Aquifer Region.

The northern part of the well field will be implemented to support lignite mining in the immediate future, and is presumed to be needed for that purpose regardless of whether the water is transferred to the South Central Texas Region.

[1] HDR Engineering, Inc., "Assessment of Groundwater Availability on CPS Property in Bastrop and Lee Counties, Texas", prepared for San Antonio Water System, San Antonio, Texas, July 1999.

The majority of the well field and the extensions of the transmission pipeline lie in and along several borders of the Blackland Prairies and Post Oak Savannah vegetational areas.[3] The project area for SCTN-3a would lie in the Texas Blackland Prairies and East Central Texas ecoregions, while SCTN-3b and 3c would extend the proposed pipeline farther into the Texas Blackland Prairies.[4] All three options cross the Texan biotic province, except for SCTN-3c, which extends a small portion of the transmission line into the Tamaulipan biotic province.[5]

The dominant vegetation of the Blackland Prairies is mesquite, post oak, bluestems, switchgrass and blackjack supported by clay soils mixed with sandy loams. The Post Oak Savannah vegetational area is characterized by gently rolling to hilly terrain with an understory that is typically tall grass and an overstory that is primarily post oak (*Quercus stellata*) and blackjack oak (*Q. marilandica*). On-site surveys will be necessary to determine the specific fauna of the corridor since the pipeline corridor is a mosaic of the Post Oak Savannah and the Blackland Prairie ecoregions and could potentially include a wide variety of species.

Table 6.3-1 lists rare and protected species that may have habitat in the project area. The Texas Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch maps several species and essential habitat in the vicinity of the well field and transmission pipeline for SCTN-3. Houston Toad (*Bufo houstonensis*) habitat is mapped in Lee and Bastrop Counties along with several sightings of the species itself, and a portion of this habitat is less than a mile from the proposed project area. The well field and resulting watertable drawdown could potentially impact *Bufo houstonensis* in this area since the endangered Houston Toad uses the temporary pools provided by the saturated sands of the Carrizo aquifer as their breeding habitat. Another protected species, the Bald Eagle, was reported directly on the transmission pipeline route for SCTN-3a. The Bald Eagle prefers habitat near large bodies of water with nearby resting sites. In addition to the Houston Toad and Bald

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[2] Dutton, Alan, R., "Assessment of Groundwater Availability in the Carrizo-Wilcox Aquifer in Central Texas—Results of Numerical Simulations of Six Groundwater Withdrawal Projections (2000-2050)," prepared for Texas Water Development Board, April 1999.
[3] Omernik, James M., "Ecoregions of the conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-135.
[4] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.
[5] Blair, W.F., "The biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.

Table 6.3-1. Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Simsboro Aquifer – Bastrop, Lee, and Milam Counties (SCTN-3)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black-capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet arroyos, canals, ditches, shallow depressions; aestivates underground during dry periods		T		Resident
Blue Sucker	*Cycleptus elongatus*	Channels and flowing pools with exposed bedrock		T	WL	Resident
Bone Cave Harvestman	*Texella reyesi*	Small, blind, cave-adapted harvestman endemic to a few caves in Travis and Williamson counties	E			Resident
Bracted Twistflower	*Streptanthus bracteatus*	Endemic; Shallow clay soils over limestone; rocky slopes			E	Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C			Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau				Resident
Coffin Cave Mold Beetle	*Batrisodes texanus*	Resident, small, cave-adapted beetle found in small Edwards Limestone caves in Travis and Williamson counties	E			
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Correll's False Dragon-Head	*Physostegia correllii*	Wet soils			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau				Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Georgetown Salamander	*Eurycea sp. 5*	Endemic; known from springs and waters in/around town of Georgetown in Williamson County				Resident
Glass Mountain Coral Root	*Hexalectris nitida*	Mesic woodlands in canyons, under oaks				Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant
Houston Toad	*Bufo houstonensis*	Loamy, friable soils, temporary rain pools, flooded fields, ponds surrounded by forest or grass; reintroduced to Colorado Co.	E	E	E	Resident
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Inland river sandbars for nesting and shallow waters for foraging	E	E	E	Nesting/Migrant
Jollyville Plateau Salamander	*Eurycea sp. 1*	Known from springs and waters of some caves of Travis and Williamson counties north of the Colorado River				Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident

Table 6.3-1 (continued)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity USFWS[1]	TPWD[1]	TOES[2,3,4]	Potential Occurrence in County
Maculated Manfreda Skipper	*Stallingsia maculosus*	Larvae feed inside leaf shelter and pupae found in cocoon made of leaves fastened by silk				Resident
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; wells in Edwards Aquifer				Resident
Mountain Plover	*Charadrius montanus*	Shortgrass plains and fields, sandy deserts, plowed fields	PT			Nesting/Migrant
Navasota Ladies'-Tresses	*Spiranthes parksii*	Margins of post oak woodlands within sandy loams	E	E	E	Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WK	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies				Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations				Resident
Scarlet Snake	*Cemophora coccinea*	Sandy soils		T	WL	Resident
South Texas Rushpea	*Caesalpinia phyllanthoides*	Thorn shrublands or grasslands on sandy to clay soils			WL	Resident
Spikerush	*Eleocharis austrotexana*	Fresh and moderately alkali marshes; along coasts in fresh and water marshes[6]				Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear				Resident
Texabama Croton	*Croton alabamensis var. texensis*	Deciduous/evergreen woodlands in duff-covered loamy clay soils on rocky slopes in mesic limestone ravines; flowering late Feb.-March			WL	Resident
Texas Fescue	*Festuca versuta*	Margins of Edwards Plateau[5]				Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures				Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March-Nov		T	T	Resident
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Bottomland hardwoods		T	T	Resident
Tooth Cave Ground Beetle	*Rhadine persephone*	Resident, small, cave-adapted beetle found in small Edwards Limestone caves in Travis and Williamson counties	E		WL	Resident
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic; San Antonio pool of the Edwards Aquifer		T	E	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Widemouth Blindcat	*Satan eurystomus*	Troglobitic; San Antonio pool of Edwards Aquifer		T	E	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Wood Stork	*Buteo americana*	Prairie ponds, flooded pastures or fields; shallow standing water		T	T	Nesting/Migrant
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
[5] Correll, D.S. and M.C. Johnston. 1979. Manual of the Vascular Plants of Texas. Texas Research Foundation. Renner, Texas.
[6] Hotchkiss, Neil. 1972. Common Marsh. Underwater & Floating-leaved Plants of the United States and Canada. Dover Publications, Inc. New York.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

Eagle, Option SCTN-3c would pass in the vicinity of several mapped species of concern: Guadalupe Bass (*Micropterus treculi*), Mountain Plover (*Charadrius montanus*), Spikerush (*Eleocharis austrotexana*), and Bracted Twistflower (*Streptanthus bracteatus*).

Several protected species were not mapped along the proposed well field or pipeline route but may have essential habitat in the project area: Timber/Canebrake Rattlesnake, Texas Tortoise, and the Spot-tailed Earless Lizard. The Timber Rattlesnake and Spot-tailed Earless Lizard can be found in woodlands consisting of oak and other hardwoods, the Texas Tortoise prefers open brush with grass understory and usually occupies shallow depressions at the base of a bush or cactus. The endangered Navasota ladies' tresses (*Spiranthes parksii*), grows at the margins of post oak woodlands within sandy loams and may be affected by construction.

Protected bird species, which may have habitat within the study area, are the Golden-cheeked Warbler (*Dendroica chrysoparia*), Black-capped Vireo (*Vireo atricapillus*), and Zone-tailed Hawk. The Golden-cheeked Warbler inhabits mature oak-Ashe juniper woods for nesting. It requires strips of Ashe juniper bark for nest material. The Black-capped Vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories, while the Zone-tailed Hawk inhabits arid, open country including deciduous or pine-oak woodlands.

Two fish species that could only be affected by the delivery pipeline of Option SCTN-3c are the Toothless Blindcat (*Trogloganis pattersoni*) and Widemouth Blindcat (*Satan eurystomus*) which occupy the Edwards Aquifer under the City of San Antonio and are found at the end of the pipeline route. If this water is used to recharge the Edwards Aquifer, these fish species may be affected if water quality is changed.

Existing regulations would require that habitat studies and surveys for protected species be conducted at the proposed well field sites, construction activity sites, and along any pipeline routes. Monitoring saturated sands of the Carrizo for effects by pumping groundwater may be required to protect the Houston Toad habitat. When potential protected species habitat or other significant resources cannot be avoided, additional studies would be required to evaluate habitat use, permit requirements, and other mitigative measures. Eligibility for inclusion in the National Register for Historic Places would be considered for migration of cultural resources that could not be avoided. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.3.4 Engineering and Costing

Groundwater would be developed by constructing wells along a line from U.S Hwy 79 near Rockdale to U.S. Hwy 290 near Elgin, a collector pipeline, pump station(s), and terminal storage at the southern end of the well field. From here, the water would be pumped through a pipeline for release into either the Colorado River west of Bastrop (Option SCTN-3a), Plum Creek east of Lockhart (Option SCTN-3b), or to the major municipal and industrial demand center of the South Central Texas Region (Option SCTN-3c). Common to all the options is the Well Field and Collection System of wells, pipelines, and pump stations and a Transmission System of storage, pipelines, and pump stations to the Colorado River. For comparison purposes, estimates of cost include the construction of all wells. For options SCTN-3a and SCTN-3b, the wells would be constructed similar to irrigation wells. For SCTN-3c, the wells would be constructed to public water supply standards. For cost estimating purposes, the project is divided into segments with Option SCTN-3a extending from the well field to the Colorado River, Option SCTN-3b includes Option SCTN-3a plus the segment between the Colorado River and Plum Creek, and Option SCTN-3c includes Option SCTN-3b plus the segment from Plum Creek to the major demand center. The major facilities required for these options are:

- Well Field and Collection and Conveyance System (to U.S. Hwy 290):
  - Wells.
  - Pipelines.
  - Pump Station.
- Transmission System (from U.S. Hwy 290 to the three discharge points – Colorado River, Plum Creek, and the major demand center):
  - Storage.
  - Pipeline.
  - Pump Station.
  - Outlet Works (SCTN-3a and SCTN-3b).
- Water Treatment Plant:
  - Iron and Manganese removal (SCTN-3c only).

The approximate locations of the well field, pipeline, and water treatment plant are shown in Figure 6.3-1.

Estimates were prepared for capital costs, annual debt service, operation and maintenance, water purchases, power, land, and environmental mitigation. These costs are summarized in Tables 6.3-2 through 6.3-4. The annual costs, including debt service for a 30-year loan at 6 percent interest and operation and maintenance costs, including power, are estimated to be $15,249,000, $21,776,000, and $53,029,000 for options SCTN-3a, SCTN-3b, and SCTN-3c, respectively (Tables 6.3-2, 6.3-3, and 6.3-4). This option produces water at an estimated cost of $203, $290, and $707 /acft/yr, respectively. However, the cost estimates do not include potential fees that might be levied by underground water conservation districts, and the cost for SCTN-3c to the major demand center is for treated water, whereas the costs for SCTN-3a and 3b are for raw water at the Colorado River and Plum Creek discharge points.

6.3.5 Implementation Issues

Major issues of the development of groundwater in the Simsboro Aquifer in Bastrop, Lee, and Milam Counties for the South Texas Water Planning Region include:

- Need for additional hydrogeology and environmental data and analyses of the effects of pumping the aquifer at 75,000 acft/yr for an extended period of time.
- Impact on:
  - Endangered species;
  - Water levels in the aquifer;
  - Baseflow in streams; and
  - Wetlands.
- Potential regulations by the newly created groundwater district (Lost Pines Groundwater Conservation District).
- Development of agreements for the exchange of groundwater from the Simsboro Aquifer and surface water from the Colorado or Guadalupe Rivers and the cost of transporting the replacement surface water to the major demand center in the South Central Texas Region.
- Potential groundwater quality degradation from leakage of groundwater through the mine.
- Accounting for water losses in 'bed and banks' transport.
- Potential change in water quality in the Colorado and Guadalupe Rivers.
- The potential losses of water in options SCTN-3a and 3b where water is discharged to the Colorado River and Plum Creek, respectively. However, legally, such losses are not considered to be a waste of water, as decided by the Texas Supreme Court in City of Corpus Christi vs. City of Pleasanton, 276 s.w. 2d 798 (Tex, 1995).
- Future purchase price of water.
- Resistance to movement of water from one river basin to another and from one planning region to another.

Table 6.3-2.
Cost Estimates for Simsboro Aquifer
Bastrop, Lee, and Milam Counties
with Delivery to the Colorado River (SCTN-3a)
(Second Quarter 1999 Prices)

Item	Estimated Cost
Capital Costs	
Well Sites	$22,497,000
Water Conveyance System	23,611,000
Transmission Pump Station (1)	2,536,000
Transmission Pipeline (60-in dia., 12.3 miles)	10,199,000
Water Treatment Plant	0
Total Capital Cost	**$58,843,000**
Engineering, Contingencies and Legal Costs	19,455,000
Environmental & Archaeology Studies, Mitigation, and Permitting	314,000
Land Acquisition and Surveying (77 acres)	725,000
Interest During Construction (2.5 years)	7,934,000
Total Project Cost	**$87,271,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$6,340,000
Operation and Maintenance:	
Well Field, Pump Stations, and Pipeline	715,000
Water Treatment Plant	0
Pumping Energy Costs (74,073,333 kWh @ $0.06 per kWh)	4,444,000
Purchase of Water (75,000 acft/yr @ $50/acft)	3,750,000
Total Annual Cost	**$15,249,000**
Available Project Yield (acft/yr)	**75,000**
Annual Cost of Water ($ per acft) Raw Water at Colorado River[1]	**$203**
Annual Cost of Water ($ per 1,000 gallons)	**$0.62**

[1] Near Bastrop.

Table 6.3-3.
Cost Estimates for Simsboro Aquifer
Bastrop, Lee, and Milam Counties
with Delivery to Plum Creek (SCTN-3b)
(Second Quarter 1999 Prices)

Item	Estimated Cost
Capital Costs	
Well Sites	$22,497,000
Water Conveyance System	23,611,000
Transmission Pump Stations (2)	12,756,000
Transmission Pipeline (60-in dia., 43.3 miles)	36,887,000
Water Treatment Plant	0
Total Capital Cost	**$95,751,000**
Engineering, Contingencies and Legal Costs	31,039,000
Environmental & Archaeology Studies, Mitigation, and Permitting	1,095,000
Land Acquisition and Surveying (269 acres)	2,534,000
Interest During Construction (2.5 years)	13,042,000
Total Project Cost	**$143,461,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$10,422,000
Operation and Maintenance:	
Well Field, Pump Stations, and Pipeline	1,214,000
Water Treatment Plant	0
Pumping Energy Costs (106,105,485 kWh @ $0.06 per kWh)	6,390,000
Purchase of Water (75,000 acft/yr @ $50/acft)	3,750,000
Total Annual Cost	**$21,776,000**
Available Project Yield (acft/yr)	**75,000**
Annual Cost of Water ($ per acft) Raw Water at Plum Creek[1]	**$290**
Annual Cost of Water ($ per 1,000 gallons)	**$0.89**

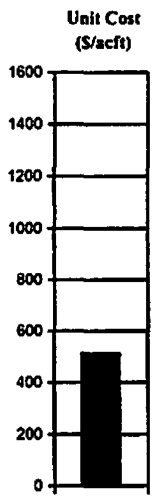
[1] Near center of Caldwell County.

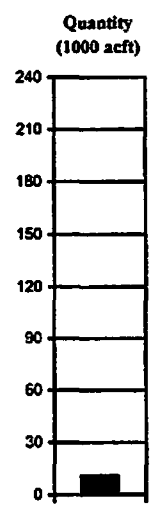
Table 6.3-4.
Cost Estimates for Simsboro Aquifer
Bastrop, Lee, and Milam Counties
with Delivery to Major Municipal Demand Center of the
South Central Texas Region (SCTN-3c)
(Second Quarter 1999 Prices)

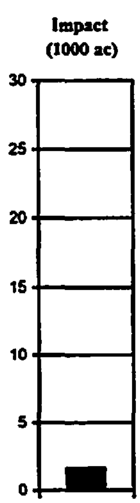
Item	Estimated Cost
Capital Costs	
Well Sites	$39,165,000
Water Conveyance System	23,611,000
Transmission Pump Stations (3)	22,839,000
Transmission Pipeline (60-in dia., 108.4 miles)	128,442,000
Water Treatment Plant (70.5 MGD)	9,145,000
Distribution	79,939,000
Total Capital Cost	**$303,141,000**
Engineering, Contingencies and Legal Costs	99,047,000
Environmental & Archaeology Studies, Mitigation, and Permitting	2,745,000
Land Acquisition and Surveying (269 acres)	6,258,000
Interest During Construction (2.5 years)	41,120,000
Total Project Cost	**$452,311,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$32,860,000
Operation and Maintenance:	
Well Field, Pump Stations, and Pipeline	3,324,000
Water Treatment Plant	3,302,000
Pumping Energy Costs (163,218,963 kWh @ $0.06 per kWh)	9,793,000
Purchase of Water (75,000 acft/yr @ $50/acft)	3,750,000
Total Annual Cost	**$53,029,000**
Available Project Yield (acft/yr) Treated Water at Demand Center[1]	**75,000**
Annual Cost of Water ($ per acft)	**$707**
Annual Cost of Water ($ per 1,000 gallons)	**$2.17**

[1] Near center of Bexar County.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: SCTN-7a

OPTION NAME: Wintergarden Carrizo Recharge Enhancement—Nueces River Alternative

OPTION DESCRIPTION: *Recharge to the Carrizo Aquifer would be enhanced through the operation of an off-channel reservoir and a system of recharge canals, supplied from the Nueces River in Zavala County. Enhanced recharge would be available for pumping by local irrigators or for pumpage and transmission to a municipality.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	$511	per acft[1]	Raw Water in Aquifer
QUANTITY OF WATER:	11,000	acft/yr[2]	
LAND IMPACTED:	1,633	acres[3]	

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Channel dam, off-channel reservoir, Nueces River diversion pump station and pipeline, reservoir intake, transmission pipeline to recharge canals, and recharge canals.

[2]**QUANTITY OF WATER:** Upstream and downstream water rights, size of off-channel reservoir, and number and size of recharge canals.

[3]**LAND IMPACTED:** Off-channel reservoir site, pipeline right-of-way, and recharge canal field.

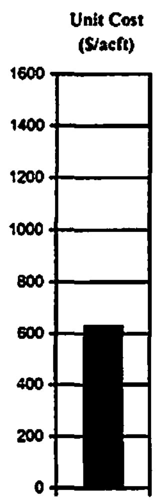
ENVIRONMENTAL ISSUES: Inundation of about 633 acres adjacent to the Nueces River on an unnamed tributary, and construction and operation of a 1,000-acre recharge canal field. Archeological and cultural resource surveys have not been conducted.

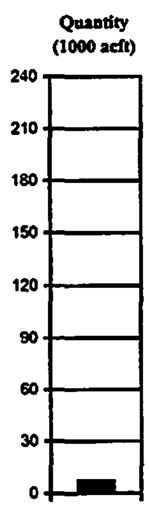
SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water high for potential irrigation uses.

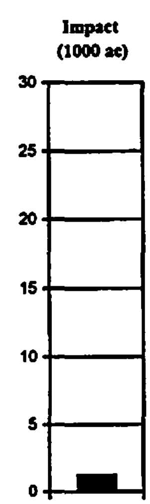
ADDITIONAL FACTORS: Ability to obtain permits to use surface water from the Nueces River and recover enhanced recharge from the Carrizo Aquifer.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-18, CZ-10C, CZ-10D, and/or SCTN-2a.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **SCTN-7b**

OPTION NAME: **Wintergarden Carrizo Recharge Enhancement—Atascosa River Alternative**

OPTION DESCRIPTION: *Recharge to the Carrizo Aquifer would be enhanced through the operation of an off-channel reservoir and a system of recharge canals, supplied from the Atascosa River in Atascosa County. Enhanced recharge would be available for pumping by local irrigators or for pumpage and transmission to a municipality.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER:	$627	per acft[1]	Raw Water in Aquifer
QUANTITY OF WATER:	7,200	acft/yr[2]	
LAND IMPACTED:	1,210	acres[3]	

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Channel dam, off-channel reservoir, Atascosa River diversion pump station and pipeline, reservoir intake, transmission pipeline to recharge canals, and recharge canals.

[2]**QUANTITY OF WATER:** Upstream and downstream water rights, size of off-channel reservoir, and number and size of recharge canals.

[3]**LAND IMPACTED:** Off-channel reservoir site, pipeline right-of-way, and recharge canal field.

ENVIRONMENTAL ISSUES: Inundation of about 210 acres adjacent to the Atascosa River, and construction and operation of a 1,000-acre recharge canal field. Archeological and cultural resource surveys have not been conducted.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water high for potential irrigation uses.

ADDITIONAL FACTORS: Ability to obtain permits to use surface water from the Atascosa River and recover enhanced recharge from the Carrizo Aquifer.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: L-18, CZ-10C, CZ-10D, and/or SCTN-2a.

6.4 Wintergarden Carrizo Recharge Enhancement (SCTN-7)

6.4.1 Description of Option

The Carrizo Aquifer is recharged through a relatively narrow outcrop extending across portions of Caldwell, Guadalupe, Gonzales, Wilson, Bexar, Atascosa, Medina, Frio, Uvalde, Zavala, and Dimmit Counties within the South Central Texas Region (Figure 6.4-1). Water is recharged where the aquifer outcrop occurs, generally travels downdip toward the south, and is available for pumpage in the counties listed above as well as La Salle, Karnes, and DeWitt Counties within the South Central Texas Region. Estimated average recharge to the Carrizo Aquifer is 13,000 acft/yr for Atascosa County; 10,000 acft/yr for Frio County; 25,000 acft/yr for Dimmit County; and 25,000 acft/yr for Zavala County.[1] The Carrizo Aquifer in the Wintergarden area is heavily pumped, with estimated pumpage in 1993 of 7,198 acft for Dimmit County; 66,440 acft for Zavala County; 350 acft for Frio County; 6,261 acft for La Salle County; and 54,078 acft for Atascosa County.[2] These counties are predominantly rural and the majority of the water pumped is used for irrigation.

This option includes evaluation of the potential for enhancing recharge of the Carrizo Aquifer in Dimmit, Zavala, Frio, and Atascosa Counties with available water from the Nueces, Frio, and Atascosa Rivers. Available flows from the Nueces, Frio, or Atascosa Rivers could be diverted into off-channel storage reservoirs, and released to facilities constructed to recharge the water to the aquifer using canals to convey water over the outcrop where infiltration would take place. Because injection of the water via wells would require some degree of treatment to remove suspended material that would otherwise clog aquifer pores and reduce well efficiency, this means of recharge is not considered herein. Water recharged under this option could be available for pumpage by local irrigators or for pumpage and transmission to a nearby municipality.

[1] LBG-Guyton Associates (LBG), "SCTN-7: Winter Garden Carrizo Recharge Enhancement," Draft Report to HDR Engineering, Inc., October 12, 1999.
[2] LBG and HDR Engineering, Inc. (HDR), "Interaction Between Groundwater and Surface Water in the Carrizo-Wilcox Aquifer," Texas Water Development Board (TWDB), August 1998.

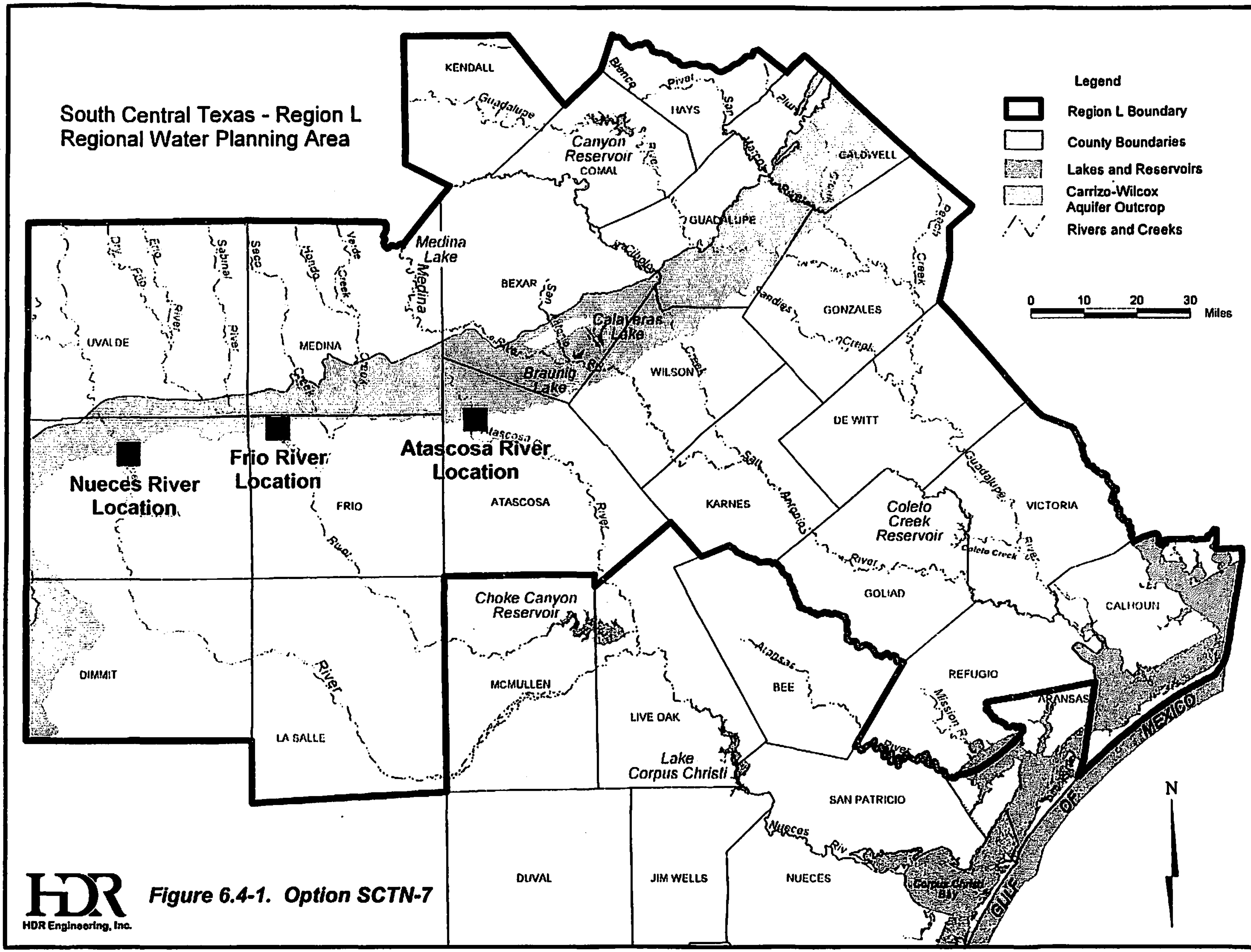


Figure 6.4-1. Option SCTN-7

6.4.2 Water Availability

Water available for recharge enhancement from the Nueces, Frio, and Atascosa Rivers is limited by upstream and downstream water rights. Water for this option would be available sporadically, during periods of high flow when existing water rights are fully satisfied. The availability of water for recharge enhancement was computed utilizing the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendices B and F). Monthly regulated streamflows and unappropriated streamflows available from the Nueces, Frio, and Atascosa Rivers were estimated using the Nueces River Basin Water Availability Model (WAM),[3] developed for the TNRCC under the SB1 Water Availability Modeling Project. The current version of the Nueces River Basin WAM includes the 1934 to 1996 historical period. The input data files for the Nueces River Basin WAM were modified so as to match the general assumptions adopted by the South Central Texas Regional Water Planning Group and listed in the Introduction.

Water availability was estimated at three sites near the southern boundary of the Carrizo Aquifer outcrop in Zavala County (Nueces River, model control point 307901), Frio County (Frio River, model control point 9910), and Atascosa County (Atascosa River, model control point 321601). The approximate locations of these sites are shown in Figure 6.4-1. Daily streamflow available for diversion at these sites was estimated by distributing the monthly regulated and unappropriated streamflows to daily values using records for nearby streamflow gaging stations.

A computer program was developed to simulate daily diversion from a site into an off-channel storage facility, with subsequent diversion to the recharge canal system, or recharge field. Data inputs to the program include the monthly regulated and available streamflows estimated using the Nueces River Basin WAM, daily gaged flows used to distribute the monthly flows to daily values, the Consensus Criteria pass-through flow requirements, the transmission capacity of the diversion facility from the river to the off-channel reservoir, the storage capacity of the off-channel reservoir, and the recharge capacity of the recharge field. Monthly unappropriated or available flows for the three sites are summarized in Figure 6.4-2. As shown in the figure, available flows in the Frio River occur substantially less frequently than in the

[3] HDR, "Water Availability in the Nueces River Basin," Texas Natural Resource Conservation Commission, October 1999.

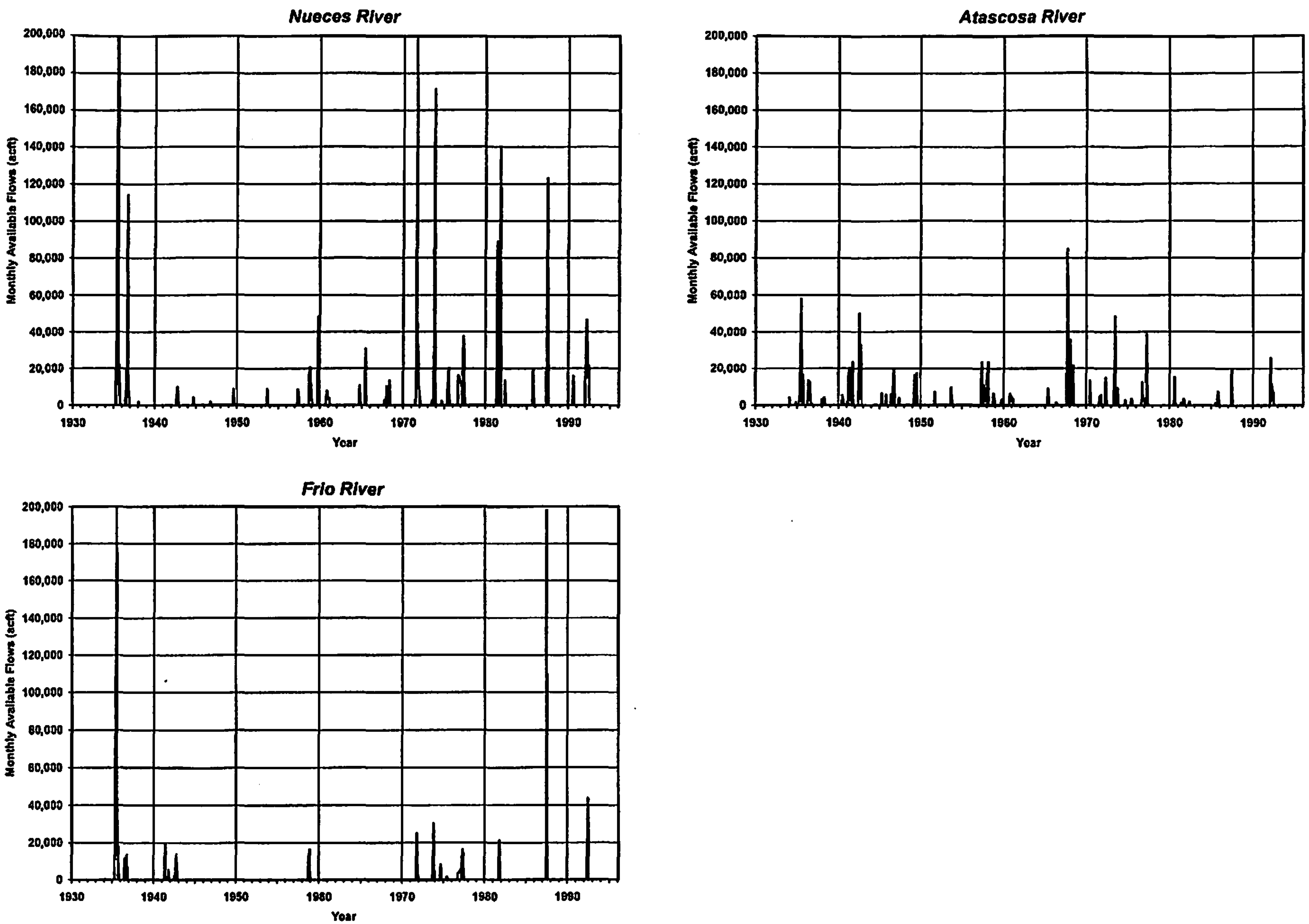


Figure 6.4-2. Monthly Available Flows at the Southern Boundary of the Carrizo Aquifer Outcrop

other two rivers. Hence, the Frio River site was eliminated from further analysis in this study. The streamflow statistics used in application of the Consensus Criteria pass-through requirements for the Nueces and Atascosa River sites are presented in Tables 6.4-1 and 6.4-2.

Table 6.4-1.
Daily Natural Streamflow Statistics for the Nueces River at the Downstream Boundary of the Carrizo Aquifer Outcrop

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25^{th} Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	46	21[2]
February	43[1]	22[2]
March	41[1]	27[2]
April	45	28[2]
May	57	32[2]
June	53	30[2]
July	54	28[2]
August	53	23[2]
September	53	26[2]
October	59	27[2]
November	56	21[2]
December	50	21[2]
Zone 3 Pass-Through Requirement[3] (acft/day)		44

[1] When the Zone 3 pass-through requirement is greater than the median flow, the median flow is superceded by the Zone 3 pass-through requirement.
[2] When the Zone 3 pass-through requirement is greater than the 25^{th} percentile flow, the 25^{th} percentile flow is superceded by the Zone 3 pass-through requirement.
[3] Water Quality Standard (7Q2).

A system of recharge canals could potentially recharge an estimated 1,500 to 2,500 acft per acre per year, based upon the hydraulic conductivity of the aquifer and the permeability of overlying soils in the area.[4] A recharge rate of 2,000 acft per acre per year is equivalent to an infiltration rate of about 5.5 feet per day. Allowing for reductions in infiltration efficiency due to

[4] LBG, Op. Cit., October 12, 1999.

Table 6.4-2.
Daily Natural Streamflow Statistics for the Atascosa River at the Downstream Boundary of the Carrizo Aquifer Outcrop

Month	Median Flows – Zone 1 Pass-Through Requirement (acft/day)	25th Percentile Flows – Zone 2 Pass-Through Requirement (acft/day)
January	7	4
February	8	5
March	8	4
April	7	3
May	10	4
June	9	2
July	5	1
August	3	1
September	5	1
October	5	1
November	6	2
December	7	3
Zone 3 Pass-Through Requirement[1] (acft/day)		0.41
[1] Water Quality Standard (7Q2).		

clogging of pore spaces or site-specific soil characteristics, an infiltration rate of 182 acft per acre per year (0.5 feet per day) was assumed. This rate generally agrees with, but is slightly lower than, permeability test data presented in soil surveys of Atascosa[5] and Zavala[6] Counties. The selected infiltration rate was assumed to occur uniformly over the land occupied by the recharge field.

For the Nueces and Atascosa River sites, the average (mean) annual recharge available for multiple combinations of off-channel storage capacity and recharge field capacity was estimated. All combinations assumed a river diversion facility consisting of a channel dam, intake structure and pump station, and parallel 120-inch pipelines to divert flood flows to the off-channel reservoir at a maximum combined rate of about 800 cfs. Capital costs for the combined facilities were estimated and used to determine an approximate optimal configuration at each

[5] U.S. Department of Agriculture, "Soil Survey of Atascosa County, Texas," August 1980.
[6] U.S. Department of Agriculture, "Soil Survey of Dimmit and Zavala Counties, Texas," November 1985.

site. The optimal configuration for the Nueces River site would be the combination of a 10,000-acft capacity off-channel reservoir with a 1,000-acre recharge field, resulting in an average annual recharge enhancement to the Carrizo Aquifer of 11,000 acft. The optimal configuration for the Atascosa River site would be the combination of a 2,500-acft capacity off-channel reservoir with a 1,000-acre recharge field, resulting in an average annual recharge enhancement to the Carrizo Aquifer of 7,200 acft.

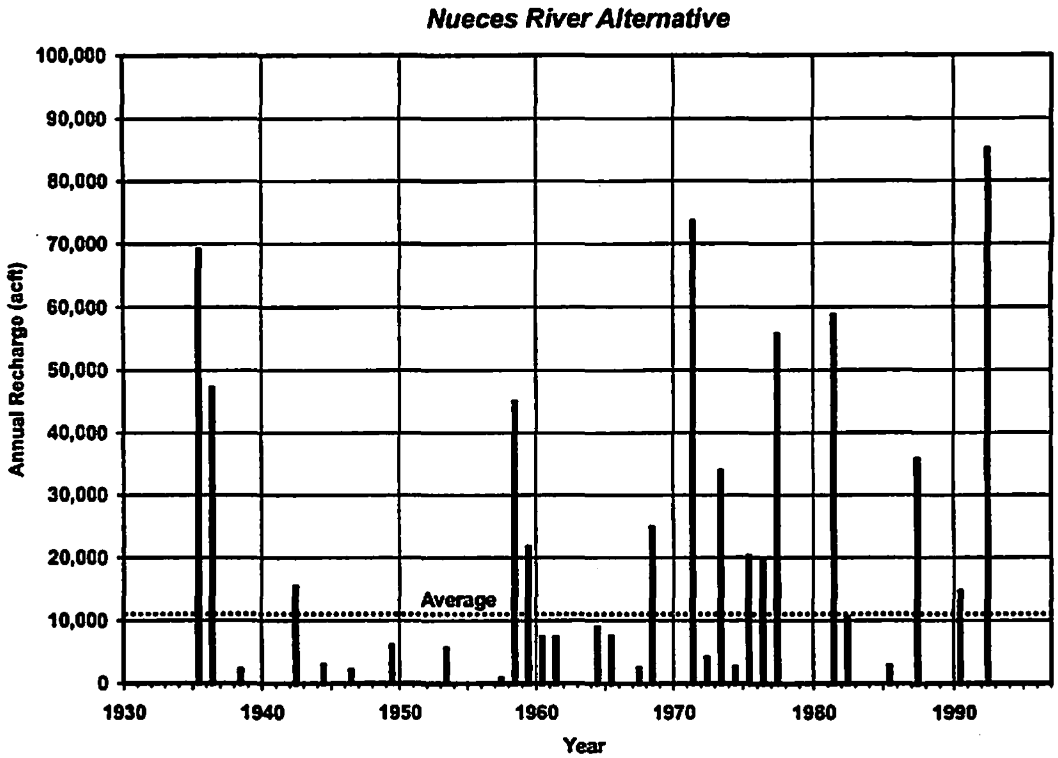
Recharge at both locations would occur sporadically, with water available only during flood events on the Nueces and Atascosa Rivers. Recharge facilities would be in operation only about 10 to 20 percent of the time. Estimated annual recharge enhancement over the 1934 to 1996 simulation period is shown for both alternatives in Figure 6.4-3. Limited additional recharge enhancement could occur from localized runoff adjacent to the recharge fields. While preliminary sites were identified for cost estimating purposes, numerous potential sites exist in the vicinity. Implementation of this option would require more detailed studies to select specific sites for recharge enhancement.

Figure 6.4-4 illustrates simulated changes in streamflow medians and frequencies near the Nueces and Atascosa River diversion locations. Monthly median streamflows would be reduced about three percent at the Nueces River location, and about 25 percent at the Atascosa River location. Reductions in inflow to the Nueces Estuary would be minimal, and would occur only during periods of high flow when Lake Corpus Christi would be spilling. There would be no change in the firm yield of the Choke Canyon Reservoir/Lake Corpus Christi System, located downstream of both projects, as the water diverted at both sites is unappropriated water.

6.4.3 Environmental Issues

Atascosa and Zavala Counties both fall within Blair's Tamaulipan biotic province[7] and the South Texas Plains vegetational area.[8] The South Texas Plains is comprised mainly of rangeland. The vegetation associated with this area has shifted from a grassland or savannah to shrubs characterized by mesquite, live oak (*Quercus virginiana*), acacia and post oak. Atascosa County lies equally within the Southern Texas Plains and East Central Texas Plains ecoregions.

[7] Blair, W.F, "The Biotic Provinces of Texas," Texas Journal of Science 2(1): pp. 93-117, 1950.
[8] Gould, F.W., "The Grasses of Texas," Texas A&M University Press, College Station, Texas, 1975.



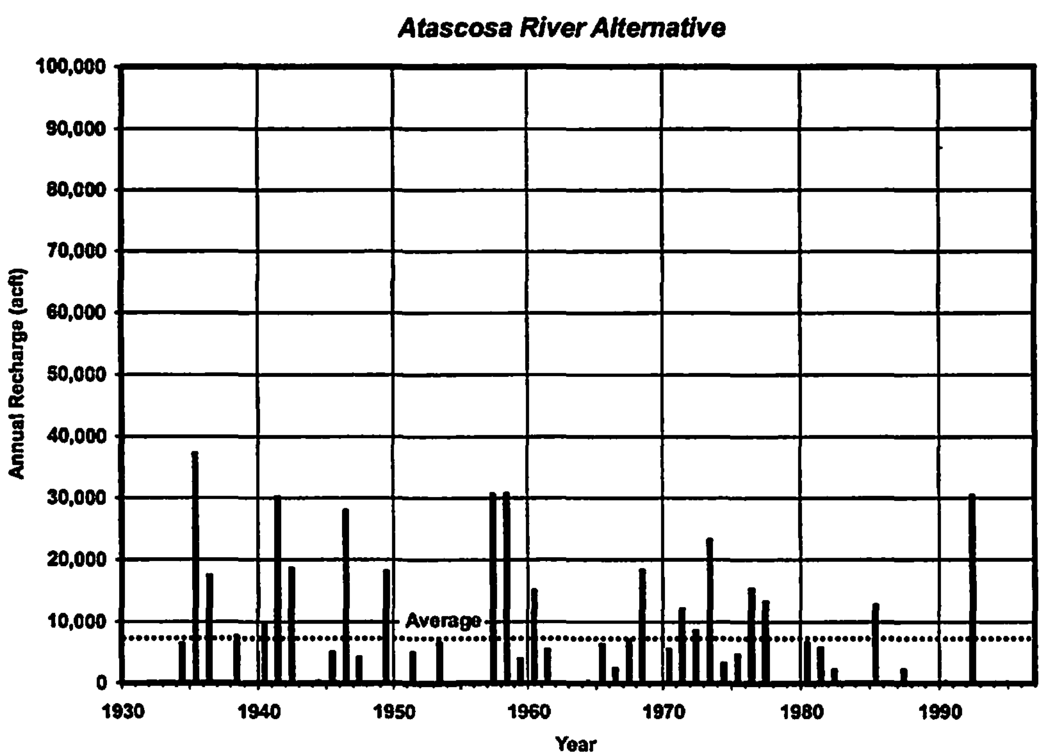


Figure 6.4-3. Carrizo Recharge Enhancement

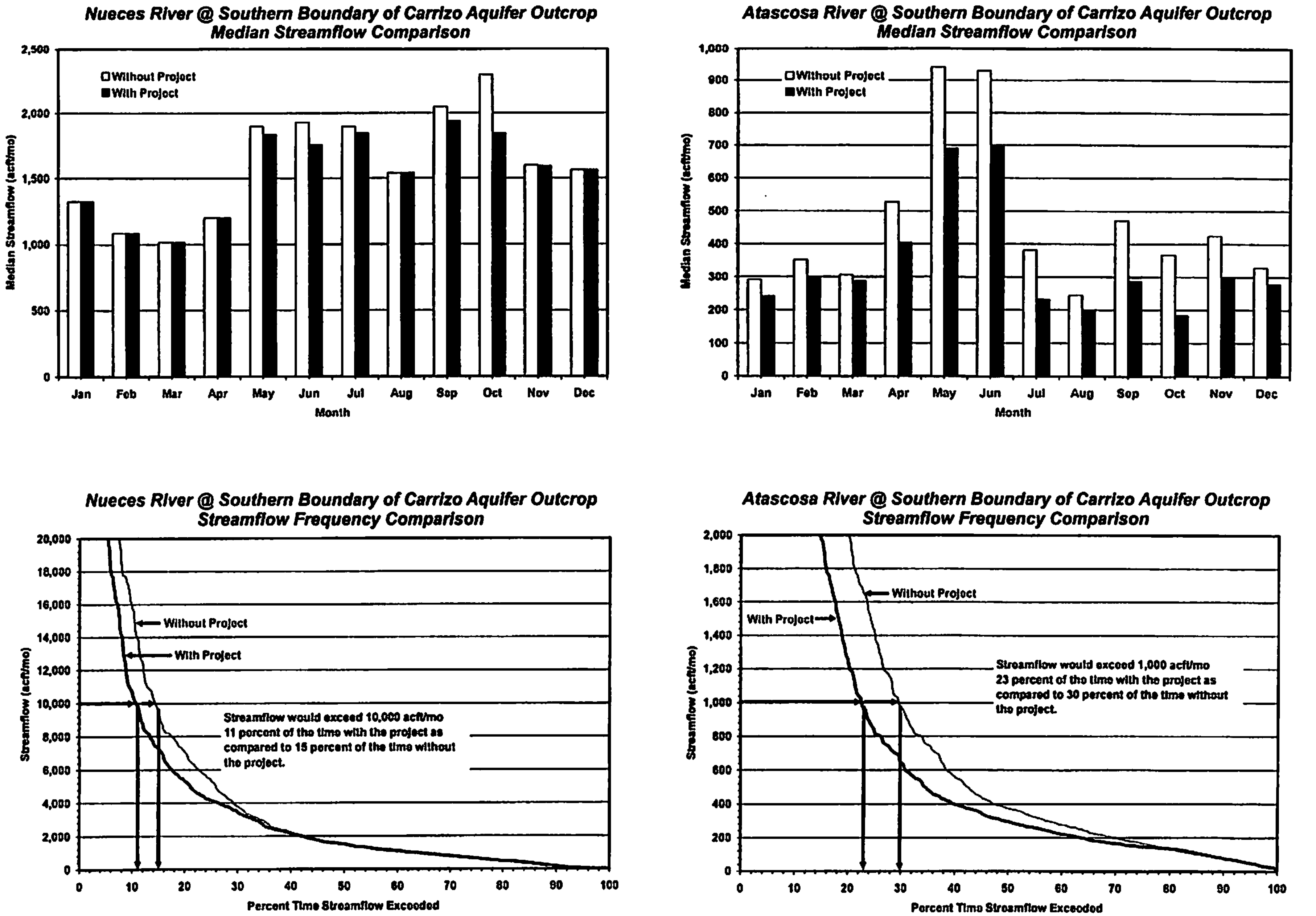


Figure 6.4-4. Carrizo Recharge Enhancement Streamflow Comparisons

Zavala County lies almost entirely in the South Texas Plains, except for the southern tip, which penetrates the Central Texas Plateau ecoregion.[9]

Table 6.4-3 presents important plant and animal species as listed by the USFWS, TPWD, and the Texas Organization for Endangered Species (TOES) for Atascosa and Zavala Counties. These species may be encountered during construction of the project. The endangered Jaguarundi (*Felis yagouaroundi*), which prefers thick brushlands, especially near water, and the Ocelot (*Felis pardalis*), which resides within mesquite-thorn scrubland and dense chaparral thickets, inhabit both Atascosa and Zavala Counties. Other species that may be encountered in the project area include the Texas Tortoise (*Gopherus berlandieri*), which inhabits open brush with a grass understory, the Plains Spotted Skunk (*Spilogale putorius interrupta*) found in both wooded and brushy areas, the Indigo Snake (*Drymarchon corais erebennus*), and Texas Garter Snake (*Thamnophis sirtalis annectens*). A survey of any potential project site may be required prior to construction to determine whether populations of, or potential habitat for, species of concern occur in the affected area.

Streamflows would be reduced as water is withdrawn from either the Atascosa or Nueces Rivers. However, streamflows up to the Consensus Criteria requirements would be passed at the project locations. As water will be diverted primarily during high flow periods, potential adverse affects should be minimal.

When potential protected species habitat cannot be avoided, additional studies would have to be conducted to evaluate habitat use. Sites of historic or prehistoric significance would be evaluated for possible inclusion in the National Register for Historic Places. Wetland impacts can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where such impacts are unavoidable.

[9] Omernik, James M., "Ecoregions of the Conterminous United States," Annals of the Association of American Geographers, 77(1) pp. 118-125, 1987.

Table 6.4-3.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affect by Option Wintergarden Carrizo Recharge Enhancement (SCTN-7)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOE[2,3,4]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C			Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau				Resident
Elmendorf's Onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations			WL	Resident
Frio Pocket Gopher	*Geomys texensis bakeri*	Sandy surface layers with loam going as deep as 2 meters				Resident
Henslow's Sparrow	*Ammodramus henslowii*	Weedy fields or cut over areas; bare ground for running and walking				Nesting/Migrant
Indigo Snake	*Drymarchon corais erebennus*	Grass prairies and sand hills; usually thornbush woodland and mesquite savannah of coastal plain		T	WL	Resident
Jaguarundi	*Felis yagouaroundi*	South Texas thick brushlands, favors areas near water	E	E	E	Resident
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, Barrier islands and sandy areas				Resident
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrubland and live oak mottes; avoids open areas; primarily extreme south Texas	E	E	E	Resident
Parks' Jointweed	*Polygonella parksii*	South Texas Plains; subherbaceous annual in deep loose sands, spring-summer			WL	Resident
Plains Spotted Skunk	*Spilogale putorius interrupta*	Catholic; Wooded, brushy areas and tallgrass prairies				Resident
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Endemic grass prairies of South Texas Plains; usually thornbrush, mesquite-blackbrush		T	T	Resident
Sandhill Woolywhite	*Hymenopappus carrizoanus*	Endemic; Open areas in deep sands derived from Carrizo and similar Eocene formations				Resident
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear				Resident
Texas Garter Snake	*Thamnophis sirtalis annectens*	Varied, especially wet areas; bottomlands and pastures				Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Tortoise	*Gopherus berlandieri*	Open brush with grass understory; open grass and bare ground avoided; occupies shallow depressions at base of bush or cactus, underground burrows, under objects; active March to November		T	T	Resident
White-faced Ibis	*Plegadis chihi*	Varied, prefers freshwater marshes, sloughs and irrigated rice fields; Nests in low trees		T	T	Nesting/Migrant
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant
Yuma Myotis Bat	*Myotis yumanensis*	Desert regions, lowland habitats near open water, mines, tunnels, and buildings				Resident
Zone-tailed Hawk	*Buteo albonotatus*	Arid, open country including deciduous or pine-oak woodland; nests in various habitats and sites		T	T	Nesting/Migrant

1 Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
2 Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
3 Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
4 Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

6.4.4 Engineering and Costing

The site identified for the Nueces River diversion alternative would include a channel dam on the Nueces River near the town of Washer in Zavala County. Water would be diverted through parallel, 120-inch diameter, 1,000-foot pipelines to an off-channel storage reservoir. Water impounded in the storage reservoir would be released under gravity flow to the recharge field via a 96-inch diameter, 8,000-foot pipeline. The recharge field would consist of approximately 59 canals, 6,600 feet in length, with 12-foot bottom widths and 3:1 side slopes. Intake, pipeline, pumping station, operation and maintenance, and right-of-way acquisition costs were developed in accordance with the cost estimating procedures presented in Appendix A. Land was assumed to be purchased for the off-channel storage reservoir and the recharge field. Costs for development of the recharge field are based on costs for similar volumes of earthwork for recently completed projects. The cost estimate for the Nueces River alternative for this option is shown in Table 6.4-4

Financing the Nueces River alternative under TWDB guidelines (40 years at 6 percent annual interest for the off-channel reservoir and 30 years at 6 percent interest for all other facilities) results in an annual expense of $4,217,000. Annual operation and maintenance and energy costs total $1,400,000. The annual cost, including debt service, operation and maintenance, and pumping energy totals $5,617,000. For an average annual recharge enhancement of 11,000 acft, the resulting annual cost of water recharged to the Carrizo Aquifer from the Nueces River is $511 per acft (Table 6.4-4).

The site identified for the Atascosa River alternative would include a channel dam on the Atascosa River near the town of Rossville in Atascosa County. Water would be diverted through parallel, 120-inch diameter, 1,500-foot pipelines to an off-channel storage reservoir. The off-channel reservoir would be formed behind an earthen dam impounding an unnamed draw. Water impounded in the storage reservoir would be released under gravity flow to the recharge field via a 96-inch diameter, 14,000-foot pipeline. The recharge field would consist of approximately 84 canals, 4,700 feet in length, with 12-foot bottom widths, and 3:1 side slopes. Land was assumed to be purchased for the off-channel storage reservoir and the recharge field. Costs for development of the recharge field are based on costs for similar volumes of earthwork for recently completed projects. The cost estimate for the Atascosa River alternative for this option is shown in Table 6.4-5.

Table 6.4-4.
Cost Estimate Summary for Carrizo Aquifer Recharge Enhancement (SCTN-7)
Recharge of Available Flows from the Nueces River
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Dam and Reservoir (10,000 acft; 618 acres)	$10,945,000
Channel Dam	1,890,000
Intake and Pump Station (9,740 HP)	9,037,000
Recharge Canals (1,000 acres; 59 canals; 6,600 ft long)	9,995,000
Pipelines from Channel Dam to Reservoir (Two 120-inch dia.; 1,000 feet)	1,040,000
Pipeline from Reservoir to Recharge Zone (96-inch; 8,000 feet)	2,536,000
Highway and Stream Crossings	116,000
Power Connection Costs ($125/HP)	1,218,000
Total Capital Cost	**$36,777,000**
Engineering, Legal Costs and Contingencies	$12,080,000
Land Acquisition and Surveying (1,633 acres)	1,335,000
Interest During Construction (4 years)	8,220,000
Environmental & Archaeology Studies, Mitigation and Permitting	1,181,000
Total Project Cost	**$59,593,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$3,008,000
Reservoir Debt Service (6 percent for 40 years)	1,209,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	293,000
Dam and Reservoir	193,000
Recharge Field Maintenance and Cleaning	150,000
Pumping Energy Costs (28,006,971kWh @ $0.06 per kWh)	764,000
Total Annual Cost	**5,617,000**
Available Annual Recharge (acft/yr) Raw Water in Aquifer[1]	**11,000**
Annual Cost of Water ($ per acft) Raw Water in Aquifer[1]	**$511**
Annual Cost of Water ($ per 1,000 gallons) Raw Water in Aquifer[1]	**$1.57**

[1] Reported Annual Cost of Water is for additional water supply in the Carrizo Aquifer.

Table 6.4-5.
Cost Estimate Summary for Carrizo Aquifer Recharge Enhancement (SCTN-7)
Recharge of Available Flows from the Atascosa River
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
Dam and Reservoir (2,500 acft; 210 acres)	$4,708,000
Channel Dam	1,890,000
Intake and Pump Station (21,429 HP)	9,037,000
Recharge Canals (1,000 acres; 84 canals; 4,700 feet long)	10,133,000
Pipelines from Channel Dam to Reservoir (Two 120-inch, 1,500 feet)	1,560,000
Pipeline from Reservoir to Recharge Zone (96-inch, 1,400 ft)	444,000
Highway and Stream Crossings	116,000
Power Connection Costs ($125/HP)	1,218,000
Total Capital Cost	**$29,106,000**
Engineering, Legal Costs and Contingencies	$9,474,000
Land Acquisition and Surveying (1,210 acres)	1,795,000
Interest During Construction (4 years)	6,719,000
Environmental & Archaeology Studies, Mitigation and Permitting	1,617,000
Total Project Cost	**$48,711,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$2,956,000
Reservoir Debt Service (6 percent for 40 years)	534,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	278,000
Dam and Reservoir	99,000
Recharge Field Maintenance and Cleaning	152,000
Pumping Energy Costs (18,331,835 kWh @ $0.06 per kWh)	500,000
Total Annual Cost	**$4,519,000**
Available Annual Recharge (acft/yr) Raw Water in Aquifer[1]	**7,200**
Annual Cost of Water ($ per acft) Raw Water in Aquifer[1]	**$627**
Annual Cost of Water ($ per 1,000 gallons) Raw Water in Aquifer[1]	**$1.93**

[1] Reported Annual Cost of Water is for additional water supply in the Carrizo Aquifer.

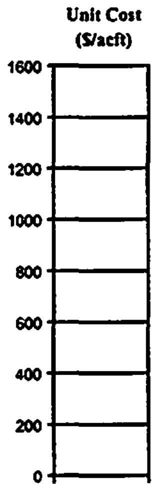
Financing the Atascosa River alternative results in an annual expense of $3,490,000. Annual operation and maintenance and energy costs total $1,029,000. The annual cost, including debt service, operation and maintenance, and pumping energy totals $4,519,000. For an average annual recharge enhancement of 7,200 acft, the resulting annual cost of water recharged to the Carrizo Aquifer from the Atascosa River is $627 per acft (Table 6.4-5).

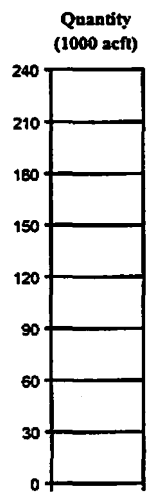
6.4.5 Implementation Issues

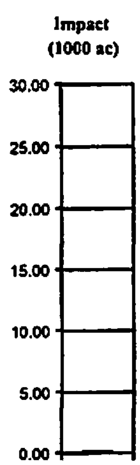
Implementation of Option SCTN-7 could directly affect the feasibility of other water supply options under consideration, including L-18, CZ-10C, CZ-10D, and/or SCTN-2a.

1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits.
   b. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. GLO Sand and Gravel Removal permits.
   d. GLO Easement for use of state-owned land.
   e. TPWD Sand, Gravel, and Marl permit.
2. Permitting may require these studies:
   a. Effects on bay and estuary inflows.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.
3. Land will need to be acquired through either negotiations or condemnation.
4. Recovery of the enhanced recharge would need to be coordinated and permitted through local groundwater conservation districts, including the Evergreen District for the Atascosa site and the Wintergarden District for the Nueces River site.

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **SCTN-2a**

OPTION NAME: **Groundwater Supplies for Municipal Water Systems in the Carrizo-Wilcox Aquifer**

OPTION DESCRIPTION: *Municipal water systems in the upper Coastal Plains area of the South Central Texas Water Planning Region commonly use the Carrizo-Wilcox Aquifer for their supply. This source is a strong preference because the water is usually readily available, inexpensive, and often suitable for public water supplies with minimal treatment. The purposes of this option are to (1) evaluate existing aquifers and well field(s) of each municipality as to its ability to meet projected water supply requirements through the year 2050; and (2) if additional supplies are needed, generally locate suitable new well fields and estimate the cost to add the additional supply to the municipal water system.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yr. ☐ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**N/A**	**per acft[1]**
QUANTITY OF WATER:	**N/A**	**acft/yr[2]**
LAND IMPACTED:	**N/A**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** See Individual City Fact Sheet.

[2]**QUANTITY OF WATER:** Not Applicable.

[3]**LAND IMPACTED:** Not Applicable.

ENVIRONMENTAL ISSUES: Not Applicable.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Not Applicable.

ADDITIONAL FACTORS: Not Applicable.

6.5 Groundwater Supplies for Municipal Water Systems in the Carrizo-Wilcox Aquifer, South Central Texas Water Planning Region (SCTN-2a)

6.5.1 Description of Municipal Water Demands and Groundwater Supplies

Municipal water systems in the upper Coastal Plains area of the South Central Texas Water Planning Region commonly use the Carrizo-Wilcox Aquifer for their supply. This source is a strong preference because the water is usually readily available, inexpensive, and often suitable for public water supplies with minimal treatment.

The purposes of this option are to:

- Evaluate aquifers and existing well field(s) of each municipality as to ability to meet projected water supply requirements through the year 2050;
- If additional supplies are needed, identify a suitable area for new well fields; and
- If additional wells are needed or if the water needs to be treated, estimate when the expansion is needed and how much the facilities will cost.

The evaluation of individual municipal water systems is at a reconnaissance level and does not include:

- An engineering analysis of the water system as to the condition or adequacy of the wells, transmission system, and storage facilities;
- A projection of maintenance or replacement costs of existing wells and facilities;
- The potential interference of new wells installed by others near the city's wells or at locations identified for new well fields;
- Impact of potential changes in groundwater use patterns in the vicinity of the city's well field and the county;
- Rules and regulations that may be developed and implemented by a groundwater conservation district or the State; nor
- Consideration of additional wells or water treatment for local purposes such as reliability, water pressure, peaking capacity, and localized growth.

The evaluation of each municipal water system consisted of the following steps:

1. Compiled information prepared for the South Central Texas Regional Water Planning Group on current (1996) and TWDB's projected populations and water demands for each of the municipalities;
2. Estimated the TNRCC required system capacity through the year 2050 for each water system;
3. Compiled and summarized publicly available information for each municipal water system from TNRCC and TWDB;

4. Analyzed aquifer information from TWDB and U.S. Geological Survey (USGS) reports as to availability of groundwater from major and minor aquifers in the vicinity of each municipality;
5. Compiled groundwater level data from the TWDB database and analyzed for short-term and long-term trends;
6. When trends showed a decline in groundwater levels, made an adjustment for an estimated decrease in well yields and groundwater availability. Considered the position of the static water level in relation to the top and bottom of the producing formation(s) and well spacing. Compared the long-term groundwater availability within the city's well field(s) with the estimated required system capacity in the year 2050;
7. If the estimated groundwater supply after adjustments was greater than the estimated required capacity in the year 2050, the evaluation concludes that the existing water supply is adequate;
8. If the estimated supply after adjustments was less than the estimated required capacity in the year 2050, the evaluation concluded that an additional water supply would be needed; and
9. If a new well field is a reasonable option, estimated when it is needed and the capital cost of adding the well field to the water system.

6.5.2 Evaluation of Municipal Water Systems

A summary description of each municipality and their well field(s) is presented in the following Fact Sheets. The Fact Sheets provide information about the current and future water demands, current well capacities, aquifer characteristics and conditions, and the conclusion of the adequacy of the water supply through the year 2050.

A discussion on the municipal water systems (Figure 6.5-1) is presented below.

6.5.2.1 Batesville, Charlotte, Crystal City, Dilley, Falls City, Floresville, Jourdanton, La Pryor, Nixon, Pearsall, Poteet, and Poth

The municipal systems servicing the communities of Batesville, Charlotte, Crystal City, Dilley, Falls City, Floresville, Jourdanton, La Pryor, Nixon, Pearsall, Poteet, and Poth have well fields that are not expected to encounter water supply problems or a need for expansion before the year 2050. However, regional water level declines in some areas may cause the system operators to lower pumps in some of their wells, and as growth in water demands occurs, it may be necessary to add wells to meet peak day demands.

Water from the Carrizo-Wilcox Aquifer often has iron concentrations greater than 0.3 milligrams per liter, which exceeds guidelines for aesthetic effects. TNRCC field surveys

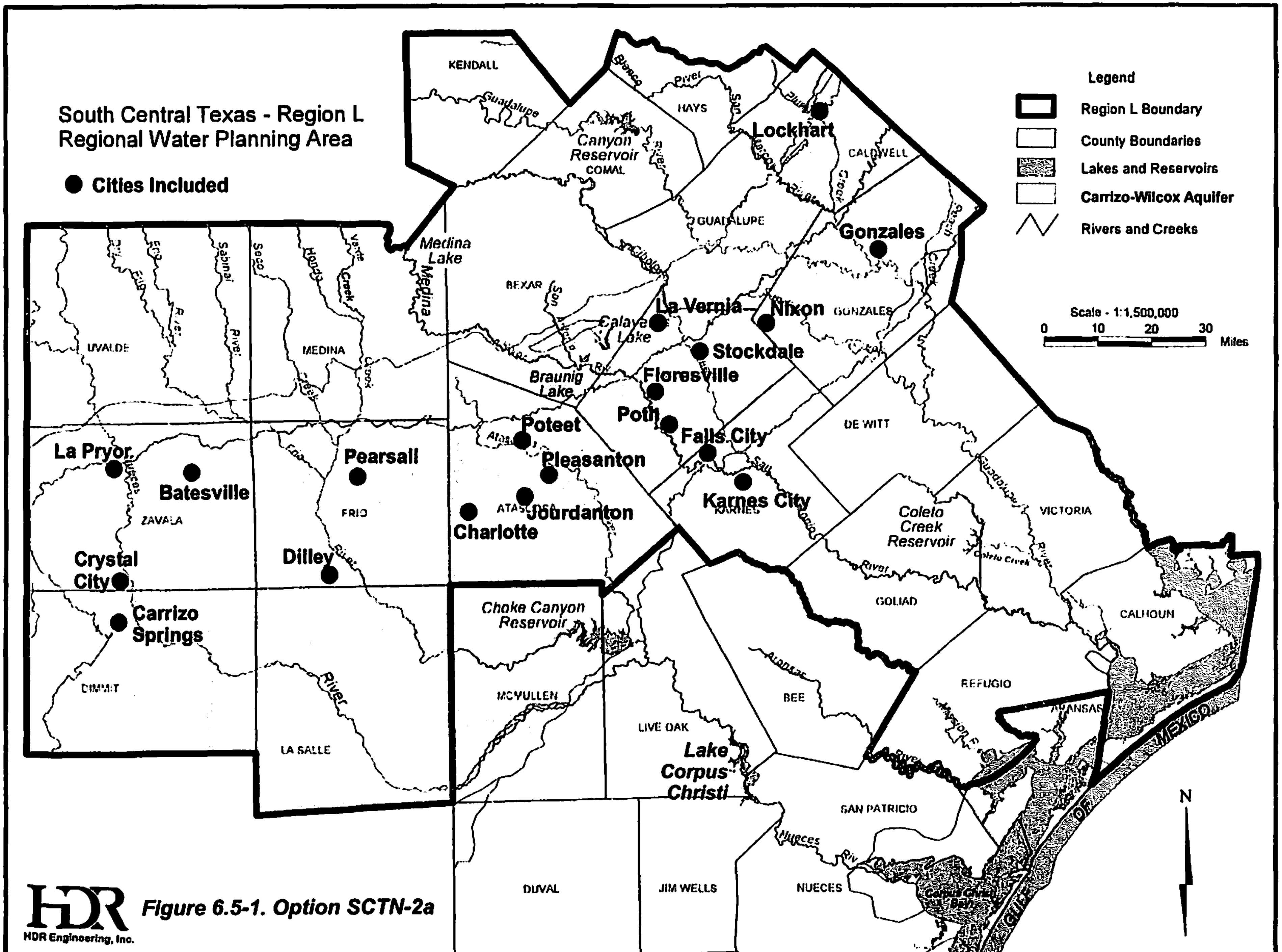


Figure 6.5-1. Option SCTN-2a

report that these guidelines are exceeded in the cities of Charlotte, Dilley, Jourdanton, Nixon, and Pearsall. The cost of adding a water treatment plant for each of these cities is provided in the Fact Sheet.

Some of the well fields are located where the Carrizo Aquifer is very deep and produces relatively hot water.

6.5.2.2 LaVernia, Gonzales

The cities of LaVernia and Gonzales have a combined surface water and groundwater supply, and are not expected to encounter water supply problems.

6.5.2.3 Carrizo Springs, Lockhart, Pleasanton, and Stockdale

The cities of Carrizo Springs, Lockhart, Pleasanton, and Stockdale appear to have sufficient groundwater supplies in their well fields. However, projections indicate that additional well(s) will be required before the year 2050. The date or year when the wells are needed and the estimated costs are provided in each city's Fact Sheet.

For the City of Lockhart, groundwater in the well field typically has iron concentrations greater than 0.3 milligrams per liter, which exceeds guidelines for aesthetic effects. The cost of adding a water treatment plant is provided in the Lockhart Fact Sheet.

6.5.2.4 Karnes City

Karnes City is between the downdip limits of the Carrizo Aquifer and the freshwater formations of the Gulf Coast Aquifer. Karnes City has one Carrizo Aquifer well near Falls City that is the primary supply. Three wells in the Catahoula Formation of the Gulf Coast Aquifer are located in the city and produce slightly saline water. They are used for emergency supplies. Additional supplies can be acquired by expanding the well field near Falls City or using a desalinization process for the Catahoula Aquifer wells in Karnes City (see Option SCTN-17 of Section 1.10).

6.5.3 Environmental Issues

In Option SCTN-2a existing municipal well fields in the upper Coastal Plains area, which use the Carrizo-Wilcox Aquifer for their water supply are evaluated. Some municipalities will need additional wells or well fields to meet projected water supply requirements to the year 2050.

Data from well fields in this area show declining trends in groundwater levels during the past 30 years. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels.

The pumping of groundwater from the Carrizo-Wilcox Aquifer could have a negative impact on springflow and temporary pools in these areas. Some species inhabit or use temporary pools as well as aquifers and springs. Possible negative effects on these species should be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primary pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.5.4 *Engineering and Costing: See Individual City Fact Sheets*

6.5.5 *Implementation Issues*

The development of additional wells and well fields in the Carrizo-Wilcox Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

- Detailed feasibility evaluation including test drilling and aquifer water quality testing.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Competition with others for groundwater in the area.
- Regulations by Underground Water conservation Districts, including the renewal of pumping permits at periodic intervals in counties where districts have been organized.

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ID 1 City Batesville TNRCC Survey Year 1995

County Zavala

Aquifer Carrizo

PWS_ID 2540005

Connections

Retail 360

Wholesale 0

Outside Water Supply No

Population

City

1996	1,303
2050	1,669
Growth (%)	28

Service Area

Survey Year	1,080
2050	1,383

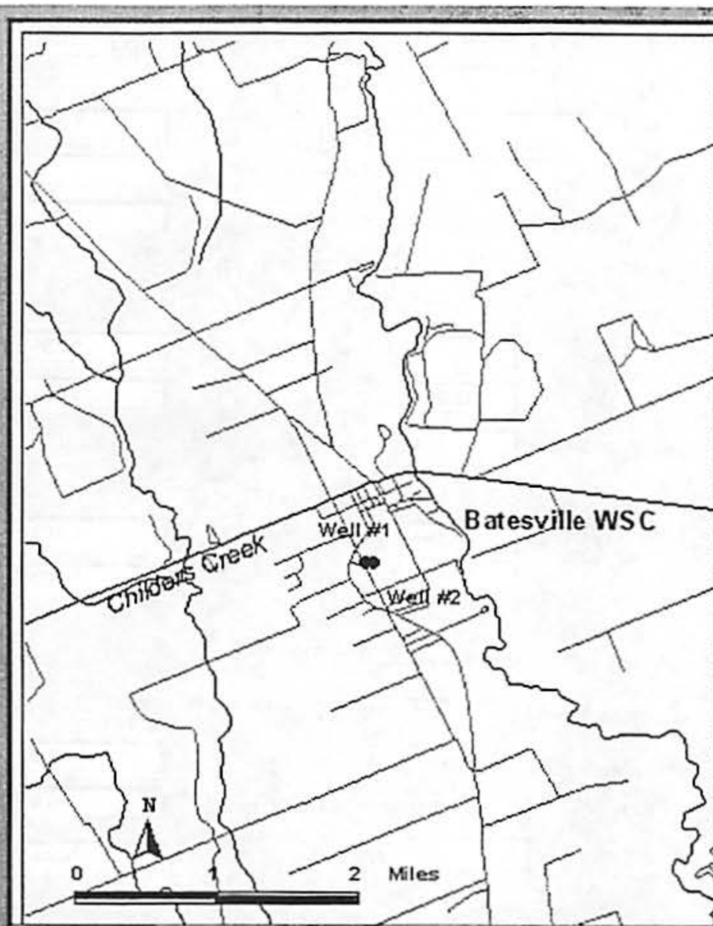
Average Use (mgd)

City

Survey Year	0.209
2050	0.207

Service Area

Survey Year	N/A
2050	



Aquifer Information

Static Water Level (ft) 340

Water-bearing Zone (ft)

Top 700

Bottom 1,000

Trend in Groundwater Levels

Last Decade (ft/yr) -2.3

Last 3 Decades (ft/yr) -2.9

Water Quality Problems None

Well Information

Total Well Capacity (gpm) 770

Total Well Capacity (mgd) 1.108

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year 0.311

2050 0.399

	Well 1	Well 2	Well	Well	Well
Depth (ft)	807	807			
Yield (gpm)	400	370			

	Well	Well	Well	Well	Well
Depth (ft)					
Yield (gpm					

	Well	Well	Well	Well	Well
Depth (ft)					
Yield (gpm					

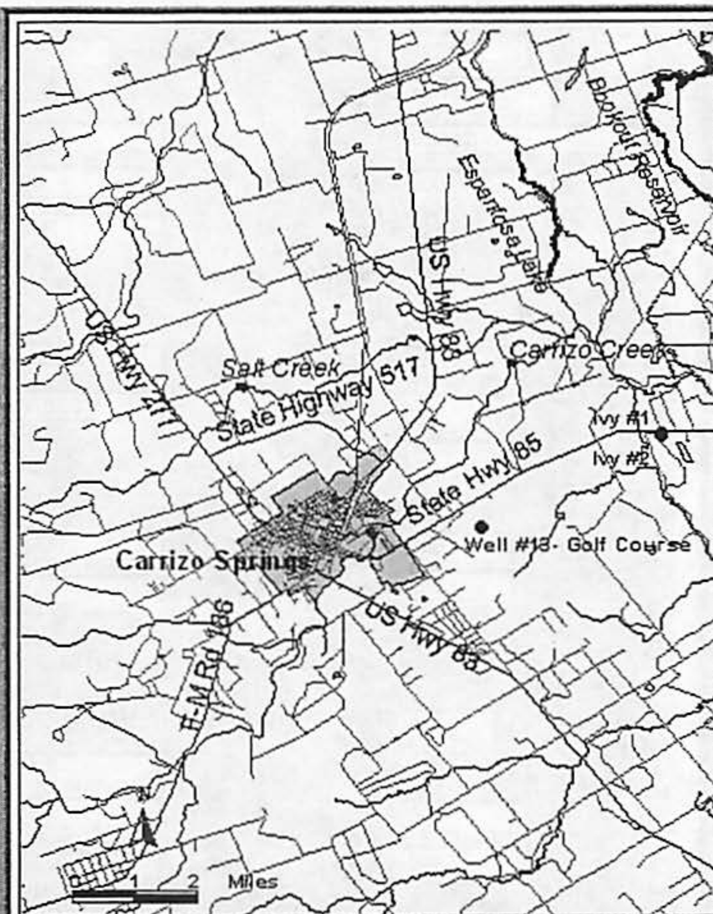
Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Batesville appear to be adequate to meet the Texas Water Development Board's projected demands for Batesville through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	2	City	Carrizo Sprs
County	Dimmit		
Aquifer	Carrizo		
PWS_ID	0640002		

TNRCC Survey Year	1998
Connections	
Retail	1,948
Wholesale	0
Outside Water Supply	No



Population

City	
1996	5,771
2050	15,262
Growth (%)	164
Service Area	
Survey Year	5,844
2050	15,455

Average Use (mgd)

City	
Survey Year	1.736
2050	3.690
Service Area	
Survey Year	1.460
2050	3.103

Aquifer Information

Static Water Level (ft)	400
Water-bearing Zone (ft)	
Top	200
Bottom	800

Trend in Groundwater Levels	
Last Decade (ft/yr)	-0.2
Last 3 Decades (ft/yr)	-0.9
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	2,700
Total Well Capacity (mgd)	3.888

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	1.684
2050	4.444

Well: Ivy #1	Well: Ivy #2	Well: 13	Well:	Well:
Depth (ft): 800	Depth (ft): 800	Depth (ft): 514	Depth (ft):	Depth (ft):
Yield (gpm): 1,150	Yield (gpm: 1,250	Yield (gpm: 300	Yield (gpm:	Yield (gpm:
Well:	Well:	Well:	Well:	Well:
Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):
Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:
Well:	Well:	Well:	Well:	Well:
Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):
Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity (within 5 miles toward the east) of Carrizo Springs appear to be adequate to meet the Texas Water Development Board's projected demands for Carrizo Springs through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

After year 2030, a new well will be needed. The estimated cost for a new well and half a mile of pipeline is $396,000.

ID	3	City	Charlotte
County	Atascosa	TNRCC Survey Year	1999
Aquifer	Carrizo		
PWS_ID	0070016		

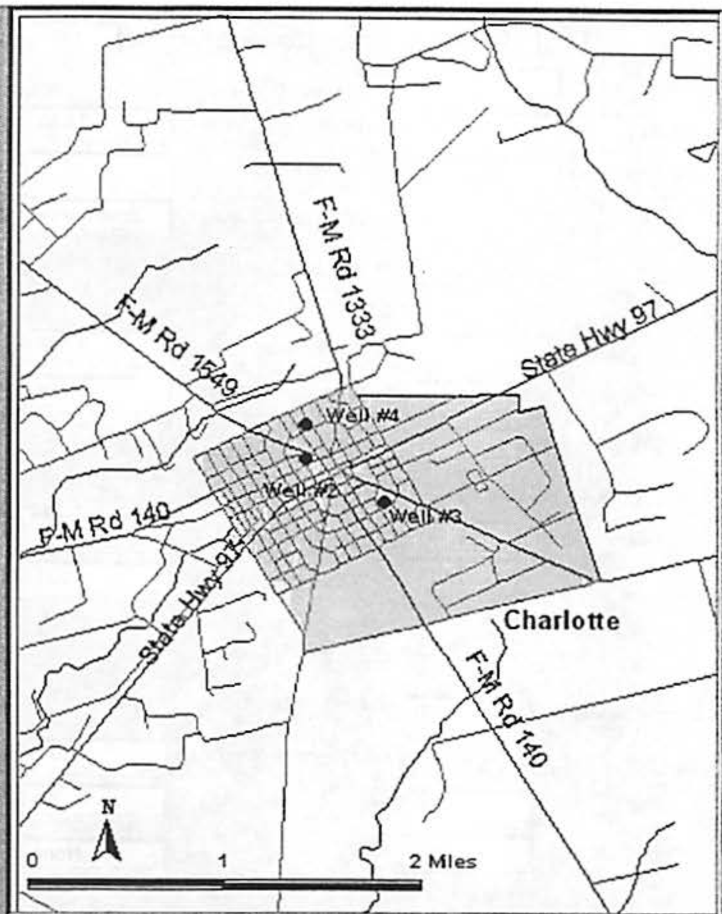
Connections

Retail	581
Wholesale	0
Outside Water Supply	No

Population		**Average Use (mgd)**	
City		City	
1996	1,604	Survey Year	0.285
2050	2,982	2050	0.507
Growth (%)	86		
Service Area		Service Area	
Survey Year	1,743	Survey Year	0.236
2050	3,240	2050	0.420

Aquifer Information

Static Water Level (ft)	240	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	-1.8
Top	1,500	Last 3 Decades (ft/yr)	-1.7
Bottom	2,300	Water Quality Problems	Iron



Well Information

Total Well Capacity (gpm)	1,820
Total Well Capacity (mgd)	2.621

TNRCC Required Capacity (mgd)		
Peak day demand in Service Area	Survey Year	0.502
	2050	0.934

Well	Depth (ft)	Yield (gpm)
2	1,864	420
3	1,993	550
4	1,930	850

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Charlotte appear to be adequate to meet the Texas Water Development Board's projected demands for Charlotte through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

A 1.0 mgd water treatment plant to remove excessive iron concentrations is estimated to cost $2,596,000.

ID: 4 | City: Crystal City | TNRCC Survey Year: 1997

County: Zavala

Aquifer: Carrizo

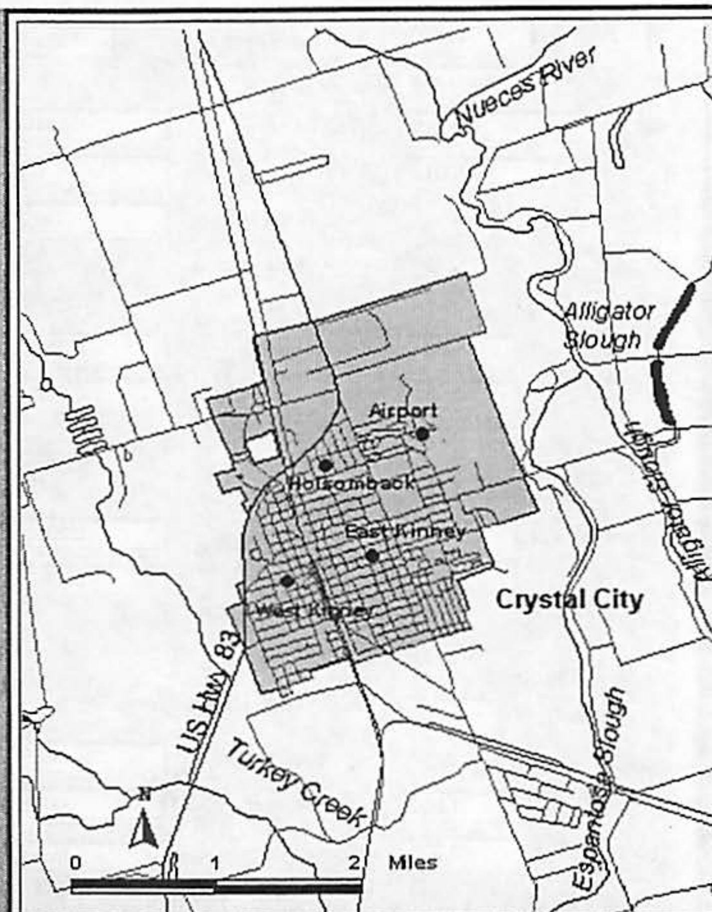
PWS_ID: 2540001

Connections

Retail: 2,049

Wholesale: 0

Outside Water Supply: Emergency



Population

City	
1996	8,227
2050	10,140
Growth (%)	23

Service Area	
Survey Year	6,147
2050	7,576

Average Use (mgd)

City	
Survey Year	1.688
2050	1.704

Service Area	
Survey Year	1.907
2050	1.925

Aquifer Information

Static Water Level (ft): 270

Water-bearing Zone (ft)

Top: 700

Bottom: 900

Trend in Groundwater Levels

Last Decade (ft/yr): -0.2

Last 3 Decades (ft/yr): 2.4

Water Quality Problems: None

Well Information

Total Well Capacity (gpm): 4,820

Total Well Capacity (mgd): 6.941

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year: 1.771

2050: 2.183

Well	West Kinney	Holsomback	Airport	East Kinney	
Depth (ft)	990	995	1,000	1,000	
Yield (gpm)	1220	1050	1230	1320	

Well					
Depth (ft)					
Yield (gpm					

Well					
Depth (ft)					
Yield (gpm					

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Crystal City appear to be adequate to meet the Texas Water Development Board's projected demands for Crystal City through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID: 5 | City: Dilley | TNRCC Survey Year: 1998

County: Frio

Aquifer: Carrizo

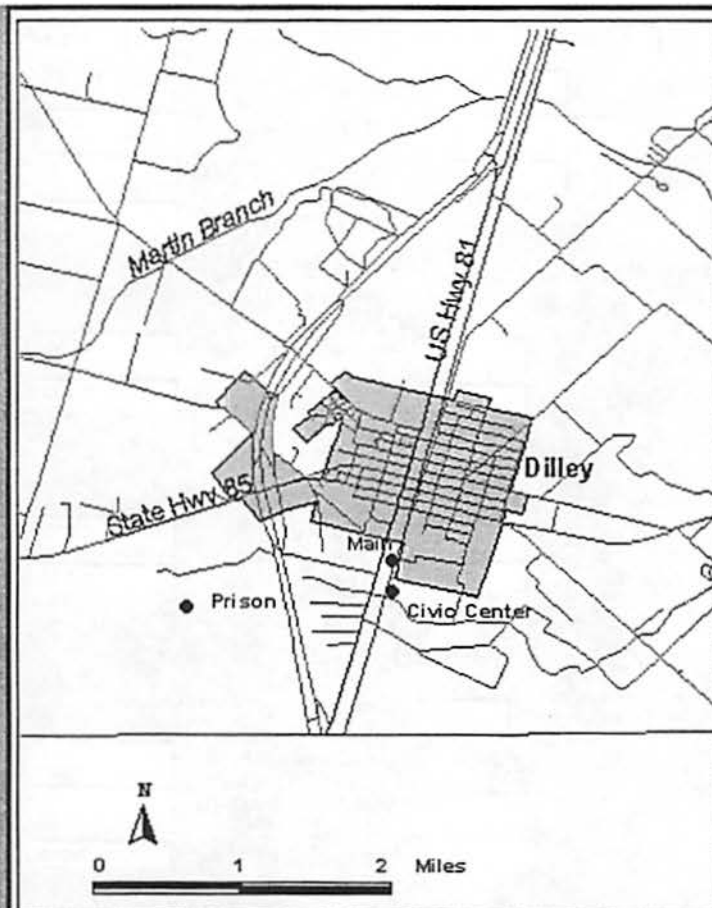
PWS_ID: 0820001

Connections

Retail: 1,305

Wholesale: 0

Outside Water Supply: No



Population

City	
1996	2,952
2050	4,209
Growth (%)	43

Service Area	
Survey Year	4,400
2050	6,274

Average Use (mgd)

City	
Survey Year	0.643
2050	0.859

Service Area	
Survey Year	0.680
2050	0.908

Aquifer Information

Static Water Level (ft): 280

Water-bearing Zone (ft)

Top: 1,700

Bottom: 2,200

Trend in Groundwater Levels

Last Decade (ft/yr): 6.5

Last 3 Decades (ft/yr): -2.7

Water Quality Problems: Iron

Well Information

Total Well Capacity (gpm): 3,400

Total Well Capacity (mgd): 4.896

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year: 1.128

2050: 1.609

Well	Depth (ft)	Yield (gpm)
Civic Center	2,200	1,100
Main - op	2,150	1,100
Prison	2,200	1,200

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Dilley appear to be adequate to meet the Texas Water Development Board's projected demands for Dilley through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

A 2.0 mgd water treatment plant to remove excessive iron concentrations is estimated to cost $3,063,000.

ID: 6 | City: Falls City | TNRCC Survey Year: 1999

County: Karnes

Aquifer: Carrizo

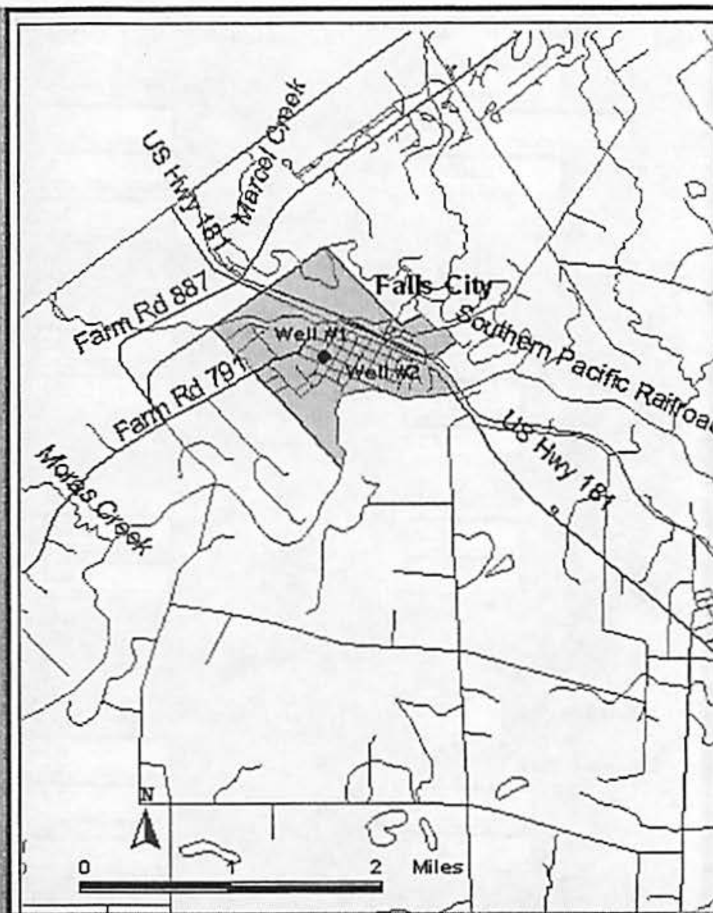
PWS_ID: 1280004

Connections

Retail: 245

Wholesale: 0

Outside Water Supply: No



Population

City	
1996	515
2050	676
Growth (%)	31

Service Area	
Survey Year	735
2050	963

Average Use (mgd)

City	
Survey Year	0.095
2050	0.103

Service Area	
Survey Year	0.099
2050	0.130

Aquifer Information

Static Water Level (ft): 180

Water-bearing Zone (ft)

Top: 2,700

Bottom: 3,800

Trend in Groundwater Levels

Last Decade (ft/yr): -1

Last 3 Decades (ft/yr): -1.1

Water Quality Problems: None

Well Information

Total Well Capacity (gpm): 625

Total Well Capacity (mgd): 0.900

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year: 0.212

2050: 0.278

Well	Depth (ft)	Yield (gpm)
1	3,564	325
2	3,607	300

Evaluation of Water Supply to Year 2050

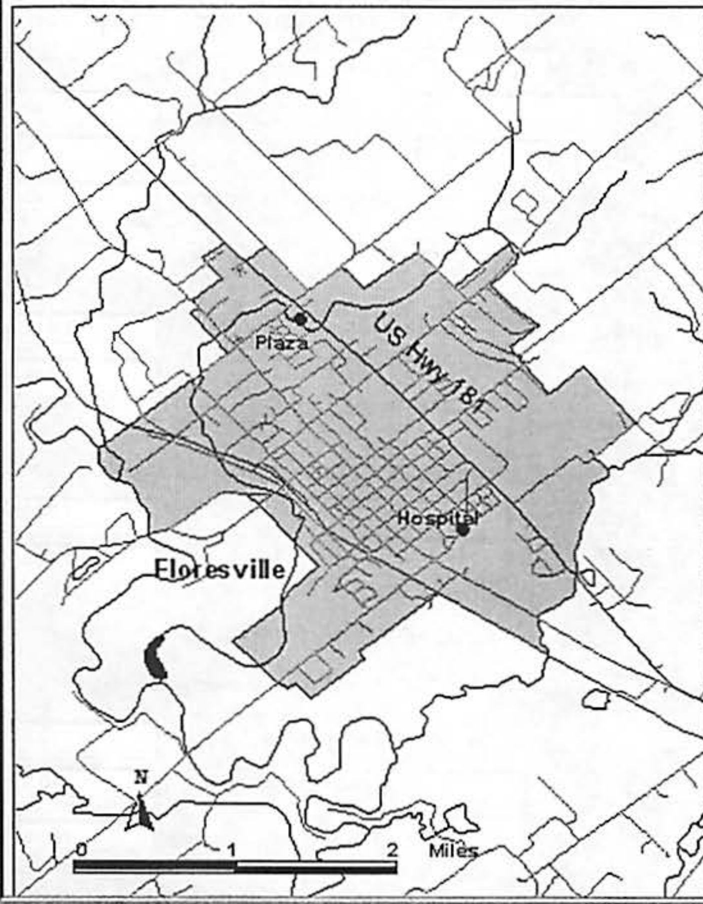
Groundwater supplies from the Carrizo Aquifer in the vicinity of Falls City appear to be adequate to meet the Texas Water Development Board's projected demands for Falls City through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	7	City	Floresville
TNRCC Survey Year	1997		
County	Wilson		
Aquifer	Carrizo		
PWS_ID	2470001		

Connections

Retail	2,064
Wholesale	0
Outside Water Supply	No



Population

City	
1996	6,309
2050	9,112
Growth (%)	44

Service Area	
Survey Year	6,192
2050	8,943

Average Use (mgd)

City	
Survey Year	1.023
2050	1.440

Service Area	
Survey Year	1.149
2050	1.617

Aquifer Information

Static Water Level (ft)	40
Water-bearing Zone (ft)	
Top	700
Bottom	1,500

Trend in Groundwater Levels	
Last Decade (ft/yr)	-0.5
Last 3 Decades (ft/yr)	-0.3
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1,820
Total Well Capacity (mgd)	2.621

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	1.784
2050	2.577

Well	Hospital	Plaza			
Depth (ft)	1,260	1,025			
Yield (gpm)	720	1100			
Well					
Depth (ft)					
Yield (gpm					
Well					
Depth (ft)					
Yield (gpm					

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carizzo Aquifer in the vicinity of Floresville appear to be adequate to meet the Texas Water Development Board's projected demands for Floresville through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

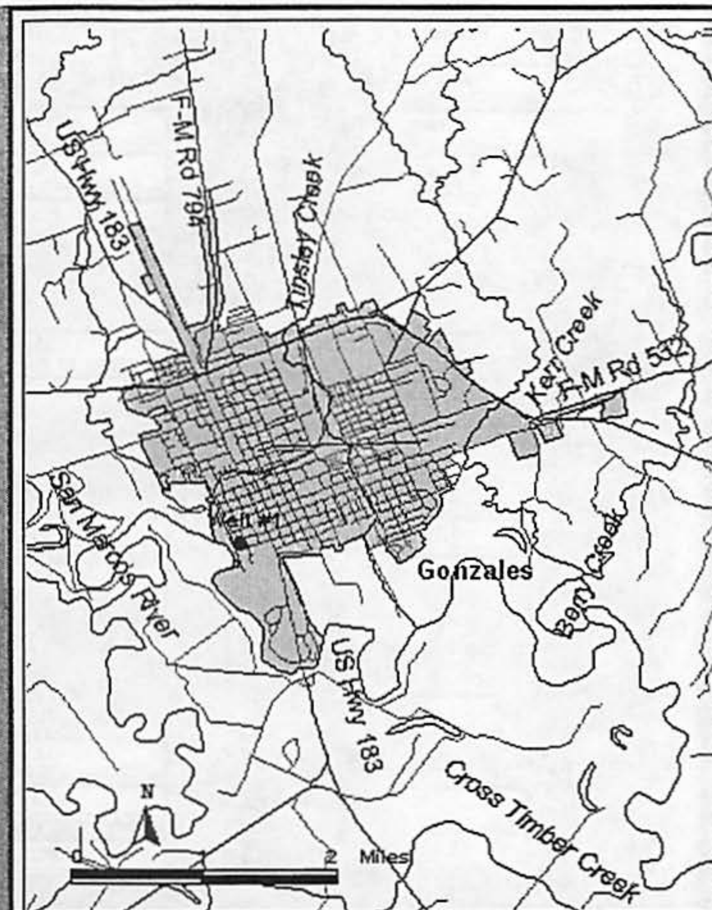
ID 8 City Gonzales TNRCC Survey Year 1998

County Gonzales

Aquifer Carrizo

PWS_ID 0890001

Connections	
Retail	2,885
Wholesale	1
Outside Water Supply	No



Population

City	
1996	6,417
2050	8,232
Growth (%)	28

Service Area	
Survey Year	8,715
2050	11,180

Average Use (mgd)

City	
Survey Year	1.512
2050	1.449

Service Area	
Survey Year	1.740
2050	1.668

Aquifer Information

Static Water Level (ft) 40

Water-bearing Zone (ft)

Top	1,400
Bottom	1,900

Trend in Groundwater Levels

Last Decade (ft/yr)	-0.8
Last 3 Decades (ft/yr)	-0.5
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1,600
Total Well Capacity (mgd)	2.304

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	2.510
2050	3.220

Well # 1	Well # 2	Well	Well	Well
Depth (ft) 1,600	Depth (ft) 1,832	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm) 400	Yield (gpm 1,200	Yield (gpm	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm

Evaluation of Water Supply to Year 2050

Water supplies for Gonzales are a combination of surface water from the Guadalupe River and the Carrizo Aquifer and appear to be adequate to meet the Texas Water Development Board's projected demands for Gonzales through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID 9 City Jourdanton TNRCC Survey Year 1997

County Atascosa

Aquifer Carrizo

PWS_ID 0070002

Connections

Retail 1,280

Wholesale 0

Outside Water Supply No

Population

City	
1996	3,597
2050	6,313
Growth (%)	76

Service Area	
Survey Year	3,840
2050	6,739

Average Use (mgd)

City	
Survey Year	0.499
2050	1.004

Service Area	
Survey Year	0.922
2050	1.855

Aquifer Information

Static Water Level (ft) 120

Water-bearing Zone (ft)

Top 1,400

Bottom 2,200

Trend in Groundwater Levels

Last Decade (ft/yr) -6.4

Last 3 Decades (ft/yr) -2.3

Water Quality Problems Iron

Well Information

Total Well Capacity (gpm) 2,550

Total Well Capacity (mgd) 3.672

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year 1.107

2050 1.942

Well	Depth (ft)	Yield (gpm)
3	2,000	700
4	2,200	1,100
5	1,960	750

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Jourdanton appear to be adequate to meet the Texas Water Development Board's projected demands for Jourdanton through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

A 2.0 mgd water treatment plant to remove excessive iron concentrations is estimated to cost $3,063,000.

ID 10 City Karnes City TNRCC Survey Year 1999

County Karnes

Connections

Aquifer Catahoula & Carrizo | Retail 1,209

PWS_ID 1280001 | Wholesale 0

Outside Water Supply Emergency

Population

City

1996	3,039
2050	4,793
Growth (%)	58

Service Area

Survey Year	3,627
2050	5,720

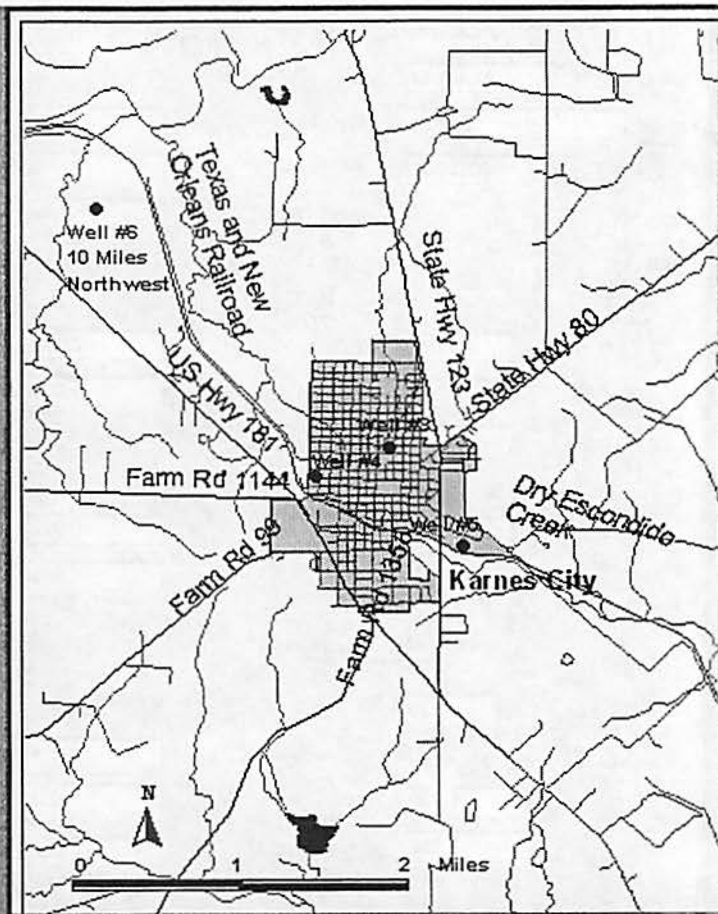
Average Use (mgd)

City

Survey Year	0.351
2050	0.460

Service Area

Survey Year	0.326
2050	0.427



Aquifer Information

Static Water Level (ft) 180

Trend in Groundwater Levels

Water-bearing Zone (ft)

Top	<100	Last Decade (ft/yr)	2.2
Bottom	4,000	Last 3 Decades (ft/yr)	3.2
		Water Quality Problems	None

Well Information

Total Well Capacity (gpm) 1,270

Total Well Capacity (mgd) 1.829

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	1.045
2050	1.649

Well 3	Well 4	Well 5	Well 6	Well
Depth (ft) 872	Depth (ft) 1,000	Depth (ft) 905	Depth (ft) 3,818	Depth (ft)
Yield (gpm) 120	Yield (gpm 250	Yield (gpm 250	Yield (gpm 650	Yield (gpm

Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm

Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm

Evaluation of Water Supply to Year 2050

Groundwater supplies in the vicinity of Karnes City are difficult to obtain. The Carrizo Aquifer is very deep and the water is hot and water bearing zones in the Catahoula Formation have limited production. Additional supplies may be needed.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	11	City	La Pryor
TNRCC Survey Year	1998		
County	Zavala		
Aquifer	Carrizo		
PWS_ID	2540003		

Connections

Retail	522
Wholesale	0
Outside Water Supply	No

Population

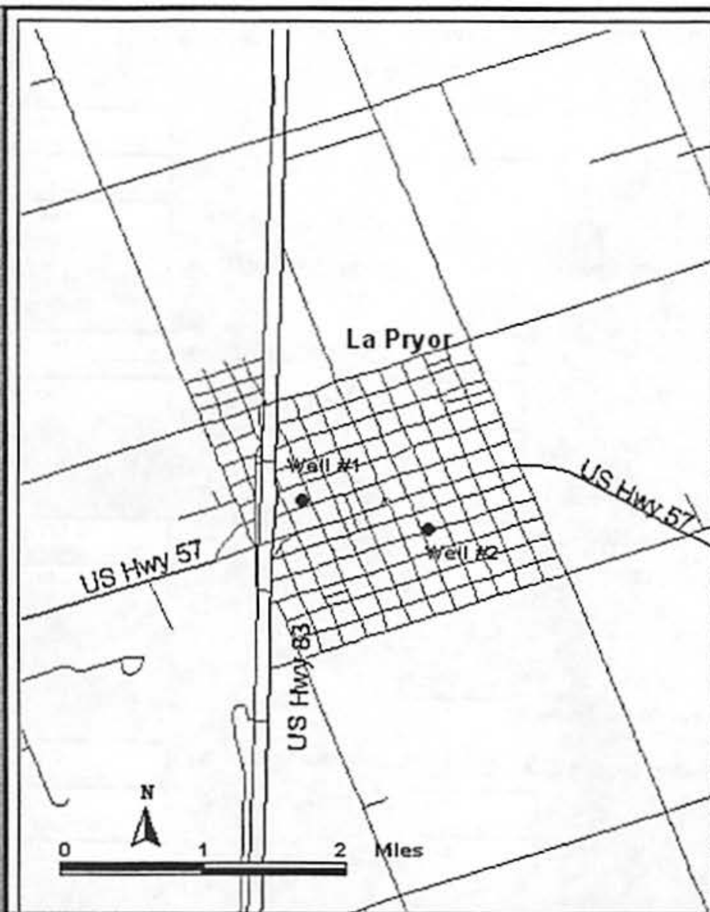
City	
1996	1,269
2050	938
Growth (%)	-26

Service Area	
Survey Year	1,566
2050	1,158

Average Use (mgd)

City	
Survey Year	0.300
2050	0.142

Service Area	
Survey Year	0.317
2050	0.150



Aquifer Information

Static Water Level (ft)	330
Water-bearing Zone (ft) Top	400
Bottom	700

Trend in Groundwater Levels	
Last Decade (ft/yr)	-0.4
Last 3 Decades (ft/yr)	-1.6
Water Quality Problems	Radium

Well Information

Total Well Capacity (gpm)	1,040
Total Well Capacity (mgd)	1.498

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	0.451
2050	0.334

Well	Depth (ft)	Yield (gpm)
1	547	700
2	580	500

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of La Pryor appear to be adequate to meet the Texas Water Development Board's projected demands for La Pryor through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	12	City	LaVernia
County	Wilson	TNRCC Survey Year	1997
Aquifer	Wilcox		
PWS_ID	2470004		

Connections

Retail	475
Wholesale	0
Outside Water Supply	Yes

Population

City

1996	860
2050	1,297
Growth (%)	51

Service Area

Survey Year	1,425
2050	2,149

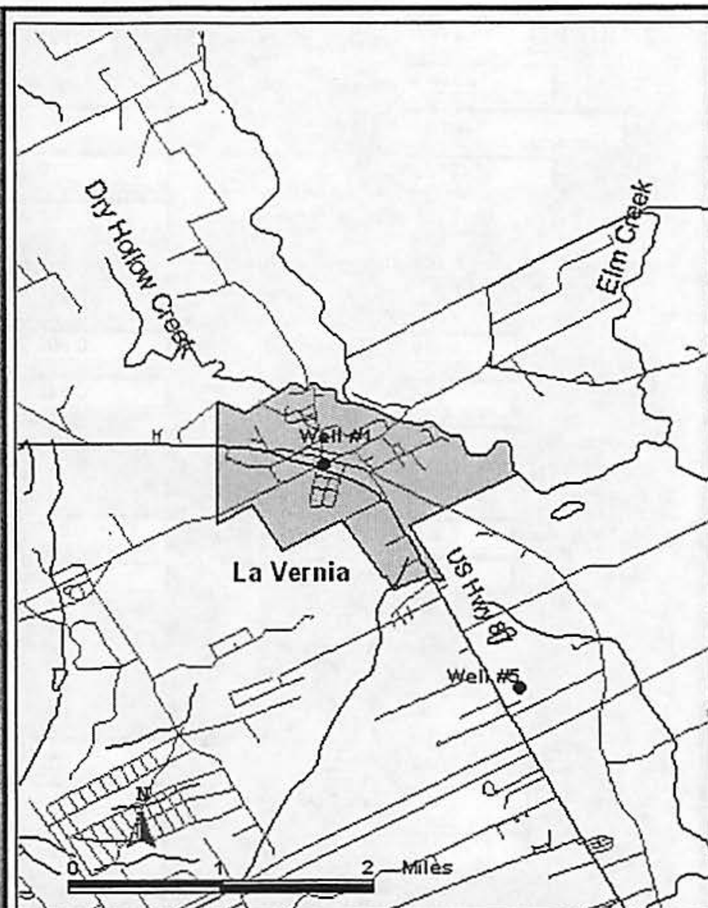
Average Use (mgd)

City

Survey Year	0.181
2050	0.255

Service Area

Survey Year	0.177
2050	0.249



Aquifer Information

Static Water Level (ft)	170
Water-bearing Zone (ft) Top	<100
Bottom	600
Trend in Groundwater Levels Last Decade (ft/yr)	-0.6
Last 3 Decades (ft/yr)	-0.1
Water Quality Problems	TDS

Well Information

Total Well Capacity (gpm)	490
Total Well Capacity (mgd)	0.706

TNRCC Required Capacity (mgd)
Peak day demand in Service Area

Survey Year	0.411
2050	0.619

Well	Depth (ft)	Yield (gpm)
1	525	240
5	520	250

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Wilcox Aquifer in the vicinity of LaVernia and from Canyon Regional Water Authority. Supplies appear to be adequate to meet the Texas Water Development Board's projected demands for LaVernia through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID: 13 | City: Lockhart | TNRCC Survey Year: 1998

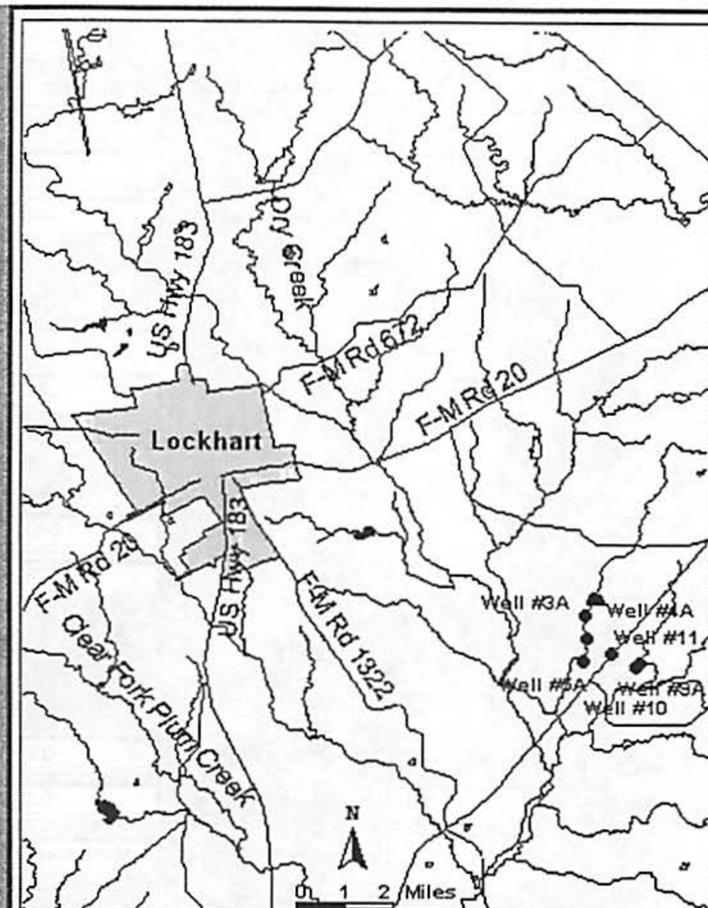
County: Caldwell

Connections

Aquifer: Wilcox | Retail: 3,257

PWS_ID: 0280001 | Wholesale: 15

Outside Water Supply: Emergency



Population

City	
1996	9,769
2050	20,605
Growth (%)	111

Service Area	
Survey Year	9,945
2050	20,984

Average Use (mgd)

City	
Survey Year	1.815
2050	2.718

Service Area	
Survey Year	1.562
2050	2.342

Aquifer Information

Static Water Level (ft): 40

Water-bearing Zone (ft)
- Top: <100
- Bottom: 700

Trend in Groundwater Levels
- Last Decade (ft/yr): -0.4
- Last 3 Decades (ft/yr): -0.5

Water Quality Problems: Iron

Well Information

Total Well Capacity (gpm): 2,864

Total Well Capacity (mgd): 4.124

TNRCC Required Capacity (mgd) — Survey Year: 2.829

Peak day demand in Service Area — 2050: 5.967

Well	Depth (ft)	Yield (gpm)
3-A	420	400
4-A	320	300
5-A	365	405
9-A	608	600
10	622	480
11	635	680

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Wilcox Aquifer in the vicinity of Lockhart appear to be adequate to meet the Texas Water Development Board's projected demands for Lockhart through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

Four new wells will be required; one before 2010, and three between 2010 and 2020. The estimated cost for each well and half mile of pipeline is $272,000. A water treatment plant to remove excessive iron is estimated to cost $4,932,000.

ID: 14 | City: Nixon | TNRCC Survey Year: 1999

County: Gonzales

Aquifer: Carrizo

PWS_ID: 0890002

Connections

Retail: 820

Wholesale: 0

Outside Water Supply: No

Population

City

1996	2,056
2050	2,511
Growth (%)	22

Service Area

Survey Year	2,460
2050	3,004

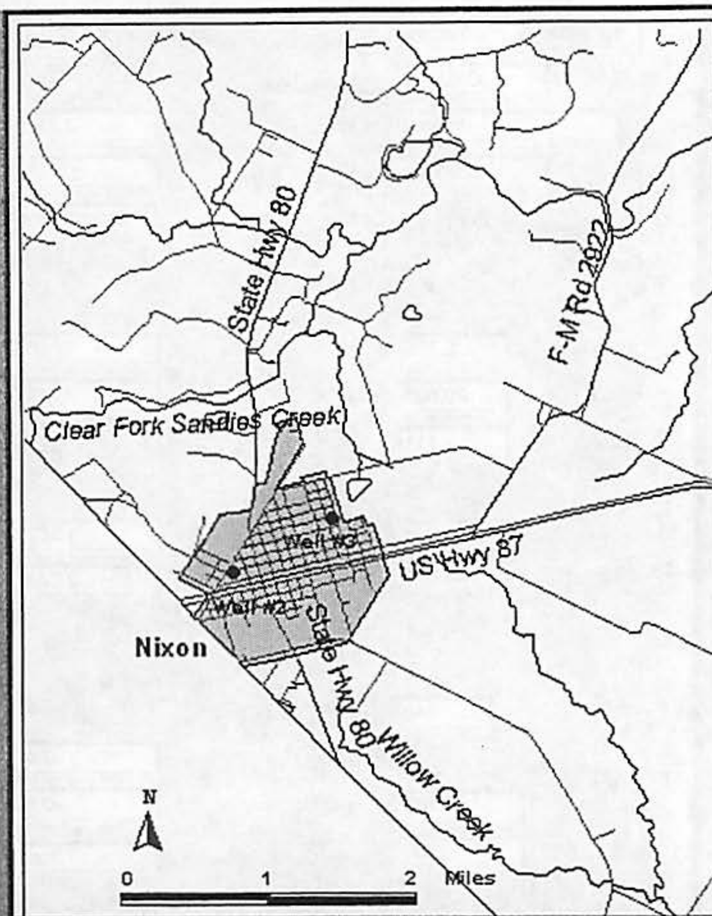
Average Use (mgd)

City

Survey Year	0.363
2050	0.324

Service Area

Survey Year	1.040
2050	0.928



Aquifer Information

Static Water Level (ft): 20

Water-bearing Zone (ft)

Top: 1,200

Bottom: 1,900

Trend in Groundwater Levels

Last Decade (ft/yr): -0.2

Last 3 Decades (ft/yr): -0.2

Water Quality Problems: Manganese

Well Information

Total Well Capacity (gpm): 1,870

Total Well Capacity (mgd): 2.692

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year: 0.709

2050: 0.866

Well	Depth (ft)	Yield (gpm)
3	1,645	1,320
2	1,396	550

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Nixon appear to be adequate to meet the Texas Water Development Board's projected demands for Nixon through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

A 1.0 mgd water treatment plant to remove excessive concentrations of manganese is estimated to cost $2,596,000.

ID: 15 | City: Pearsall | TNRCC Survey Year: 1997

County: Frio

Aquifer: Carrizo

PWS_ID: 0820002

Connections

Retail	2,682
Wholesale	0
Outside Water Supply	N/A

Population

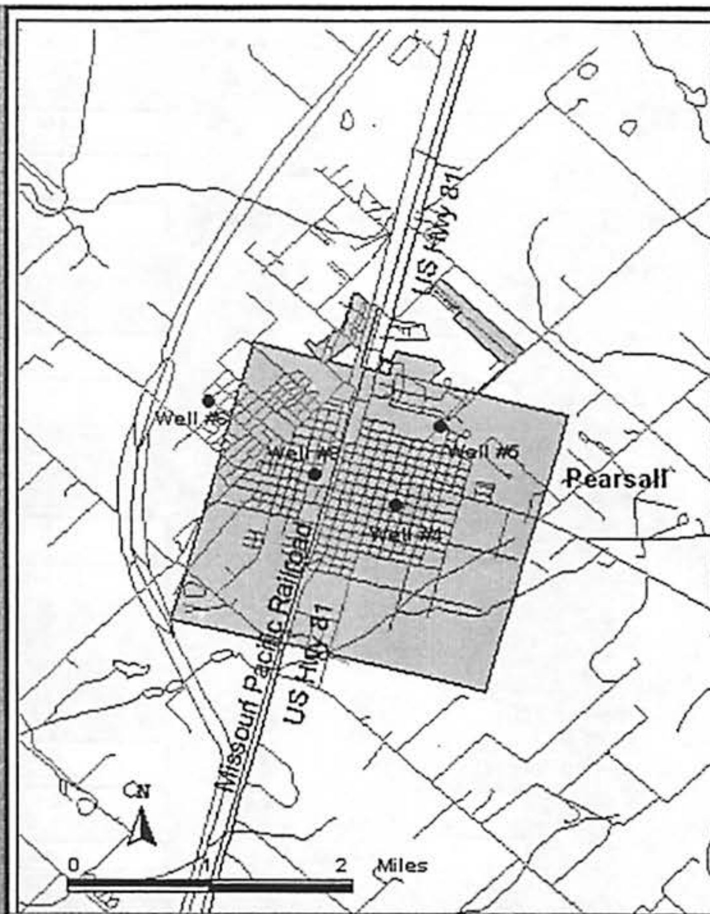
City	
1996	7,821
2050	10,979
Growth (%)	40

Service Area	
Survey Year	8,046
2050	11,295

Average Use (mgd)

City	
Survey Year	1.291
2050	2.021

Service Area	
Survey Year	1.320
2050	2.066



Aquifer Information

Static Water Level (ft): 300

Water-bearing Zone (ft)

Top	1,200
Bottom	1,900

Trend in Groundwater Levels

Last Decade (ft/yr)	-2.2
Last 3 Decades (ft/yr)	-2.1
Water Quality Problems	Iron

Well Information

Total Well Capacity (gpm): 4,180

Total Well Capacity (mgd): 6.019

TNRCC Required Capacity (mgd) Peak day demand in Service Area

Survey Year	2.319
2050	3.255

Well	Depth (ft)	Yield (gpm)
4	1,290	580
5	1,400	1,200
6	1,541	1,100
8	1,500	1,300

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Pearsall appear to be adequate to meet the Texas Water Development Board's projected demands for Pearsall through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

A 3.0 mgd water treatment plant to remove excessive concentrations of iron is estimated to cost $3,531,000.

ID 16 City Pleasanton TNRCC Survey Year 1998

County Atascosa

Aquifer Queen City & Carrizo

PWS_ID 0070003

Connections

Retail	3,444
Wholesale	302
Outside Water Supply	No

Population

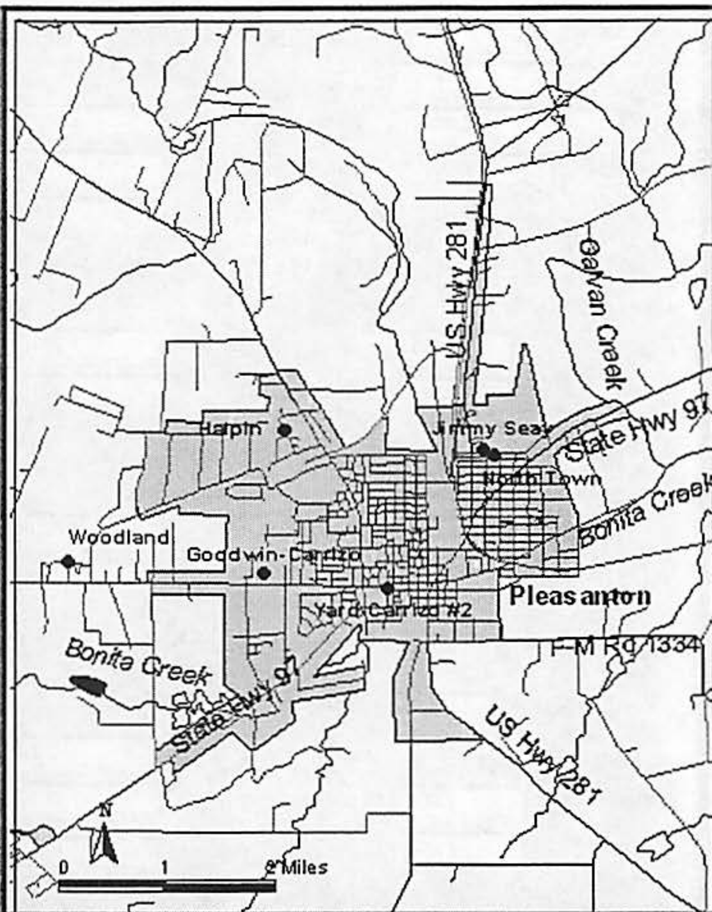
City	
1996	8,611
2050	17,092
Growth (%)	98

Service Area	
Survey Year	9,681
2050	19,168

Average Use (mgd)

City	
Survey Year	1.710
2050	3.143

Service Area	
Survey Year	1.826
2050	3.359



Aquifer Information

Static Water Level (ft) 50

Water-bearing Zone (ft)

Top	100
Bottom	2,000

Trend in Groundwater Levels

Last Decade (ft/yr)	-0.5
Last 3 Decades (ft/yr)	-0.8
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	4,370
Total Well Capacity (mgd)	6.292

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	3.237
2050	6.409

Well	Depth (ft)	Yield (gpm)
Woodland	750	400
North Town	790	500
Jimmy Seay	763	400
Halpin	723	370
Goodwin-Carri	1,700	1,500
Yard-Carr #2	1,710	1,200

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Queen City and Carrizo Aquifers in the vicinity of Pleasanton appear to be adequate to meet the Texas Water Development Board's projected demands for Pleasanton through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

After year 2040, a new well will be needed. The estimated cost for a Carrizo well and a half mile of pipeline is $525,000.

ID 17 City Poteet TNRCC Survey Year 1999

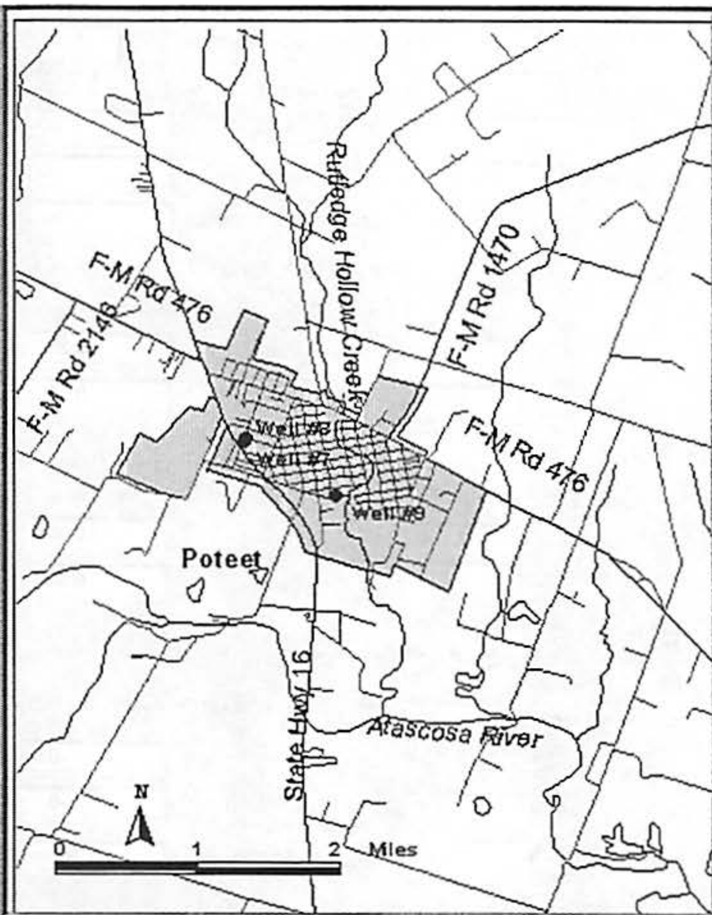
County Atascosa

Aquifer Carrizo

PWS_ID 0070005

Connections

Retail	1,024
Wholesale	66
Outside Water Supply	No



Population

City	
1996	3,663
2050	5,887
Growth (%)	61

Service Area	
Survey Year	3,270
2050	5,265

Average Use (mgd)

City	
Survey Year	0.663
2050	1.454

Service Area	
Survey Year	0.533
2050	1.169

Aquifer Information

Static Water Level (ft) 120

Water-bearing Zone (ft)

Top	700
Bottom	1,400

Trend in Groundwater Levels

Last Decade (ft/yr)	-1.5
Last 3 Decades (ft/yr)	-1.6
Water Quality Problems	Iron

Well Information

Total Well Capacity (gpm)	2,490
Total Well Capacity (mgd)	3.586

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	0.942
2050	1.515

Well 7	Well 8	Well 9	Well	Well
Depth (ft) 925	Depth (ft) 925	Depth (ft) 1,100	Depth (ft)	Depth (ft)
Yield (gpm) 430	Yield (gpm 1,000	Yield (gpm 1,060	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Poteet appear to be adequate to meet the Texas Water Development Board's projected demands for Poteet through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

A 1.5 mgd water treatment plant to remove excessive concentrations of iron is estimated to cost $2,830,000.

ID 18 City Poth | TNRCC Survey Year 1997

County Wilson

Aquifer Carrizo

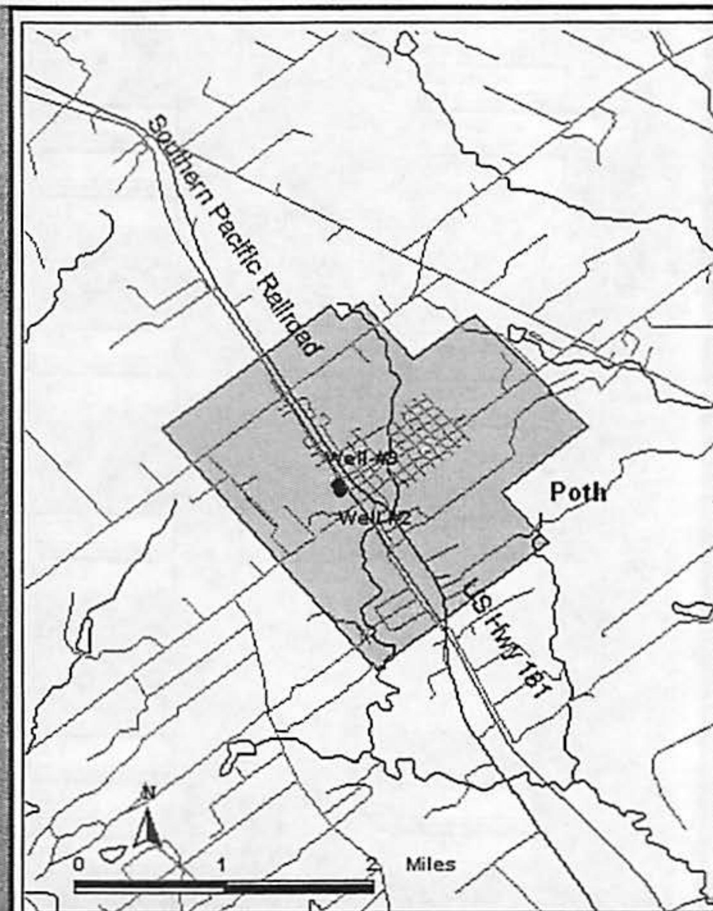
PWS_ID 2470002

Connections

Retail 700

Wholesale 0

Outside Water Supply No



Population

City

1996	1,970
2050	3,114
Growth (%)	58

Service Area

Survey Year	2,100
2050	3,319

Average Use (mgd)

City

Survey Year	0.290
2050	0.536

Service Area

Survey Year	0.305
2050	0.564

Aquifer Information

Static Water Level (ft) 40

Water-bearing Zone (ft)

Top 1300

Bottom 2,100

Trend in Groundwater Levels

Last Decade (ft/yr) -0.6

Last 3 Decades (ft/yr) -0.8

Water Quality Problems None

Well Information

Total Well Capacity (gpm) 2500

Total Well Capacity (mgd) 3601

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year 0.605

2050 0.957

Well	Depth (ft)	Yield (gpm)
2	2,012	400
3	2,031	600
4	2035	1500

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Poth appear to be adequate to meet the Texas Water Development Board's projected demands for Poth through the year 2050. Well #4 is under contract.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID 19 City Stockdale TNRCC Survey Year 1999

County Wilson

Aquifer Queen City & Carrizo

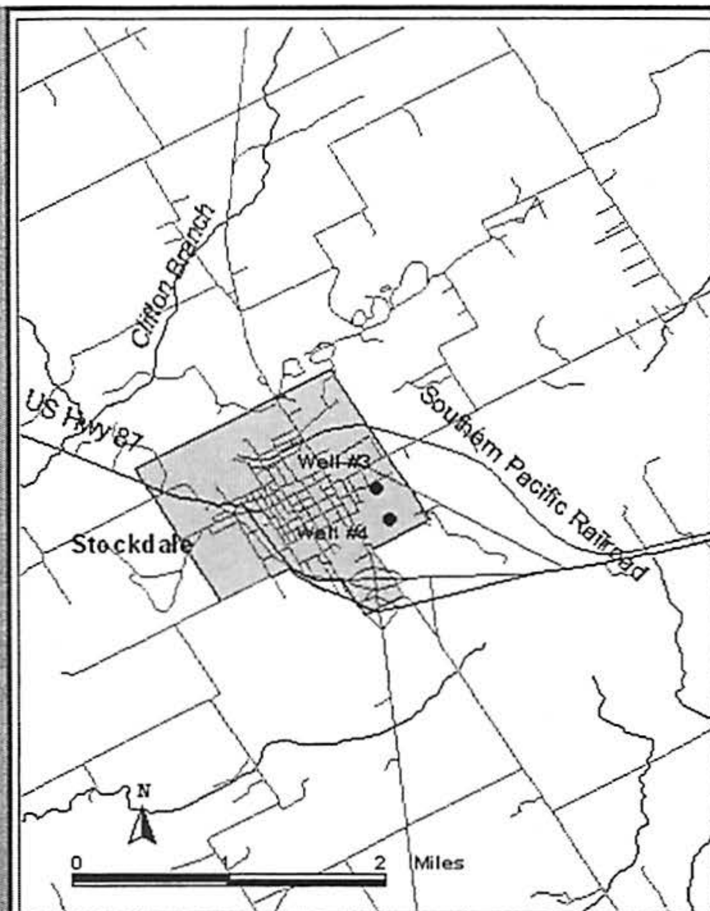
PWS_ID 2470003

Connections

Retail 593

Wholesale 0

Outside Water Supply Emergency



Population

City

1996	1,426
2050	2,378
Growth (%)	67

Service Area

Survey Year	1,779
2050	2,967

Average Use (mgd)

City

Survey Year	0.283
2050	0.400

Service Area

Survey Year	0.268
2050	0.379

Aquifer Information

Static Water Level (ft) 100

Water-bearing Zone (ft)

Top	400
Bottom	1,100

Trend in Groundwater Levels

Last Decade (ft/yr)	-1.1
Last 3 Decades (ft/yr)	-0.5
Water Quality Problems	None

Well Information

Total Well Capacity (gpm) 1700

Total Well Capacity (mgd) 2.45

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	0.513
2050	0.855

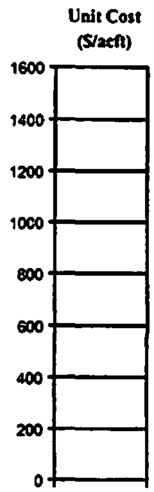
Well	3	4			
Depth (ft)	916	900			
Yield (gpm)	500	1200			
Well					
Depth (ft)					
Yield (gpm					
Well					
Depth (ft)					
Yield (gpm					

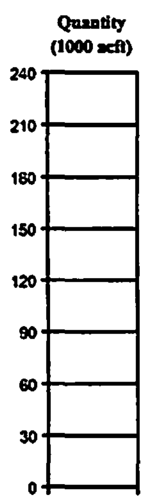
Evaluation of Water Supply to Year 2050

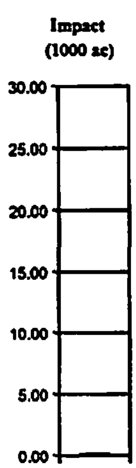
Groundwater supplies from the Carrizo and Queen City Aquifers in the vicinity of Stockdalle appear to be adequate to meet the Texas Water Development Board's projected demands for Stockdale through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

In late 1999 or early 2000 will drill new Well #4 into the Carrizo, and pump at 1200 gpm.







SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

January 2001

OPTION NUMBER: **SCTN-2b**

OPTION NAME: **Groundwater Supplies for Municipal Water Systems in the Gulf Coast Aquifer**

OPTION DESCRIPTION: *Municipal water systems in the lower Coastal Plains area of the South Central Texas Water Planning Region commonly use the Gulf Coast Aquifer for their supply. This source is a strong preference because the water is usually readily available, inexpensive, and often suitable for public water supplies with minimal treatment. The purposes of this option are to (1) evaluate existing aquifers and well field(s) of each municipality as to ability to meet projected water supply requirements through the year 2050; and (2) if additional supplies are needed, generally locate suitable new well fields and estimate the cost to add the additional supply to the municipal water system.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yr. ☐ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	**N/A**	**per acft[1]**
QUANTITY OF WATER:	**N/A**	**acft/yr[2]**
LAND IMPACTED:	**N/A**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** See Individual City Fact Sheet.

[2]**QUANTITY OF WATER:** Not Applicable.

[3]**LAND IMPACTED:** Not Applicable.

ENVIRONMENTAL ISSUES: Not Applicable.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Not Applicable.

ADDITIONAL FACTORS: Not Applicable.

6.6 Groundwater Supplies for Municipal Water Systems in the Gulf Coast Aquifer, South Central Texas Water Planning Region (SCTN-2b)

6.6.1 Description of Municipal Water Demands and Groundwater Supplies

Municipal water systems in the lower Coastal Plains area of the South Central Texas Water Planning Region commonly use the Gulf Coast Aquifer for their supply. This source is a strong preference because the water is usually readily available, inexpensive, and often suitable for public water supplies with minimal treatment.

The purposes of this option are to:

- Evaluate aquifers and existing well field(s) of each municipality as to ability to meet projected water supply requirements through year 2050;
- If additional supplies are needed, identify a suitable area for new well field(s); and
- If additional wells are needed or if the water needs to be treated, estimates are made as to when the expansion is needed and how much the facilities will cost.

The evaluation of individual municipal water systems is at a reconnaissance level and does not include:

- An engineering analysis of the water system as to the condition or adequacy of the wells, transmission system, and storage facilities;
- A projection of maintenance or replacement costs of existing wells and facilities;
- The potential interference of new wells installed by others near the city's wells or at locations identified for new well fields;
- Impact of potential changes in groundwater use patterns in the vicinity of the city's well field and the county;
- Rules and regulations that may be developed and implemented by a groundwater conservation district or the State; nor
- Consideration of additional wells or water treatment for local purposes such as reliability, water pressure, peaking capacity, and localized growth.

The evaluation of each municipal water system consisted of the following steps:

1. Compiled information prepared for the South Central Texas Regional Water Planning Group on current (1996) and TWDB's projected populations and water demands for each of the municipalities;
2. Estimated the TNRCC required system capacity in the year 2050 for each water system;
3. Compiled and summarized publicly available information for each municipal water system from TNRCC and TWDB;

4. Analyzed aquifer information from TWDB and U.S. Geological Survey (USGS) reports as to availability of groundwater from major and minor aquifers in the vicinity of each municipality;
5. Compiled groundwater level data from the TWDB database and analyzed for short-term and long-term trends;
6. When trends showed a decline in groundwater levels, made an adjustment for an estimated decrease in well yields and groundwater availability. Considered the position of the static water level in relation to the top and bottom of the producing formation(s) and well spacing. Compared the long-term groundwater availability within the city's well field(s) with the estimated required system capacity in the year 2050;
7. If the estimated groundwater supply after adjustments was greater than the estimated required capacity in the year 2050, the evaluation concludes that the existing water supply is adequate;
8. If the estimated supply after adjustments was less than the estimated required capacity in the year 2050, the evaluation concluded that an additional water supply would be needed; and
9. If a new well field is a reasonable option, estimated when it is needed and the capital cost of adding the well field to the water system.

6.6.2 Evaluation of Municipal Water Systems

A summary description of each municipality and their well field(s) is presented in the following Fact Sheets. The Fact Sheets provide information about the current and future water demands, current well capacities, aquifer characteristics and conditions, and the conclusion of the adequacy of the water supply through the year 2050.

A discussion on the municipal water systems (Figure 6.6-1) is presented below.

6.6.2.1 Cuero, Goliad, Kenedy, Refugio, Runge, Yorktown, and Woodsboro

The municipal systems servicing the communities of Cuero, Goliad, Kenedy, Refugio, Runge, Yorktown, and Woodsboro have well fields that are not expected to encounter water supply problems or a need for expansion before the year 2050.

6.6.2.2 Bloomington

The City of Bloomington appears to have sufficient groundwater supplies in their well field. However, projections indicate that additional wells will be required. Details on when the additional supplies are needed and the estimated cost are provided in the City's Fact Sheet.

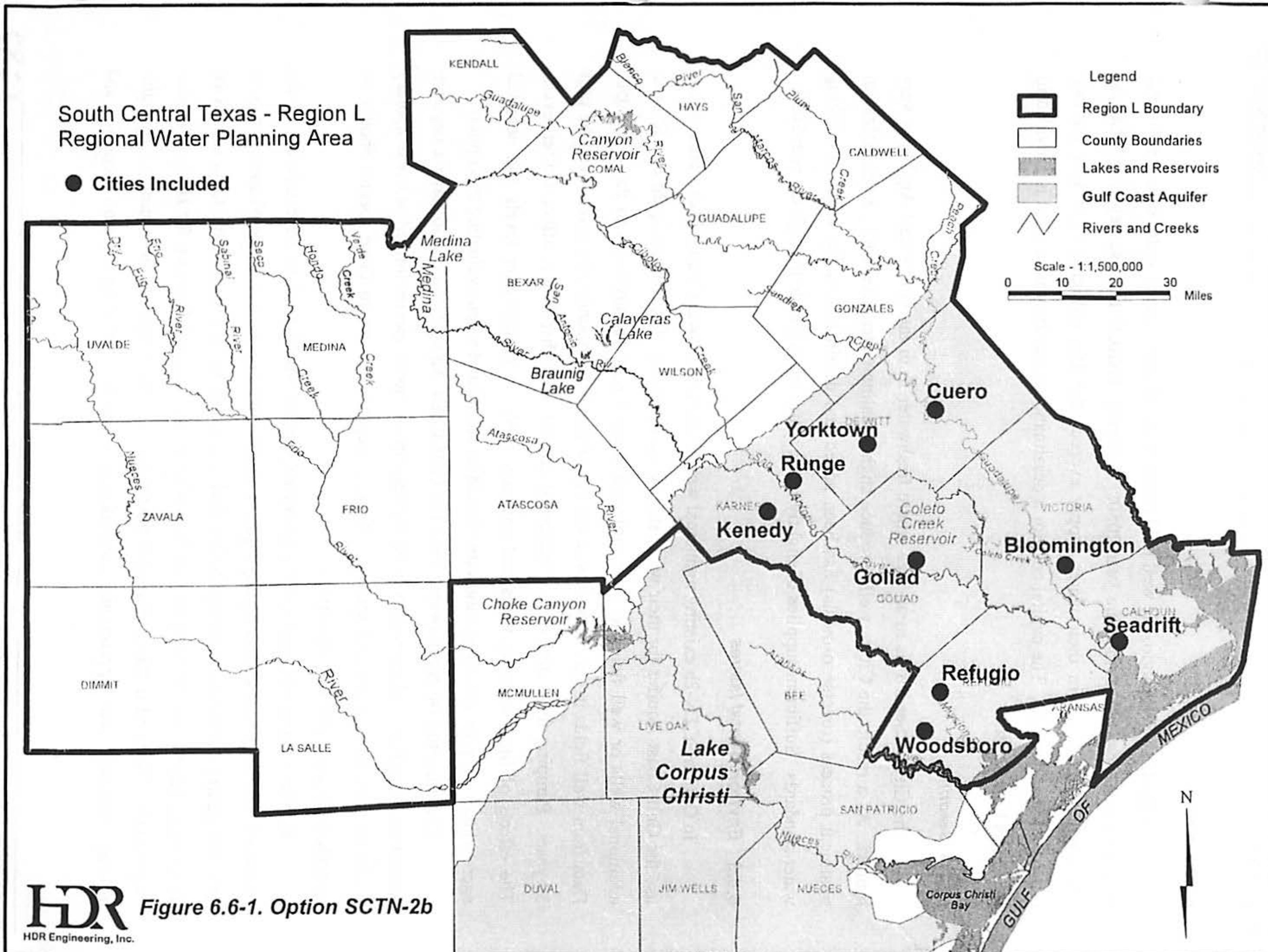


Figure 6.6-1. Option SCTN-2b

6.6.2.3 Refugio

For the City of Refugio, the well field is not expected to encounter water supply problems or a need for expansion before the year 2050. However, TNRCC field survey notes that the chloride concentrations in their water supply exceeds the 250 milligrams per liter primary drinking water standard. The capital cost for a desalination water treatment plant is provided in the City's Fact Sheet.

6.6.2.4 Seadrift

The City of Seadrift is in an area where freshwater from the Gulf Coast Aquifer is very limited. As a result, the City's wells produce slightly saline water. Recently, a desalinization treatment process (reverse osmosis) has been added and demineralizes the water to drinking water standards. Sufficient supplies of slightly saline water are available through the year 2050.

6.6.3 Environmental Issues

In Option SCTN-2b existing municipal well fields in the lower Coastal Plains area, which use the Gulf Coast Aquifer for their water supply are evaluated. Some municipalities will need additional wells or well fields to meet projected water supply requirements to the year 2050. Data from well fields in this area show a variety of trends in groundwater levels over the past 30 years. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels. The effects of these existing wells and any new wells on groundwater levels and potential encroachment of poor quality groundwater should be considered when evaluating this option.

The pumping of groundwater from the Gulf Coast Aquifer could also have a negative impact on springflow and temporary pools in these areas. Some species inhabit or use temporary pools, as well as aquifers and springs. Possible negative effects in these species should be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegeration procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.6.4 Engineering and Costing: See Individual City Fact Sheets

6.6.5 Implementation Issues

The development of additional wells and well fields in the Gulf Coast Water Planning Region must address several issues. Major issues include:

- Detailed feasibility evaluations including test drilling, and aquifer and water quality testing.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands
- Competition with others for groundwater in the area.
- Regulations by Underground Water Conservation Districts, including the renewal of pumping permits at periodic intervals in counties where districts have been organized.

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ID	20	City	Bloomington
TNRCC Survey Year	1997		
County	Victoria		
Aquifer	Gulf Coast		
PWS_ID	2350001		

Connections

Retail	850
Wholesale	0
Outside Water Supply	No

Population

City	
1996	2,055
2050	4,442
Growth (%)	116
Service Area	
Survey Year	1,800
2050	3,891

Average Use (mgd)

City	
Survey Year	0.230
2050	0.374
Service Area	
Survey Year	0.225
2050	0.366

Aquifer Information

Static Water Level (ft)	50
Water-bearing Zone (ft)	
Top	<100
Bottom	1,400

Trend in Groundwater Levels	
Last Decade (ft/yr)	0.4
Last 3 Decades (ft/yr)	0
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	700
Total Well Capacity (mgd)	1.008

TNRCC Required Capacity (mgd)
Peak day demand in Service Area

Survey Year	0.735
2050	1.588

Well	4	5			
Depth (ft)	1,010	1,002			
Yield (gpm)	350	350			

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Bloomington appear to be adequate to meet the Texas Water Development Board's projected demands for Bloomington through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

One new well will be needed after year 2010 and another after year 2040. The estimated cost for one new well and a half mile of pipeline is $319,000.

ID 21 City Goliad TNRCC Survey Year 1999

County Goliad

Aquifer Gulf Coast

PWS_ID 0880001

Connections

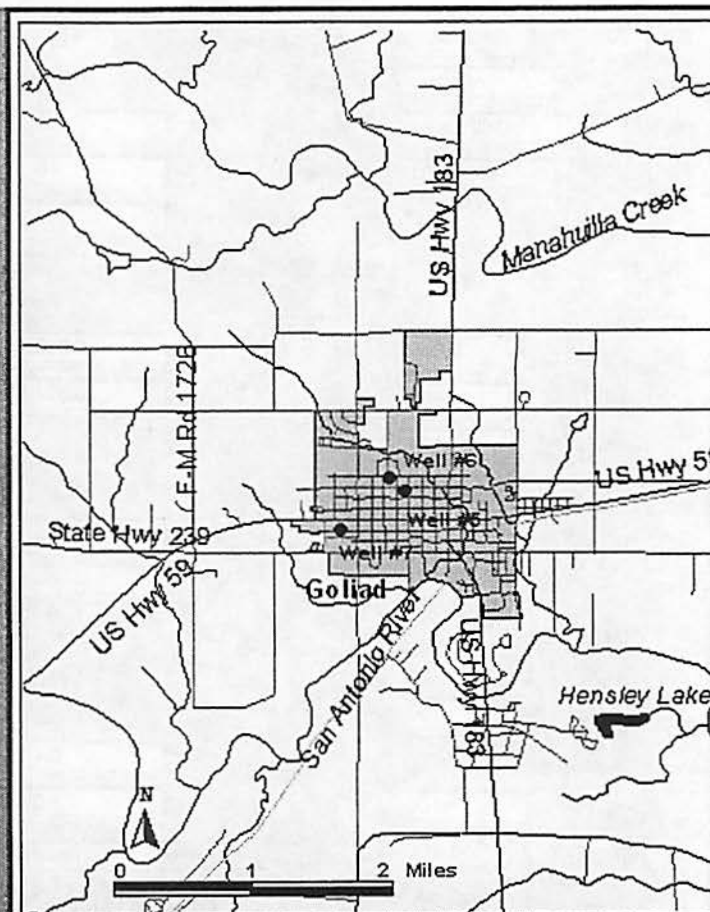
Retail	985
Wholesale	0
Outside Water Supply	No

Population

City	
1996	2,221
2050	2,636
Growth (%)	19
Service Area	
Survey Year	1,998
2050	2,371

Average Use (mgd)

City	
Survey Year	0.370
2050	0.393
Service Area	
Survey Year	0.367
2050	0.390



Aquifer Information

Static Water Level (ft)	40
Water-bearing Zone (ft) Top	<100
Bottom	900
Trend in Groundwater Levels: Last Decade (ft/yr)	0.7
Last 3 Decades (ft/yr)	0.3
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1,680
Total Well Capacity (mgd)	2.419

TNRCC Required Capacity (mgd)
Peak day demand in Service Area

Survey Year	0.852
2050	1.010

Well	Depth (ft)	Yield (gpm)
5	557	460
6	575	650
7	550	570

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Goliad appear to be adequate to meet the Texas Water Development Board's projected demands for Goliad through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	22	City	Cuero
TNRCC Survey Year	1999		
County	DeWitt		
Aquifer	Gulf Coast		
PWS_ID	0620001		

Connections

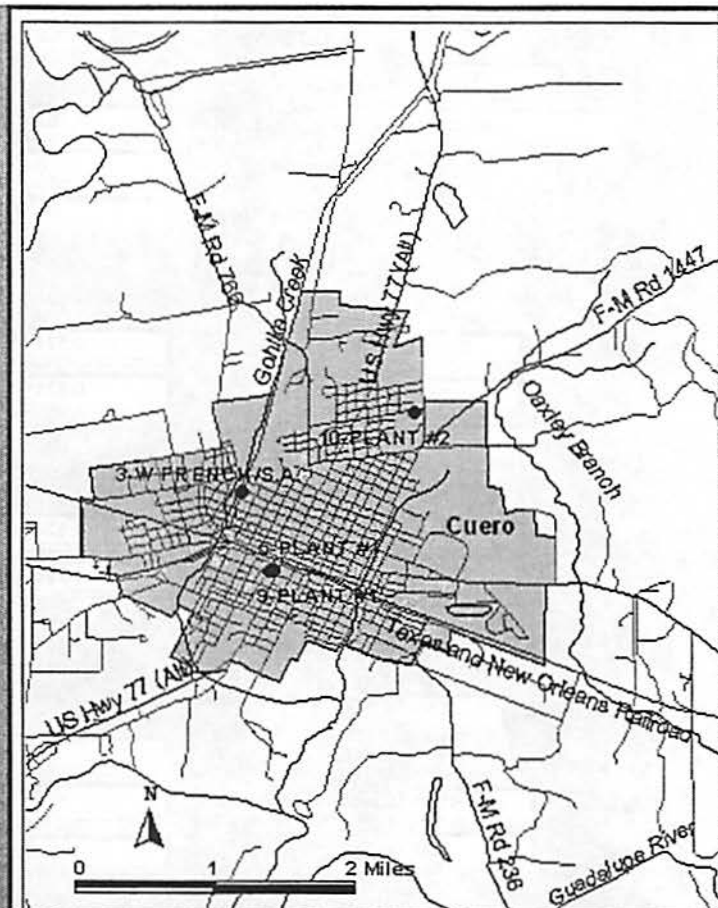
Retail	2,804
Wholesale	0
Outside Water Supply	No

Population

City	
1996	6,932
2050	9,074
Growth (%)	31
Service Area	
Survey Year	8,412
2050	11,011

Average Use (mgd)

City	
Survey Year	1.305
2050	1.688
Service Area	
Survey Year	1.43
2050	1.87



Aquifer Information

Static Water Level (ft)	10
Water-bearing Zone (ft) Top	<100
Bottom	1,500
Trend in Groundwater Levels	
Last Decade (ft/yr)	1.5
Last 3 Decades (ft/yr)	0.4
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	3,425
Total Well Capacity (mgd)	4.932

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	2.422
2050	3.170

Well	Plant #1	Plant #1	Plant #2	Plant #3	
Depth (ft)	1,173	1,150	1,422	870	
Yield (gpm)	850	400	1,050	1,125	

Well					
Depth (ft)					
Yield (gpm					

Well					
Depth (ft)					
Yield (gpm					

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Cuero appear to be adequate to meet the Texas Water Development Board's projected demands for Cuero through the year 2050.

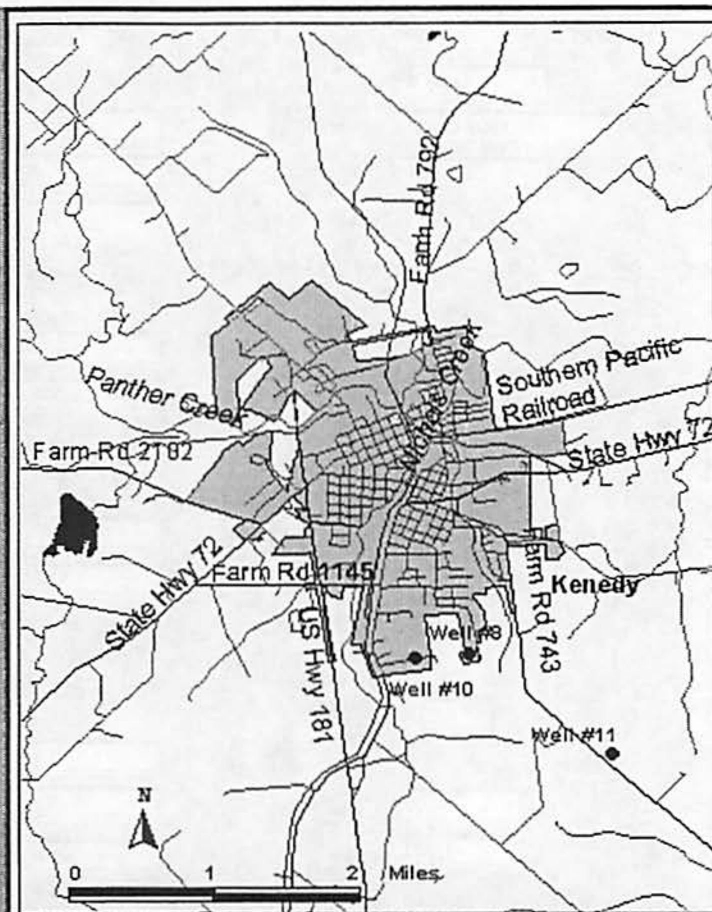
If needed, potential location of new well field and estimated cost to adding new supply to system

ID	23	City	Kenedy
County	Karnes		
Aquifer	Catahoula		
PWS_ID	1280002		

TNRCC Survey Year: 1998

Connections

Retail	1,782
Wholesale	0
Outside Water Supply	No



Population

City	
1996	6,463
2050	6,155
Growth (%)	-5

Service Area	
Survey Year	7,341
2050	6,991

Average Use (mgd)

City	
Survey Year	0.524
2050	0.831

Service Area	
Survey Year	1.134
2050	1.798

Aquifer Information

Static Water Level (ft)	130
Water-bearing Zone (ft)	
Top	<100
Bottom	600

Trend in Groundwater Levels	
Last Decade (ft/yr)	2.7
Last 3 Decades (ft/yr)	-0.3
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1,450
Total Well Capacity (mgd)	2.172

TNRCC Required Capacity (mgd)

Survey Year	1.541
Peak day demand in Service Area 2050	1.467

Well	8	Well	10	Well	11	Well		Well	
Depth (ft)	650	Depth (ft)	650	Depth (ft)	320	Depth (ft)		Depth (ft)	
Yield (gpm)	570	Yield (gpm	540	Yield (gpm	340	Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Evaluation of Water Supply to Year 2050

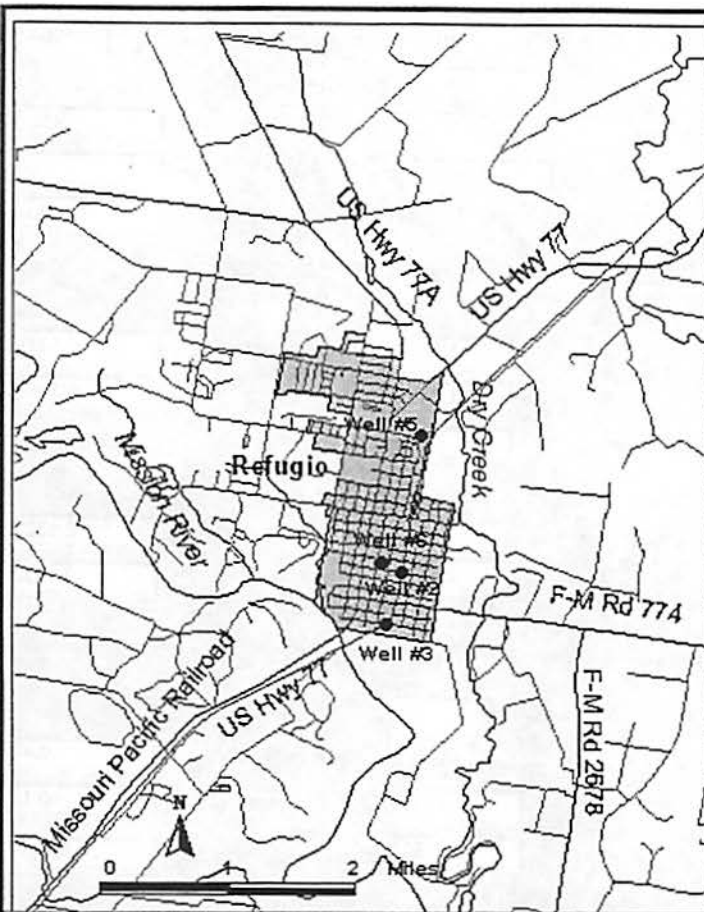
Groundwater supplies from the Catahoula formation in the vicinity of Kenedy appear to be adequate to meet the TWDB's projected demands for Kenedy through the year 2050. Water treatment includes reverse osmosis to reduce TDS concentrations.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	24	City	Refugio
County	Refugio	TNRCC Survey Year	1999
Aquifer	Gulf Coast	Connections	
PWS_ID	1960001	Retail	1,353
		Wholesale	0
		Outside Water Supply	No

Population / **Average Use (mgd)**

City		City	
1996	3,153	Survey Year	0.550
2050	3,732	2050	0.526
Growth (%)	18		
Service Area		**Service Area**	
Survey Year	3,156	Survey Year	0.560
2050	3,736	2050	0.536



Aquifer Information

Static Water Level (ft)	20	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	-0.4
Top	<100	Last 3 Decades (ft/yr)	-0.4
Bottom	1,200	Water Quality Problems	Chloride

Well Information

Total Well Capacity (gpm)	2,350	**TNRCC Required Capacity (mgd)**	Survey Year	1.170
Total Well Capacity (mgd)	3.384	Peak day demand in Service Area	2050	1.385

Well 2	Well 3	Well 5	Well 6	Well
Depth (ft) 835	Depth (ft) 835	Depth (ft) 900	Depth (ft) 900	Depth (ft)
Yield (gpm) 450	Yield (gpm 500	Yield (gpm 700	Yield (gpm 700	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Refugio appear to be adequate to meet the TWDB's projected demands for Refugio through the year 2050. TNRCC surveys indicate chloride concentrations exceed drinking water standards.

If needed, potential location of new well field and estimated cost to adding new supply to system

The installation of a desalinization unit that uses reverse osmosis technology is estimated to cost $587,000.

ID: 25 | City: Runge | TNRCC Survey Year: 1999

County: Karnes

Aquifer: Gulf Coast

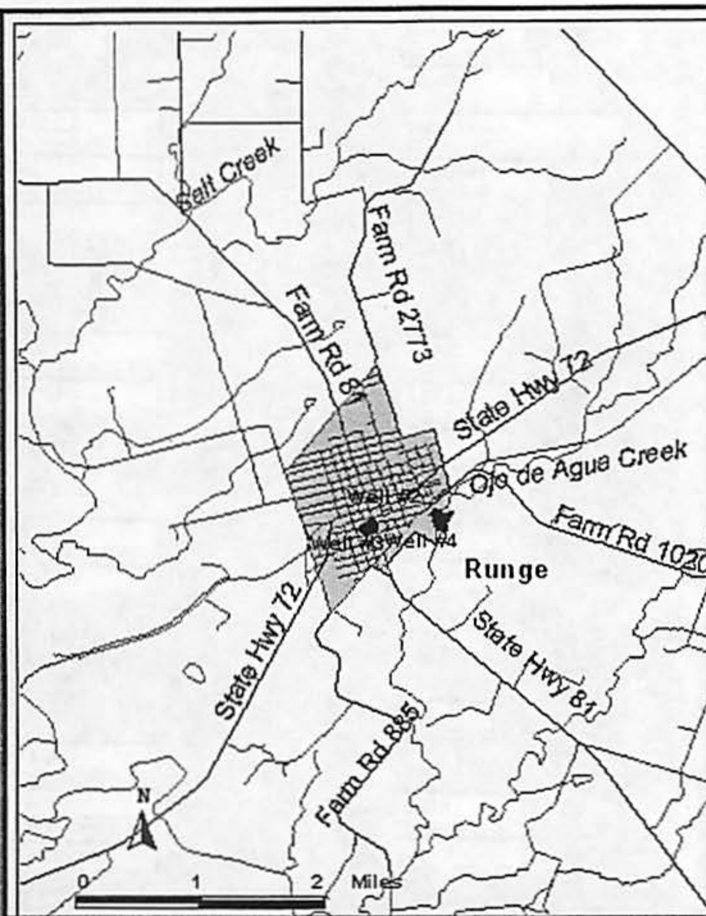
PWS_ID: 1280003

Connections

Retail: 460

Wholesale: 0

Outside Water Supply: No



Population

City

1996	1,197
2050	1,845
Growth (%)	54

Service Area

Survey Year	1,380
2050	2,127

Average Use (mgd)

City

Survey Year	0.137
2050	0.190

Service Area

Survey Year	0.132
2050	0.183

Aquifer Information

Static Water Level (ft): 30

Water-bearing Zone (ft)

Top: <100

Bottom: 750

Trend in Groundwater Levels

Last Decade (ft/yr): -0.4

Last 3 Decades (ft/yr): -0.1

Water Quality Problems: None

Well Information

Total Well Capacity (gpm): 580

Total Well Capacity (mgd): 0.835

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year: 0.398

2050: 0.613

Well	2	3	4		
Depth (ft)	212	210	710		
Yield (gpm)	120	100	360		

Well					
Depth (ft)					
Yield (gpm					

Well					
Depth (ft)					
Yield (gpm					

Evaluation of Water Supply to Year 2050

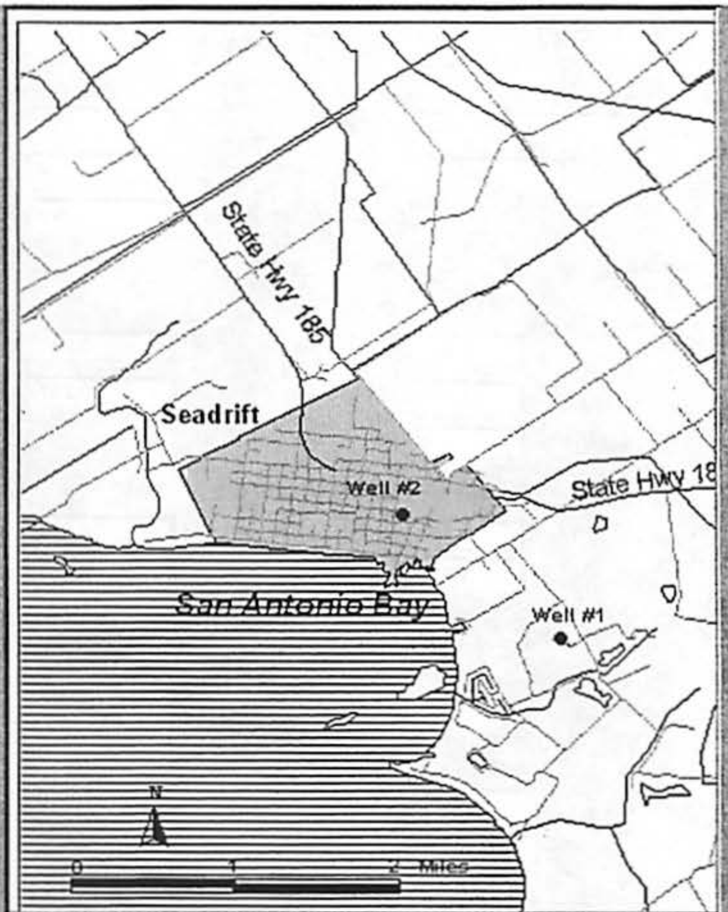
Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Runge appear to be adequate to meet the Texas Water Development Board's projected demands for Runge through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	26	City	Seadrift
County	Calhoun	TNRCC Survey Year	1999
Aquifer	Gulf Coast		
PWS_ID	0290004		

Connections

Retail	650
Wholesale	0
Outside Water Supply	No



Population

City

1996	1,516
2050	3,012
Growth (%)	99

Service Area

Survey Year	1,950
2050	3,874

Average Use (mgd)

City

Survey Year	0.171
2050	0.250

Service Area

Survey Year	0.190
2050	0.278

Aquifer Information

Static Water Level (ft)	10
Water-bearing Zone (ft) Top	<100
Bottom	300

Trend in Groundwater Levels

Last Decade (ft/yr)	0.5
Last 3 Decades (ft/yr)	0.2
Water Quality Problems	Salinity

Well Information

Total Well Capacity (gpm)	505
Total Well Capacity (mgd)	0.727

TNRCC Required Capacity (mgd)
Peak day demand in Service Area

Survey Year	0.562
2050	1.117

Well	Depth (ft)	Yield (gpm)
1	268	295
2	285	210

Evaluation of Water Supply to Year 2050

Groundwater from the Gulf Coast Aquifer in the vicinity of Seadrift is naturally slightly saline and does not meet public drinking water standards. The salinity problem is corrected with a desalinization unit that use reverse osmosis technology.

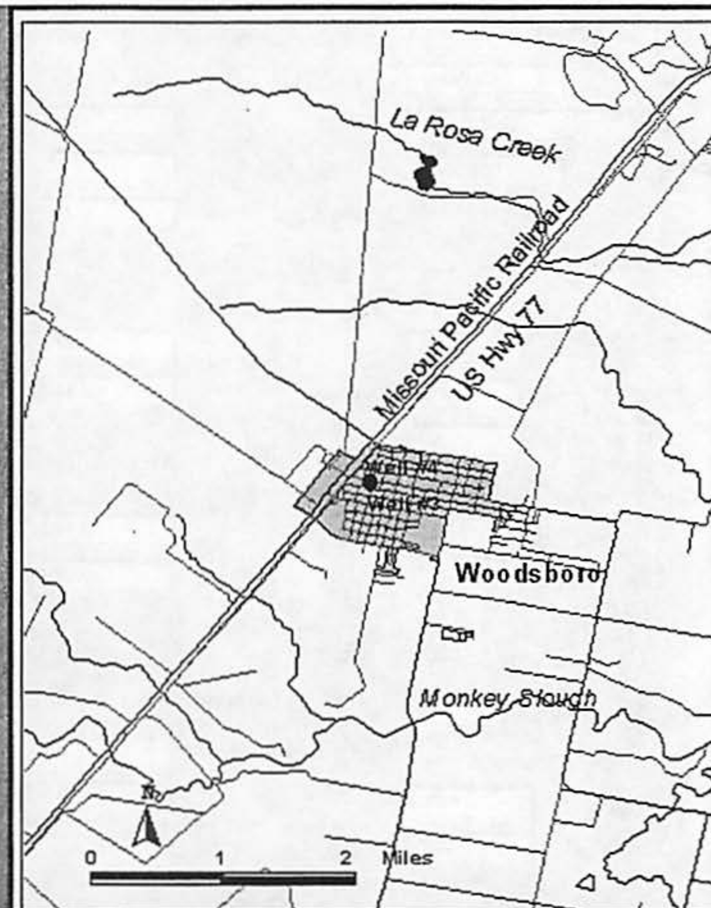
If needed, potential location of new well field and estimated cost to adding new supply to system

ID	27	City	Woodsboro
TNRCC Survey Year	1999		
County	Refugio		
Aquifer	Gulf Coast		
PWS_ID	1960003		

Connections

Retail	753
Wholesale	0
Outside Water Supply	No

Population		**Average Use (mgd)**	
City		City	
1996	1,857	Survey Year	0.233
2050	1,922	2050	0.257
Growth (%)	4		
Service Area		Service Area	
Survey Year	1,750	Survey Year	0.291
2050	1,811	2050	0.321



Aquifer Information

Static Water Level (ft)	20	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	0
Top	<100	Last 3 Decades (ft/yr)	0
Bottom	1,200	Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	580	**TNRCC Required Capacity (mgd)**	Survey Year	0.651
Total Well Capacity (mgd)	0.836	Peak day demand in Service Area	2050	0.674

Well	3	Well	4	Well		Well		Well	
Depth (ft)	279	Depth (ft)	170	Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm)	330	Yield (gpm	250	Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Woodsboro appear to be adequate to meet the Texas Water Development Board's projected demands for Woodsboro through the year 2050.

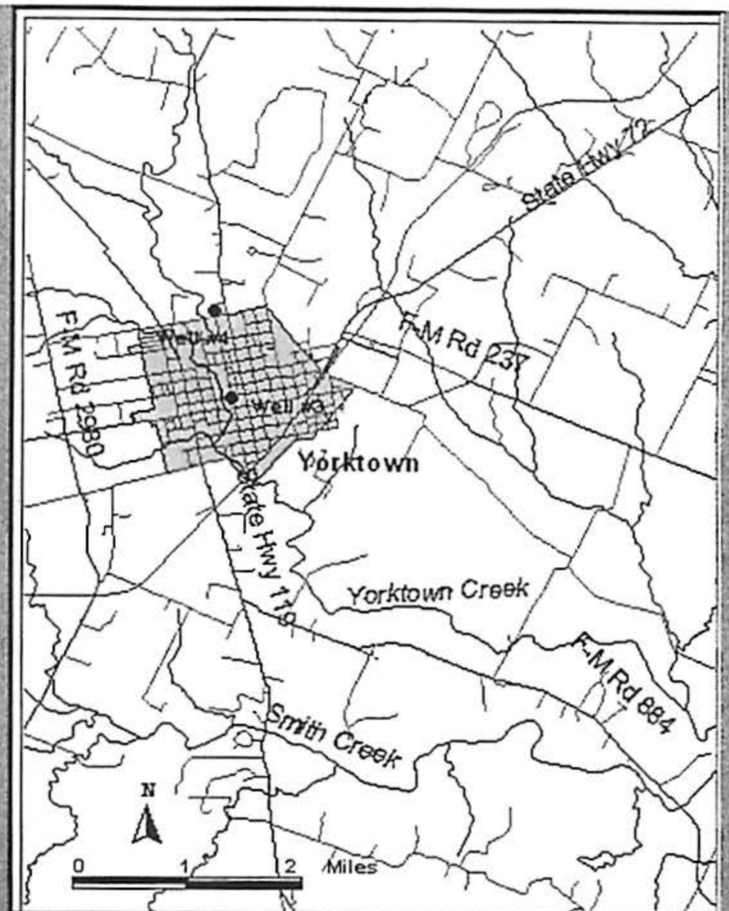
If needed, potential location of new well field and estimated cost to adding new supply to system

ID	28	City	Yorktown
TNRCC Survey Year	1999		
County	DeWitt		
Aquifer	Gulf Coast		
PWS_ID	0620004		

Connections

Retail	1,147
Wholesale	0
Outside Water Supply	No

Population		**Average Use (mgd)**	
City		City	
1996	2,334	Survey Year	0.363
2050	3,450	2050	0.455
Growth (%)	48		
Service Area		Service Area	
Survey Year	2,206	Survey Year	0.330
2050	3,261	2050	0.414



Aquifer Information

Static Water Level (ft)	20	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	0.3
Top	<100	Last 3 Decades (ft/yr)	0.1
Bottom	1,100	Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1,500	**TNRCC Required Capacity (mgd)**	Survey Year	0.992
Total Well Capacity (mgd)	2.160	Peak day demand in Service Area	2050	1.466

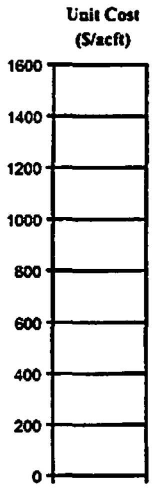
Well 3	Well 4	Well	Well	Well
Depth (ft) 963	Depth (ft) 955	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm) 650	Yield (gpm 850	Yield (gpm	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm

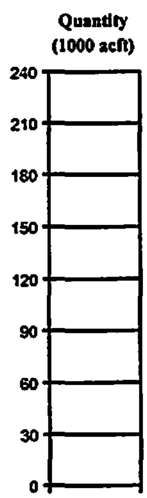
Evaluation of Water Supply to Year 2050

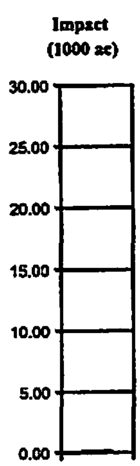
Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Yorktown appear to be adequate to meet the Texas Water Development Board's projected demands for Yorktown through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **SCTN-2c**

OPTION NAME: **Groundwater Supplies for Municipal Water Systems in the Trinity Aquifer**

OPTION DESCRIPTION: *Municipal water systems in the Hill Country area of the South Central Texas Water Planning Region commonly use the Trinity Aquifer for their supply. This source is a strong preference because the water is usually conveniently located, although limited in quantities, inexpensive, and often suitable for public water supplies with minimal treatment. The purposes of this option are to (1) evaluate existing aquifers and well field(s) of each municipality as to ability to meet projected water supply requirements through the year 2050; and (2) if additional supplies are needed, generally locate suitable new well fields and estimate the cost to add the additional supply to the municipal water system.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yr. ☐ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	N/A	per acft[1]
QUANTITY OF WATER:	N/A	acft/yr[2]
LAND IMPACTED:	N/A	acres[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** See Individual City Fact Sheets.

[2]**QUANTITY OF WATER:** Not Applicable.

[3]**LAND IMPACTED:** Not Applicable.

ENVIRONMENTAL ISSUES: Not Applicable.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Not Applicable.

ADDITIONAL FACTORS: Not Applicable.

6.7 Groundwater Supplies for Municipal Water Systems in the Trinity Aquifer, South Central Texas Water Planning Region (SCTN-2c)

6.7.1 Description of Municipal Water Demands and Groundwater Supplies

Municipal water systems in the Hill Country area of the South Central Texas Water Planning Region commonly use the Trinity Aquifer for their supply. This source is a strong preference because the water is usually conveniently located, although limited in quantity, inexpensive, and suitable for public water supplies with minimal treatment. However, a very rapid growth of population in the cities as well as the development of rural areas is clashing with the rather modest supply of groundwater. Two ongoing efforts to address the water supply issue are (1) the formation of the Cow Creek Groundwater Conservation District (Kendall County), and (2) the planned construction of the West Comal Water Supply Project by GBRA.

The purposes of this option are to:

- Evaluate aquifers and existing well field(s) of each municipality as to ability to meet projected water supply requirements through the year 2050;
- If additional supplies are needed, identify a suitable area for a new well field(s); and
- If additional wells are needed or if the water needs to be treated, estimate when the expansion is needed and how much the facilities will cost.

The evaluation of individual municipal water systems is at a reconnaissance level and does not include:

- An engineering analysis of the water system as to the condition or adequacy of the wells, transmission system, and storage facilities;
- A projection of maintenance or replacement costs of existing wells and facilities;
- The potential interference of new wells installed by others near the city's wells or at locations identified for new well fields;
- Impact of potential changes in groundwater use patterns in the vicinity of the city's well field and the county;
- Rules and regulations that may be developed and implemented by a groundwater conservation district or the State; nor
- Consideration of additional wells or water treatment for local purposes such as reliability, water pressure, peaking capacity, and localized growth.

The evaluation of each municipal water system consisted of the following steps:

1. Compiled information prepared for the South Central Texas Regional Water Planning Group on current (1996) and TWDB's projected populations and water demands for each of the municipalities;

2. Estimated the TNRCC required system capacity in the year 2050 for each water system;
3. Compiled and summarized publicly available information for each municipal water system from TNRCC and TWDB;
4. Analyzed aquifer information from TWDB and U.S. Geological Survey (USGS) reports as to availability of groundwater from major and minor aquifers in the vicinity of each municipality;
5. Compiled groundwater level data from the TWDB database and analyzed for short-term and long-term trends;
6. When trends showed a decline in groundwater levels, made an adjustment for an estimated decrease in well yields and groundwater availability. Considered the position of the static water level in relation to the top and bottom of the producing formation(s) and well spacing. Compared the long-term groundwater availability within the city's well field(s) with the estimated required system capacity in the year 2050;
7. If the estimated groundwater supply after adjustments was greater than the estimated required capacity in the year 2050, the evaluation concludes that the existing water supply is adequate;
8. If the estimated supply after adjustments was less than the estimated required capacity in the year 2050, the evaluation concluded that an additional water supply would be needed; and
9. If a new well field is a reasonable option, estimated when it is needed and the capital cost of adding the well field to the water system.

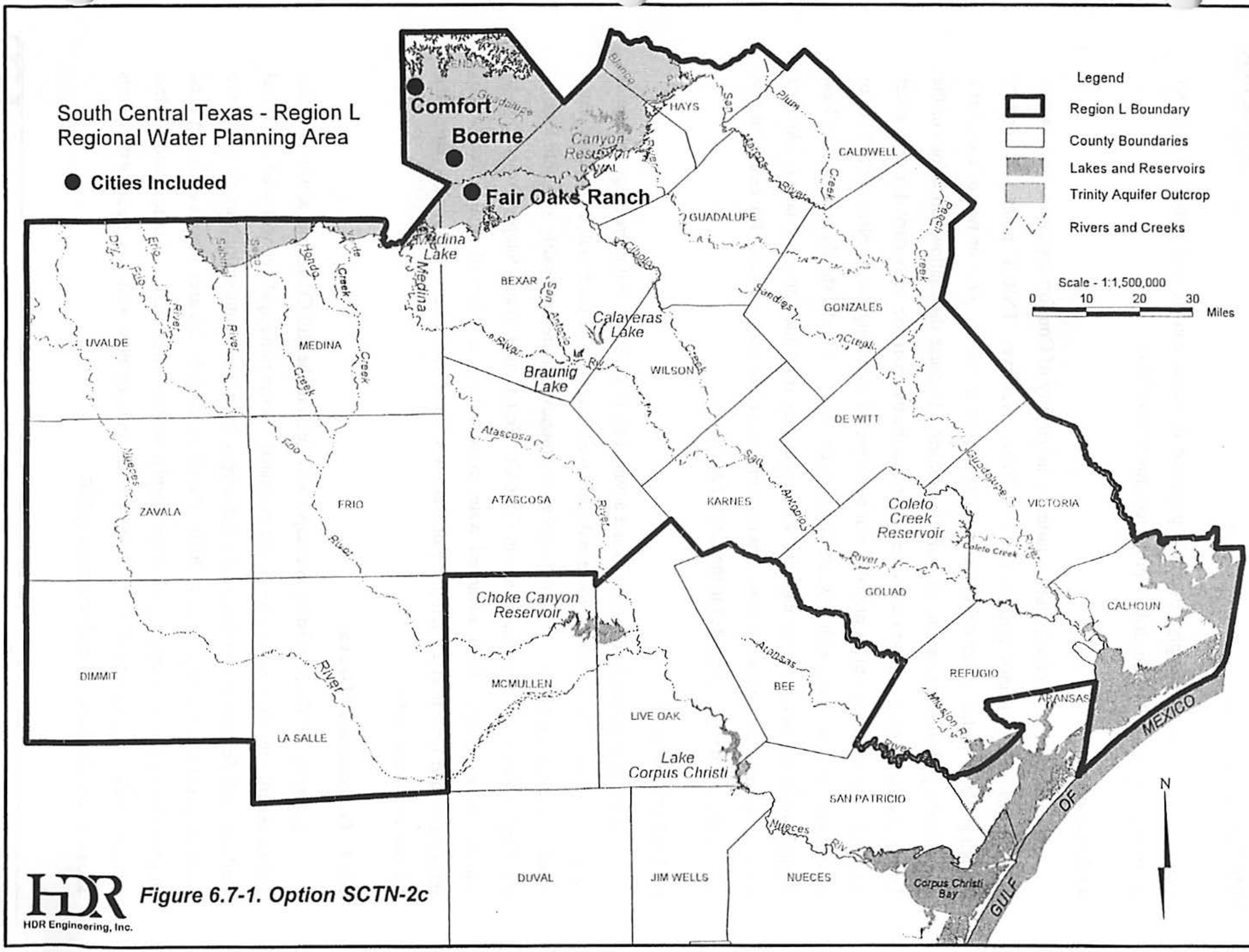
6.7.2 Evaluation of Municipal Water Systems

A summary description of each municipality and their well field(s) is presented in the following Fact Sheets. The Fact Sheet provides information about the current and future water demands, current well capacities, aquifer characteristics and conditions, and the conclusion of the adequacy of the water supply through the year 2050.

A discussion on the evaluation of the systems (Figure 6.7-1) that are having difficulties or will be expected to have difficulties before the year 2050 is provided below.

6.7.2.1 Boerne

Groundwater supplies from the Trinity Aquifer are inadequate and have been for many years. Consequently, Boerne has been drawing over 800 acre-feet/year from Cibolo Creek. In the near future these combined supplies will not be adequate. Consequently, Boerne has plans to connect to GBRA's West Comal Water Supply Project that draws water from Canyon Lake.



HDR Engineering, Inc.

Figure 6.7-1. Option SCTN-2c

Given these sources of supply, Boerne's projected demands can be met through 2040, but additional supplies will be needed for projected growth after 2040.

6.7.2.2 Comfort

Groundwater from the Trinity Aquifer in the vicinity of Comfort appears to be adequate to meet projected demands through the year 2050. However, TNRCC notes a Secondary Drinking Water violation for chlorides and total dissolved solids. One or two of Comfort's deeper wells probably are causing the salinity problem. Because the shallow formations of the Trinity Aquifer typically produces water somewhat better than the secondary drinking water standards, the salinity problem probably can be corrected by taking the problem well(s) out of service and replacing them with new, shallower wells. The new wells should be located at least .5 miles from the nearest large capacity well producing from the same formation. Another option is to add a desalinization water treatment process to the water system. The estimated cost for a replacement well is provided in the City's Fact Sheet.

6.7.2.3 Fair Oaks Ranch

With rapid growth in demands in and around Fair Oaks Ranch and decreasing well yields caused by declining water levels, more and more wells and/or well fields will be required. As a result, and given the fact that suitable supplies of groundwater are not readily available locally, the City of Fair Oaks is participating in GBRA's West Comal Water Supply Project for an outside water supply. With advanced water conservation, and use of small quantities of reclaimed water (less than 25 acft/yr), Fair Oaks would not need additional supplies during the 50-year planning horizon.

6.7.3 Environmental Issues

In Option SCTN-2c existing municipal well fields in the Hill Country area, which use the Trinity Aquifer for their water supply, are evaluated. Some municipalities will need additional wells or well fields or a supplemental water supply from other aquifers or surface sources to meet projected water supply needs to 2050. Data from wells in this area show a declining trend in groundwater levels. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels. The effects of these existing wells and any new wells on groundwater levels should be considered when evaluating this option.

The pumping of groundwater from the Trinity Group of aquifers could also have a negative impact on springflow in these areas. Some species inhabit or use the aquifers and springs of the area. Possible negative effects on these species should be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.7.4 Engineering and Costing: See Individual City Fact Sheet

6.7.5 Implementation Issues

The development of additional wells in the Trinity Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

- Detailed feasibility evaluation including test drilling, and aquifer and water quality testing.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Competition with others for groundwater in the area,
- Regulations by Underground Water Conservation Districts, including the renewal of pumping permits at periodic intervals in counties where underground water conservation districts have been organized.

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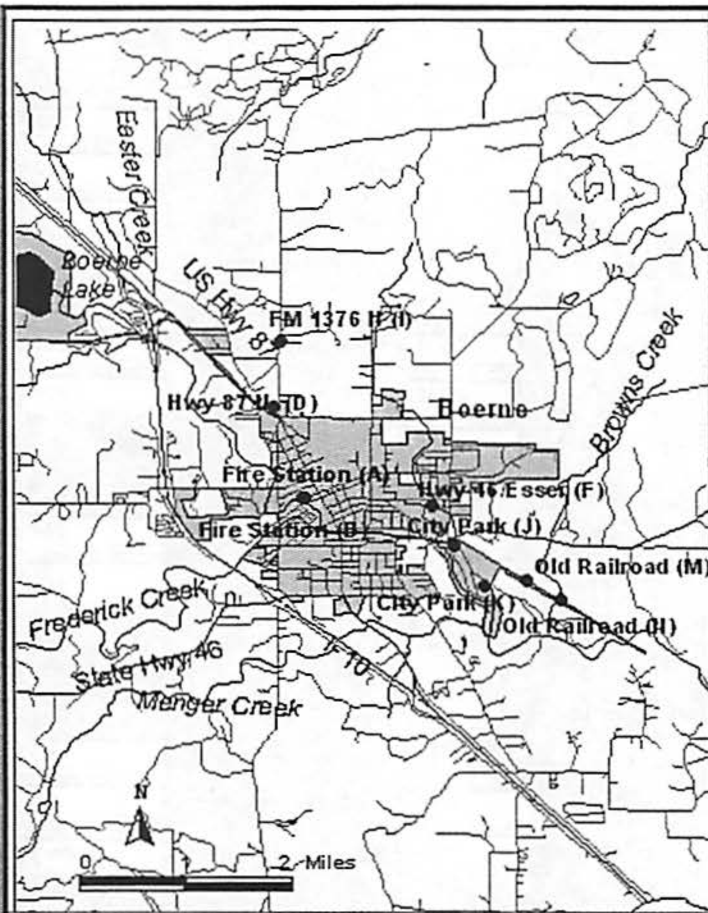
ID	29	City	Boerne
County	Kendall	TNRCC Survey Year	1999
Aquifer	Trinity		
PWS_ID	1300001		

Connections

Retail	2,437
Wholesale	0
Outside Water Supply	No

Population		**Average Use (mgd)**	
City		City	
1996	5,754	Survey Year	0.967
2050	22,302	2050	3.213
Growth (%)	288		
Service Area		Service Area	
Survey Year	7,311	Survey Year	0.980
2050	28,337	2050	3.323



Aquifer Information

Static Water Level (ft)	210	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	-0.2
Top	20	Last 3 Decades (ft/yr)	0.1
Bottom	600	Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1744	**TNRCC Required Capacity (mgd)**	Survey Year	2.107
Total Well Capacity (mgd)	2.512	Peak day demand in Service Area	2050	8.160

Well	A	B	D	F	I
Depth (ft)	42	42	522	580	580
Yield (gpm)	200	200	140	250	100

Well	J	K	M	N	
Depth (ft)	420	418	420	430	
Yield (gpm	169	215	220	250	

Well					
Depth (ft)					
Yield (gpm					

Evaluation of Water Supply to Year 2050

Boerne draws water supplies from the Edwards - Trinity Aquifer and Cibolo Creek. These sources are adequate for current demands. In the future, supplies will be supplemented from the GBRA West Comal Water Supply Project.

If needed, potential location of new well field and estimated cost to adding new supply to system

See text for discussion.

ID: 30 | City: Comfort | TNRCC Survey Year: 1997

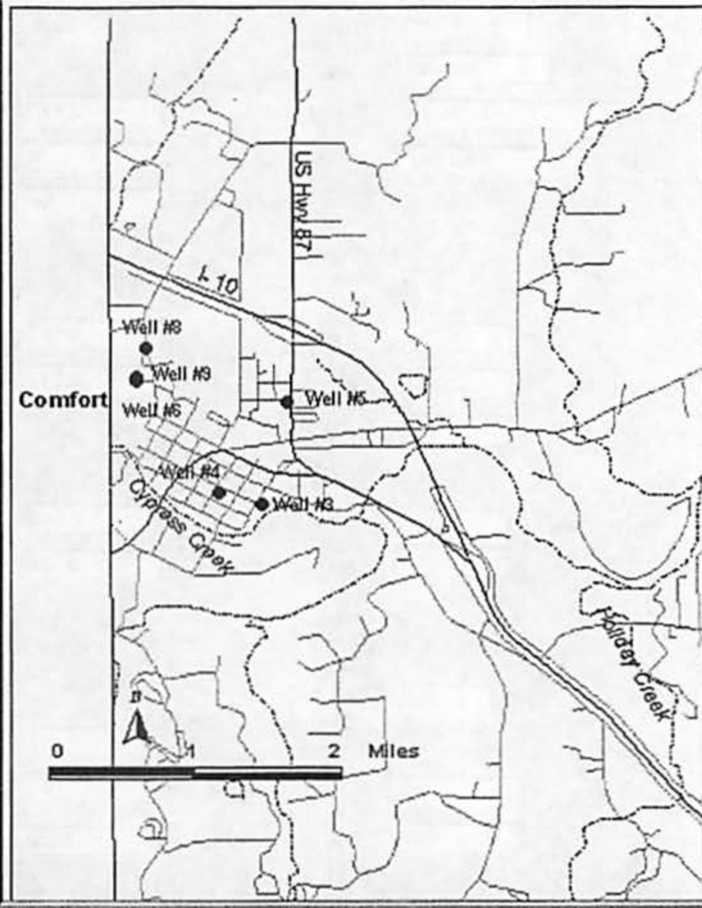
County: Kendall

Aquifer: Edwards-Trinity

PWS_ID: 1300002

Connections

Retail	725
Wholesale	0
Outside Water Supply	No



Population

City	
1996	1,729
2050	2,359
Growth (%)	36

Service Area	
Survey Year	2,175
2050	2,967

Average Use (mgd)

City	
Survey Year	0.261
2050	0.254

Service Area	
Survey Year	0.244
2050	0.238

Aquifer Information

Static Water Level (ft): 90

Water-bearing Zone (ft)

Top	<100
Bottom	>650

Trend in Groundwater Levels

Last Decade (ft/yr)	-1.5
Last 3 Decades (ft/yr)	-0.5
Water Quality Problems	Salinity

Well Information

Total Well Capacity (gpm)	795
Total Well Capacity (mgd)	1.145

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	0.626
2050	0.854

Well	Depth (ft)	Yield (gpm)
3	360	70
4	640	120
5	315	110
6	310	85
8	493	190
9	490	220

Evaluation of Water Supply to Year 2050

Groundwater from the Edwards-Trinity Aquifer in the vicinity of Comfort appears to be adequate for TWDB projections to the year 2050. However, TNRCC's survey indicates salinity concentrations greater than secondary drinking water standards.

If needed, potential location of new well field and estimated cost to adding new supply to system

Replace the well that is producing the slightly saline water. A replacement well and pipe is expected to cost $258,000.

ID: 32 | City: Fair Oaks Rh | TNRCC Survey Year: 1998

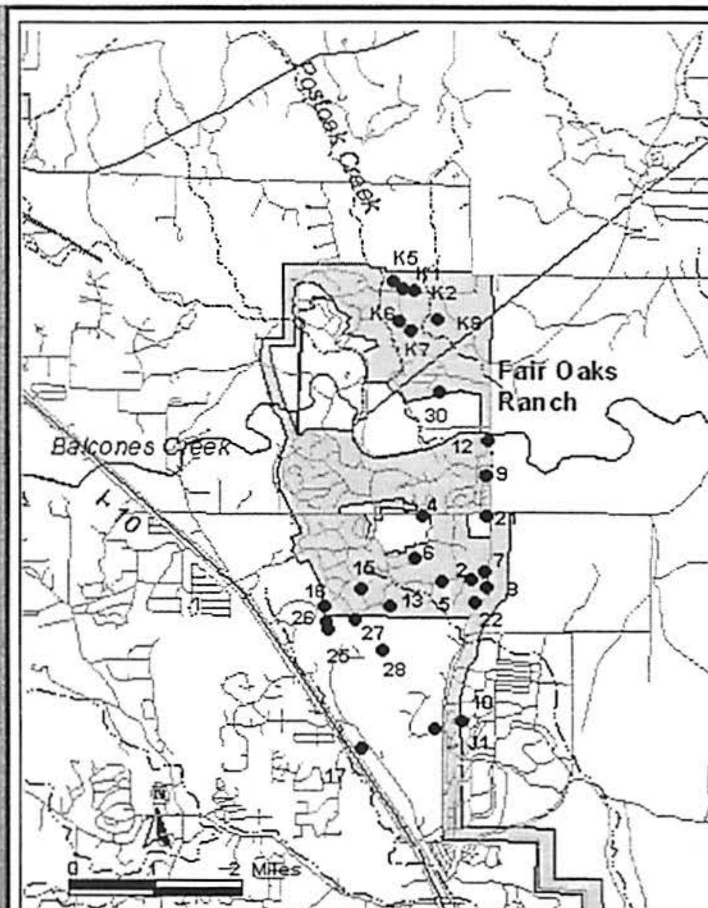
County: Bexar

Aquifer: Edwards-Trinity

PWS_ID: 0150216

Connections

Retail	1664
Wholesale	0
Outside Water Supply	No



Population

City

1996	3101
2050	4833
Growth (%)	56

Service Area

Survey Year	4492
2050	6985

Average Use (mgd)

City

Survey Year	1071
2050	1213

Service Area

Survey Year	1095
2050	1240

Aquifer Information

Static Water Level (ft): ~450

Water-bearing Zone (ft)

Top	300
Bottom	800

Trend in Groundwater Levels

Last Decade (ft/yr)	-4.4
Last 3 Decades (ft/yr)	-3.2

Water Quality Problems: None

Well Information

Total Well Capacity (gpm)	2515
Total Well Capacity (mgd)	3.62

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	1438
2050	2.243

Well	2,5,7,8 & 22	4 & 6	9,12, & 21	10	30
Depth (ft)	505-552	613-625	435-500	419	660
Yield (gpm)	418	220	249	47	92

Well	,15,16,27& 28	J-1	25	26	K-1 & K-2
Depth (ft)	525-650	500	485	660	330-332
Yield (gpm	346	95	88	43	227

Well	K-5, K-6 & K-7	K-8	K-3		
Depth (ft)	360-380	395	340		
Yield (gpm	290	95	95		

Evaluation of Water Supply to Year 2050

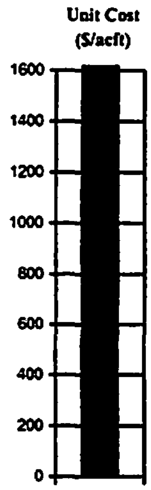
Substantial water level declines and a continued increase in groundwater use in the area indicate that groundwater supplies from the Edwards - Trinity Aquifer will not be adequate in 2050. Future supplies will be supplemented from the GBRA West Comal WSP.

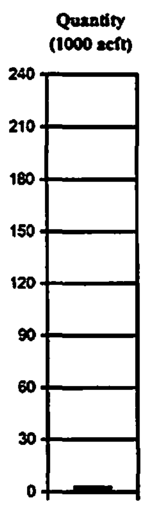
If needed, potential location of new well field and estimated cost to adding new supply to system

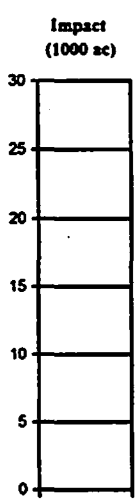
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

January 2001







OPTION NUMBER: SCTN-1a

OPTION NAME: Aquifer Storage and Recovery (ASR) – Regional Option

OPTION DESCRIPTION: *Option SCTN-1a evaluates regional scale municipal and industrial utilities that would benefit from storing surplus groundwater or surface water in the Carrizo and Gulf Coast Aquifers and recovering the water when demand exceeds supply or system capacity. A regional scale facility is considered to have a capacity of 10 to 20 million gallons per day. For this option, two facilities are evaluated. One of the facilities would use the Carrizo-Wilcox Aquifer to support water suppliers in the major municipal and industrial demand center. The other one would support utilities in the Victoria area and would use the Gulf Coast Aquifer.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yrs. ☐ 5-15 yrs. ☐ > 15 yrs.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF CAPACITY (average):	$2,428 and $1,009	per acft[1]
QUANTITY OF CAPACITY (each facility):	2,792	acft/yr[2] (Capacity only)
LAND IMPACTED (average):	286	acres[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Water treatment, transmission system from water treatment plant to ASR wells and from wells to central storage for blending, and ASR wells. Costs of a water supply and a transmission system to get raw water to the water treatment plant and to the ASR facility are not included. Costs presented here are for installation and operation of an ASR facility.

[2]**QUANTITY OF WATER:** ASR facilities are sized at 10 million gallons per day and would operate in a pumping cycle for three months each year. The facilities do not produce any new water supplies, rather, they provide storage to better manage existing supplies and facilities.

[3]**LAND IMPACTED:** Land impacts will be well sites and transmission facilities. The facility for the major municipal and industrial demand center would impact about 278 acres in rural areas while the Victoria facility would impact about 8 acres of urban area.

ENVIRONMENTAL ISSUES: Considered to be minimal – well field sites and pipeline rights-of-way.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing a supply of ASR water, suitability of local aquifer conditions, control of potential water losses to other users of local groundwater, and balancing the operation of injection and recovery.

ADDITIONAL FACTORS: Lack of experience with ASR technology and in operating the facilities, permits from groundwater conservation districts, and TNRCC regulations.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: Cannot be determined until ASR water source is specified.

6.8 Aquifer Storage and Recovery (ASR) – Regional Option (SCTN-1a)

6.8.1 Description of Option

For purposes of this evaluation, Aquifer Storage and Recovery (ASR) is defined as the use of dual-purpose well(s) to inject available water into an aquifer for storage, with recovery of the water using the well(s)' pumping systems. This management strategy would be useful to water suppliers that have quantities surplus to immediate needs but do not have storage for such quantities. In addition, ASR can be used to store treated water during off-peak seasons, thereby eliminating the need (part or all) for treatment plant capacity to meet peak day and peak season demands. In other words, ASR is a way to store water in aquifers during times when water is available and recovering the water when it is needed. If the water management issue is meeting high summer demands, water would be injected into the aquifer during the fall, winter, and spring and pumped during the summer. This strategy more fully utilizes the available capacities of the water treatment plant and, possibly, the availability of the supply. If the water management issue is a supply for emergencies or drought, water could be stored in the aquifer for several years before it is recovered. ASR wells would be designed to accommodate the injection of water as well as pumping water. However, the water utility operating plan must be designed to balance the injection and recovery cycles.

Option SCTN-1a evaluates regional scale ASR facilities for municipal and industrial water supply management. A regional scale facility is considered to have a capacity of 10 to 20 MGD (11,201 to 22,402 acft/yr), if operated continuously. For this option, three facilities are evaluated. Two of the facilities would support municipal and industrial utilities located in the major municipal and industrial demand center of the South Central Texas Region and would use nearby sites located over the Carrizo-Wilcox Aquifer. The other facility would support municipal and industrial water suppliers in the Victoria area and would use the Gulf Coast Aquifer. It is emphasized, however, that this is a strategy for use in management of existing or new water supplies and is not a water supply in and of itself.

The following report section provides a listing and description of characteristics of the important elements involved in determining the feasibility of adding ASR wells to a water supply system. These guidelines or considerations are intended for screening purposes only and not to be criteria for suitability.

6.8.1.1 Source Water

Quality of Source Water to be Injected: When injecting water into an aquifer that is being used for drinking water supplies, TNRCC regulations require that the injected water be at least as good in quality as the water already in the aquifer (native water). This generally means that the injected water has to meet Drinking Water Standards (e.g., for surface water sources, the water will most likely need to be treated).

Availability of Water: Water for recharge must be available in sufficient quantities, durations, and frequencies for development of viable ASR projects. Each project will have to be sized and designed to consider the hydrology of the source water and the storage characteristics of aquifers, as well as the recovery requirements. In addition, the water demand parameters and technical features of supply sources have to be incorporated into the optimization analyses.

Location of Facilities: ASR wells should be near the water treatment and distribution system in order to reduce the cost of constructing new pipelines and pumping the water to and from the ASR wells, however, each project must be evaluated on its own merits, including location and suitability of aquifer materials.

6.8.1.2 Aquifer System

Productivity of the Aquifer: The water yielding characteristics of an aquifer typically should allow the construction of wells producing 700 gpm (about 1 MGD) or more to improve the prospects of being able to make the project cost effective. Both the Carrizo and Gulf Coast Aquifers possess this characteristic. The lowest yield of an ASR well that is documented in the literature is about 200 gpm.

Aquifer Conditions: A confined water-bearing zone is preferable to a shallow water table aquifer.

Aquifer Thickness: The most suitable thickness of a target water-bearing zone is generally between 50 and 200 feet.

Depth to Water-Bearing Zone: The most suitable depths are from 200 to 500 feet. However, depth to water-bearing zones up to 2,500 feet may prove to be cost-effective.

Aquifer Material: A formation having a strong resistance to dissolution, such as sand, gravel, limestone, and sandstone is preferable. In any case, geochemical analyses are necessary to determine if any negative water quality issues are evident that could affect operation of an

ASR facility, such as cation exchange or mineral precipitation, which would result from a reaction with clay in the aquifer.

Water Quality: The most desirable aquifers have water quality that is at or near drinking water standards. However, successful ASR operations have been developed in aquifers with saline water in which the injection of freshwater would displace saline water and create a "freshwater" bubble. In fact, aquifers with saline water may be preferable because of few or no other users of the aquifer, but the well design must consider the fact that freshwater is lighter than saline water, since the freshwater would float to the top of water-bearing zones. Potential adverse geochemical processes such as precipitation, bacterial activity, ion exchange, and adsorption are possible and require a geochemical analysis to determine the expected reactions between the native water and injected water. On the positive side, ASR may improve water quality through reductions in disinfection byproducts, iron and manganese, and hydrogen sulfides.

Aquifer Water Levels and Wellhead Pressures: The desirable range in depth to water depends on the productivity of the aquifer. In aquifers with a high productivity, water levels can be near the land surface. For moderately transmissive water bearing zones, depth to water should be in the range of 100 to 300 feet below land surface. An existing cone of depression is desirable but not necessary. However, the formation of a water level mound that has a potentiometric surface that is above the land surface would increase springflows and cause uncapped wells to flow, which, in turn, would cause a waste of water and could damage existing facilities.[1] In any event, well design and operational requirements must consider expected wellhead pressures of the project.

Data Availability: Existing and reliable geophysical logs, geologic characteristics, water quality data, aquifer properties data, hydrogeologic reports, and groundwater models are very helpful.

Wells: Existing wells are often used, but many are unsuitable or would require modifications and more maintenance during operation. New wells, especially if constructed with PVC casing, are the most trouble free. Well screens should be stainless steel or PVC.

Other Groundwater Users: Natural or regulatory restrictions are needed to prohibit unauthorized withdrawals of stored surface water.

[1] The potentiometric surface is the level to which water of an artesian aquifer will rise if the confining layers are punctured. The Carrizo-Wilcox and the Gulf Coast Aquifers are artesian (confined) in the proposed well fields.

Regulations: The TNRCC regulates artificial recharge of aquifers. Local groundwater conservation districts may regulate artificial recharge and groundwater withdrawals.

6.8.2 Available Capacity

For purposes of evaluating this option, regional size water supply facilities are considered in order to be useful to major municipal and industrial water utilities in the major municipal and industrial demand center of the South Central Texas Region and in the vicinity of Victoria. The Carrizo Aquifer, from northern Atascosa to southwestern Gonzales Counties, offers suitable characteristics for an ASR facility to serve the major municipal and industrial demand center in Bexar County. The Gulf Coast Aquifer is suitable for the City of Victoria. The locations are shown in Figure 6.8-1.

The development of an ASR facility requires use of water to sufficiently flush the formation and to create a bubble of injected water. This quantity of water used to flush the formation is lost, and varies from site to site. However, once the site of the projects identified in this option become fully operational, it is estimated that 90 to 95 percent of the injected water can be recovered.

6.8.2.1 Municipal and Industrial Utilities in Region

The selected conceptual application of an ASR facility to serve the major municipal and industrial demand center is based upon the long-term ASR approach. In this case, excess supplies form the Edwards Aquifer and treated surface water, either from local watersheds or the Guadalupe River, would be candidate water supplies. The location for the potential ASR facility is a section of the Carrizo where all or most all the guidelines listed above can be met (Figure 6.8-1). The ASR well fields should parallel the outcrop of the Carrizo Formation and be located about 5 to 7 miles southeast of the downdip limit of the outcrop. [2,3,4] In these locations, the Carrizo Sands are sufficiently permeable and thick so that well capacities can range from 1,000 to 2,000 gpm. For a 10-MGD facility, five to eight high capacity wells would be required,

[2] Klemt, W.B., et al., "Ground-Water Resources of the Carrizo Aquifer in the Winter Garden Area of Texas," Texas Water Development Board (TWDB) Report 210, Vols. 1 and 2, 1976.
[3] HDR Engineering, Inc and LBG-Guyton Associates, "Interaction Between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," TWDB, 1998.
[4] Ryder, P.D. and Ardis, A.F., "Hydrology of the Texas Gulf Coast Aquifer System." U.S. Geological Survey Open-File Report 91-64, 1991.

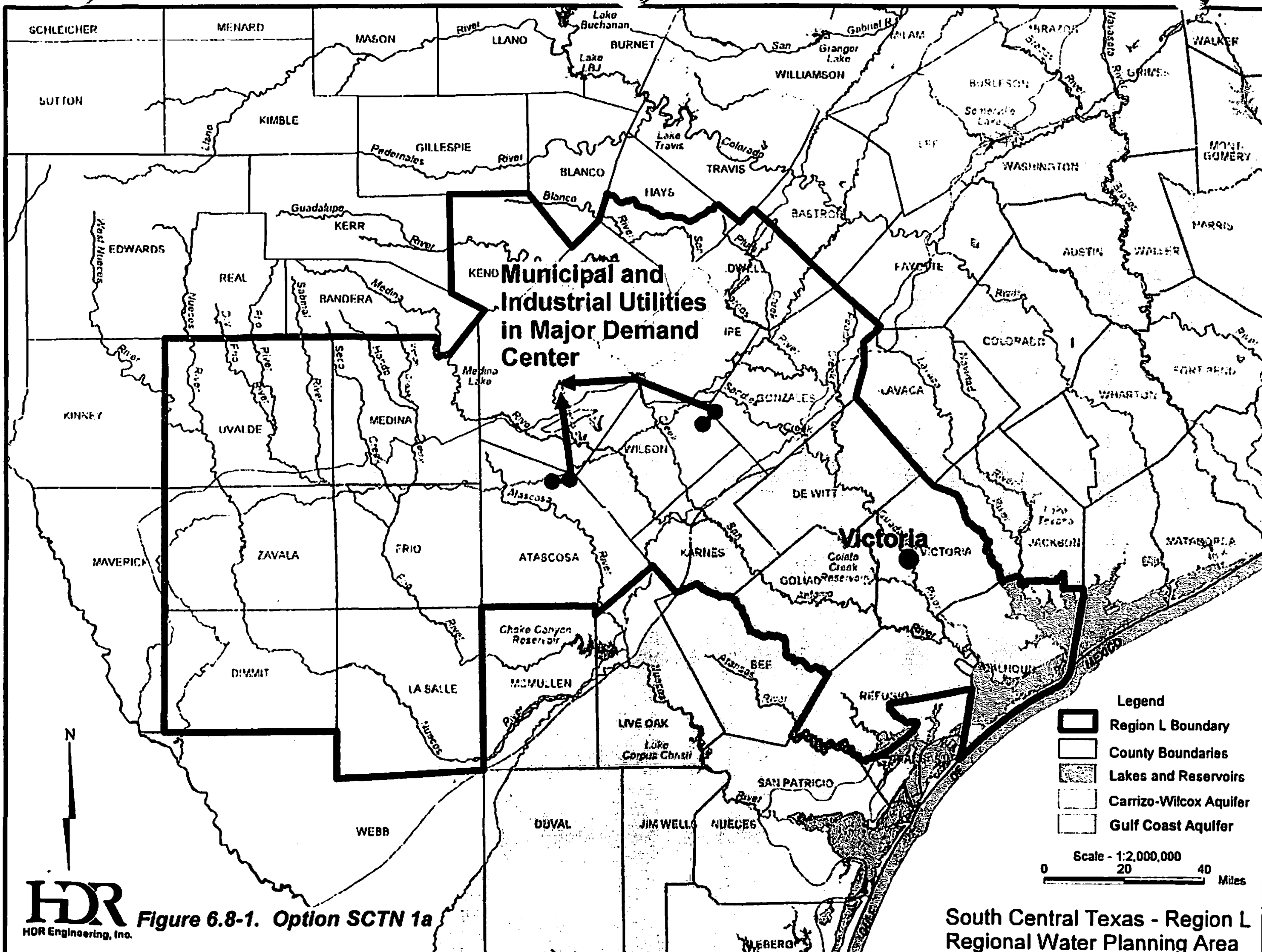


Figure 6.8-1. Option SCTN 1a

however, the facility should be sized and operated in an optimum configuration in order to balance injection and recovery cycles with respect to supplies available for injection, aquifer characteristics, and demand patterns of the utilities that are using ASR. To maintain continuity in depth and to prevent water levels from rising above the land surface (flowing at the surface), the wells would need to be in a line and spaced about 0.5 miles apart. Because of the extent of the Carrizo Aquifer in this area, well fields could be extended for several miles.

6.8.2.2 *Victoria Area*

The selected conceptual application of an ASR facility for a municipal and industrial water utility in the Victoria area uses the annual approach, as opposed to the long-term approach stated above for the municipal and industrial utilities in the region. In this case, treated surface water from the Guadalupe River would be a candidate water supply. The water could be diverted and treated during the fall, winter, and spring and injected into the Gulf Coast Aquifer for storage. The water could then be recovered during the summer months when water demands are high. This concept allows the selection and operation of smaller-sized water treatment facilities than are needed for peaking demands, with use of the water treatment facilities at near capacity throughout the year. ASR wells would be available for the injection cycle 8 to 9 months of the year and suitable to the recovery cycle for the remaining 3 to 4 months.

The site for the ASR facility would be the service area of municipal and industrial water suppliers in the vicinity of Victoria. A review of existing reports listed above and other reports[5,6,7] indicates that an ASR well field located within the City of Victoria would be satisfactory. In this location, the Gulf Coast Aquifer is sufficiently transmissive so that well capacities can range from 1,000 to 1,500 gpm. For a 10-MGD facility, six to nine high capacity wells would be required, however, as in the Carrizo example above, the facility should be sized for optimum operation with respect to injection and recovery cycles, taking into account supplies available for injection, aquifer characteristics, and needs of water suppliers using ASR. To maintain continuity in depth and to prevent water levels rising above the land surface, the wells

[5] Marvin, R.F., et al., "Ground-Water Resources of Victoria and Calhoun Counties, Texas," Texas Board of Water Engineers Bulletin 6202, 1962.
[6] Carr, J.E., et al., "Digital Models for Simulation of Ground-Water Hydrology of the Chicot and Evangeline Aquifers along the Gulf Coast of Texas," Texas Department of Water Resources Report 289, 1985.
[7] Wood, L.A., et al., "Reconnaissance Investigation of Ground-Water Resources of the Gulf Coast Region, Texas," Texas Water Commission Bulletin 6305, 1963.

would need to be distributed throughout the city and spaced about 0.5 mile apart. Locating the wells in the city of Victoria provides a means of controlling who can pump the stored water.

6.8.3 Environmental Issues

Option SCTN-1a involves the construction of well fields in the Carrizo-Wilcox and Gulf Coast Aquifers regions that would support municipal and industrial utilities in the major demand center, and utilities in the Victoria area, respectively. These regional scale facilities would store surplus groundwater or surface water in the aquifers and recover the water when demand exceeds ordinary supply. The facilities would have a capacity of 10 to 20 MGD.

Well fields in this option that use local stream or river systems as the water supply would result in reduced streamflows, which would be a potential environmental concern. Reduced streamflow could affect species endemic to the water systems, terrestrial species that rely on the river or stream as a water supply, and the riparian zone along the river's course.

Data from well fields in the ASR location area show a variety of trends in groundwater levels over the past 30 years. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels. The effects of these new wells on groundwater levels would need to be considered when evaluating this option.

The injection of water into aquifers and the pumping of groundwater from aquifers where ASR is practiced would be expected to contributed to variations in aquifer levels, spring flow, and temporary pools in these areas. Some species inhabit or use temporary pools as well as aquifers and springs. Possible negative effects on these species need to be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.8.4 Engineering and Costing

Securing a water supply for the ASR option is beyond the scope of this option, which is to locate potential sites for ASR facilities and to calculate the costs of constructing and operating such facilities, in case water supplies can be obtained and delivered to the sites. The major facilities required for the ASR options described above are:

- Water Treatment Plant (if needed):
  - Conventional treatment of surface water (projected to be necessary).
  - Necessary treatment (if any of groundwater).
- Transmission System from water treatment plant or Edwards wells (for major demand center) to ASR wells and to a central storage facility for blending:
  - Pipeline(s).
  - Pump Station(s).
- ASR Well Field(s):
  - ASR wells.
  - Injection controls.
  - Monitoring wells.
  - Pumps and motors.

The approximate locations of the well fields, pipelines, and water treatment plants for the two areas are shown in Figure 6.8-1.

Estimates were prepared for capital costs, annual debt service, operation and maintenance, power, and land. The costs are based on operating the facilities in the injection cycle 9 months per year and the pumping cycle 3 months per year. These costs are summarized in Tables 6.8-1 and 6.8-2. As shown, the annual costs for a 10 MGD facility, including debt service for a 30-year loan at 6 percent interest and operation and maintenance costs, including power, are estimated to be $6,778,000 and $2,817,000 for the major municipal and industrial demand center and the Victoria area, respectively. The annual cost for storing and recovering the water is estimated at $2,428/acft, and $1,009/acft, respectively. It is reiterated, however, that these cost estimates do not include the cost of securing a water supply nor the transportation of water to the water treatment plant or the ASR facility. The ASR facility at Victoria is considerably less expensive per unit of capacity because of the shorter distance from the ASR wells to the distribution system than is the case for the major demand center. It is important to note, however, that neither the Carrizo nor the Gulf Coast cases presented are necessarily optimum in size nor injection/recovery cycles. Detailed optimization analyses will be required in order to consider ASR as a part of any water supply system.

Table 6.8-1
Cost Estimate Summary
Municipal and Industrial Users in
Major Demand Center in the Region (SCTN 1a)
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
ASR Wells (8 wells, 10 MGD total)	$4,248,000
Transmission Pump Stations (3)	3,987,000
Transmission Pipeline (24 in dia., 48.9 miles)	14,272,000
Water Treatment Plant (10 MGD)	10,303,000
Distribution Connections	12,880,000
Total Capital Cost	**$45,690,000**
Engineering, Legal Costs and Contingencies	$15,079,000
Environmental & Archaeology Studies and Mitigation	2,303,000
Land Acquisition and Surveying (278 acres)	3,167,000
Interest During Construction (2 years)	5,300,000
Total Project Cost	**$71,539,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$5,197,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	225,000
Water Treatment Plant	973,000
Pumping Energy Costs (6,391,324 kWh @ $0.06 per kWh)	383,000
Total Annual Cost	$6,778,000
Project Capacity (acft/yr) (for 3 months of operation)*	**2,792**
Annual Cost of ASR ($ per acft)	**$2,428**
Annual Cost of ASR ($ per 1,000 gallons)	**$7.45**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.8-2
Cost Estimate Summary
Municipal and Industrial Users
in Victoria Area (SCTN 1a)
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
ASR Wells (8 wells, 10 MGD total)	$4,432,000
Transmission Pipeline (24 in dia., 6 miles)	2,408,000
Water Treatment Plant (10 MGD)	10,303,000
Total Capital Cost	**$17,143,000**
Engineering, Legal Costs and Contingencies	$5,880,000
Environmental & Archaeology Studies and Mitigation	11,000
Land Acquisition and Surveying (8 acres)	15,000
Interest During Construction (2 years)	922,000
Total Project Cost	**$23,971,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$1,741,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	24,000
Water Treatment Plant	973,000
Pumping Energy Costs (1,321,333 kWh @ $0.06 per kWh)	79,000
Total Annual Cost	$2,817,000
Project Capacity (acft/yr)*	**2,792**
Annual Cost of ASR ($ per acft)	**$1,009**
Annual Cost of ASR ($ per 1,000 gallons)	**$3.10**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

6.8.5 Implementation Issues

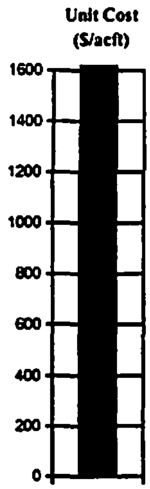
Implementation of the ASR concepts includes the following issues:

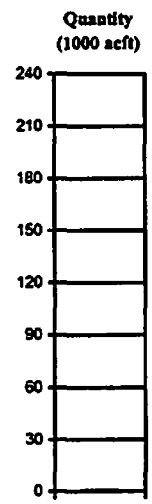
- Suitable supplies of water for injection;
- Rules and regulations of groundwater conservation districts where ASR facilities would be located;
- Water treatment prior to injection;
- Lack of experience to develop confidence in the ability to inject and recover water from an aquifer. This includes the uncertainty about the compatibility of the injected water with native groundwater and aquifer materials;
- Availability of access to local aquifers for an efficient application of ASR;
- Regulations by the TNRCC;
- Controlling the loss of injected water to neighboring groundwater users;
- Initial cost;
- Experience in operating the facilities; and/or
- Developing a management plan to efficiently use the ASR wells with balanced injection and recovery cycles.

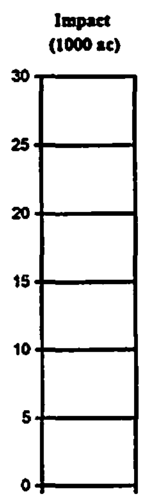
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

January 2001







OPTION NUMBER: **SCTN-1b**

OPTION NAME: **Aquifer Storage and Recovery (ASR) — Local Option**

OPTION DESCRIPTION: *Option SCTN-1b evaluates local-scale municipal and industrial water supply facilities that would benefit by storing surplus groundwater or surface water in the Carrizo and Gulf Coast Aquifers and recovering the water when needed. A local-scale facility is considered to have a capacity of 0.5 to 1.0 million gallons per day. For this option, four facilities are evaluated. Two use the Carrizo-Wilcox Aquifer (Cities of Carrizo Springs and Luling) and the other two use the Gulf Coast Aquifer (Karnes City and City of Seadrift.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yrs. ☐ 5-15 yrs. ☐ > 15 yrs.

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER (average):	$2,089	per acft[1]
QUANTITY OF WATER (each facility):	279	acft/yr [2]
LAND IMPACTED (average)	3	acres[3]

POSITION RELATIVE TO ALL OPTIONS			
UNIT COST OF WATER:		of	(1=lowest unit)
QUANTITY OF WATER:		of	(1=highest volume)
LAND IMPACTED:		of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Water treatment, transmission system from water treatment plant to ASR wells and from wells to central storage for blending, and ASR wells. Costs of a water supply and a transmission system to get the raw water to the water treatment plant and not included.

[2]**QUANTITY OF WATER:** ASR facilities are sized at 1.0 million gallons per day and would operate in a pumping cycle for three months each year. The facilities do not produce additional water supplies, rather, they provide storage to better manage existing supplies and facilities.

[3]**LAND IMPACTED:** Land impacts would be for water treatment plant, well sites, and transmission facilities within urban areas. Waterlines are considered to be located on city easements and are not included.

ENVIRONMENTAL ISSUES: Considered to be minimal—well field sites and pipeline rights-of-way.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing a supply of water, water treatment, suitability of local aquifer conditions, control of water losses to other users of local groundwater, and balancing the operation of injection and recovery.

ADDITIONAL FACTORS: Lack of experience with ASR technology and in operating the facilities, permits from groundwater conservation districts, and TNRCC regulations.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: Cannot be determined until ASR water source is specified.

6.9 Aquifer Storage and Recovery (ASR) – Local Option (SCTN-1b)

6.9.1 Description of Option

For purposes of this evaluation, Aquifer Storage and Recovery (ASR) is defined as the use of dual-purpose well(s) to inject available water into an aquifer for storage, with recovery of the water using the well(s)' pumping systems. This management strategy would be useful to water suppliers that have quantities surplus to immediate needs but do not have storage for such quantities. In addition, ASR can be used to store treated water during off-peak seasons, thereby eliminating the need (part or all) for treatment plant capacity to meet peak day and peak season demands. In other words, ASR is a way to store water in aquifers during times when water is available and recovering the water when it is needed. If the water management issue is meeting high summer demands, water would be injected into the aquifer during the fall, winter, and spring and pumped during the summer. This strategy more fully utilizes the available capacities of the water treatment plant and, possibly, the availability of the supply. If the water management issue is a supply for emergencies or drought, water could be stored in the aquifer for several years before it is recovered. ASR wells would be designed to accommodate the injection of water as well as pumping water. However, the water utility operating plan must be designed to balance the injection and recovery cycles.

Option SCTN-1b evaluates local scale ASR facilities for municipal and industrial water supply management. A local scale facility is considered to have a capacity of 0.5 to 1.0 MGD (560 to 1,120 acft/yr), if operated continuously. For this option, four facilities are evaluated. Two of the facilities (Cities of Carrizo Springs and Luling) would use nearby sites located over the Carrizo-Wilcox Aquifer. The other two facilities (Karnes City and coastal area municipal and industrial water suppliers in Calhoun County) would use the Gulf Coast Aquifer. It is emphasized, however, that this is a strategy for use in management of existing or new water supplies and is not a water supply in and of itself.

The following report section provides a listing and description of characteristics of the important elements involved in determining the feasibility of adding ASR wells to a water supply system. These guidelines or considerations are intended for screening purposes only and not to be criteria for suitability.

6.9.1.1 Source Water

Quality of Source Water to be Injected: When injecting water into an aquifer that is being used for drinking water supplies, TNRCC regulations require that the injected water be at least as good in quality as the water already in the aquifer (native water). This generally means that the injected water has to meet Drinking Water Standards (e.g., for surface water sources, the water will most likely need to be treated).

Availability of Water: Water for recharge must be available in sufficient quantities, durations, and frequencies for development of viable ASR projects. Each project will have to be sized and designed to consider the hydrology of the source water and the storage characteristics of aquifers, as well as the recovery requirements. In addition, the water demand parameters and technical features of supply sources have to be incorporated into the optimization analyses.

Location of Facilities: ASR wells should be near the water treatment and distribution system in order to reduce the cost of constructing new pipelines and pumping the water to and from the ASR wells, however, each project must be evaluated on its own merits, including location and suitability of aquifer materials.

6.9.1.2 Aquifer System

Productivity of the Aquifer: The water yielding characteristics of an aquifer typically should allow the construction of wells producing 700 gpm (about 1 MGD) or more to improve the prospects of being able to make the project cost effective. Both the Carrizo and Gulf Coast Aquifers possess this characteristic. The lowest yield of an ASR well that is documented in the literature is about 200 gpm.

Aquifer Conditions: A confined water-bearing zone is preferable to a shallow water table aquifer.

Aquifer Thickness: The most suitable thickness of a target water-bearing zone is generally between 50 and 200 feet.

Depth to Water-Bearing Zone: The most suitable depths are from 200 to 500 feet. However, depth to water-bearing zones up to 2,500 feet may prove to be cost-effective.

Aquifer Material: A formation having a strong resistance to dissolution, such as sand, gravel, limestone, and sandstone is preferable. In any case, geochemical analyses are necessary to determine if any negative water quality issues are evident that could affect operation of an

ASR facility, such as cation exchange or mineral precipitation, which would result from a reaction with clay in the aquifer.

Water Quality: The most desirable aquifers have water quality that is at or near drinking water standards. However, successful ASR operations have been developed in aquifers with saline water in which the injection of freshwater would displace saline water and create a "freshwater" bubble. In fact, aquifers with saline water may be preferable because of few or no other users of the aquifer, but the well design must consider the fact that freshwater is lighter than saline water, since the freshwater would float to the top of water-bearing zones. Potential adverse geochemical processes such as precipitation, bacterial activity, ion exchange, and adsorption are possible and require a geochemical analysis to determine the expected reactions between the native water and injected water. On the positive side, ASR may improve water quality through reductions in disinfection byproducts, iron and manganese, and hydrogen sulfides.

Aquifer Water Levels and Wellhead Pressures: The desirable range in depth to water depends on the productivity of the aquifer. In aquifers with a high productivity, water levels can be near the land surface. For moderately transmissive water bearing zones, depth to water should be in the range of 100 to 300 feet below land surface. An existing cone of depression is desirable but not necessary. However, the formation of a water level mound that has a potentiometric surface that is above the land surface would increase springflows and cause uncapped wells to flow, which, in turn, would cause a waste of water and could damage existing facilities.[1] In any event, well design and operational requirements must consider expected wellhead pressures of the project.

Data Availability: Existing and reliable geophysical logs, geologic characteristics, water quality data, aquifer properties data, hydrogeologic reports, and groundwater models are very helpful.

Wells: Existing wells are often used, but many are unsuitable or would require modifications and more maintenance during operation. New wells, especially if constructed with PVC casing, are the most trouble free. Well screens should be stainless steel or PVC.

[1] The potentiometric surface is the level to which water of an artesian aquifer will rise if the confining layers are punctured. The Carrizo-Wilcox and the gulf Coast Aquifers are artesian (confined) in the proposed well fields.

Other Groundwater Users: Natural or regulatory restrictions are needed to prohibit unauthorized withdrawals of stored surface water.

Regulations: The TNRCC regulates artificial recharge of aquifers. Local groundwater conservation districts may regulate artificial recharge and groundwater withdrawals.

6.9.2 Available Capacity

For purposes of evaluating this option, local size water supply facilities are considered to be typical of communities with less than 2,500 connections. The cities selected for evaluation include Carrizo Springs and Luling in the Carrizo-Wilcox Aquifer and Karnes City and coastal water suppliers in Calhoun County in the Gulf Coast Aquifer. The locations are shown in Figure 6.9-1.

6.9.2.1 City of Carrizo Springs

The selected conceptual application of an ASR facility to serve Carrizo Springs combines the annual and long-term ASR approach. In this case, a long-term basis refers to the injection of water from a supply that is considered to be available on an intermittent basis over the long-term, but not on an annual basis or during selected seasons. Candidate sources are a local watershed or the Nueces River. The annual basis refers to the recovery cycle to meet summer peak demands. This scenario is based on injecting water over many months, and perhaps years, and withdrawing some of the water each summer, as needed. Considering the variability in the availability of surface water and the peak demands, it is estimated that four wells would be needed for the injection and recovery cycle.

In the vicinity of the City of Carrizo Springs, the Carrizo Aquifer meets most all the guidelines listed above. A review of existing reports[2,3,4] and the extent of other groundwater users in the area indicates that an ASR well field could be located on the eastern side of the city. In this location, the Carrizo Sands are sufficiently permeable and thick so that well capacities can

[2] Klemt, W.B., et al., "Ground-Water Resources of the Carrizo Aquifer in the Winter Garden Area of Texas," Texas Water Development Board (TWDB) Report 210, Vols. 1 and 2, 1976.
[3] HDR Engineering, Inc and LBG-Guyton Associates, "Interaction between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," TWDB, 1998
[4] Ryder, P.D. and Ardis, A.F., "Hydrology of the Texas Gulf Coast Aquifer System." U.S. Geological Survey Open-File Report 91-64, 1991.

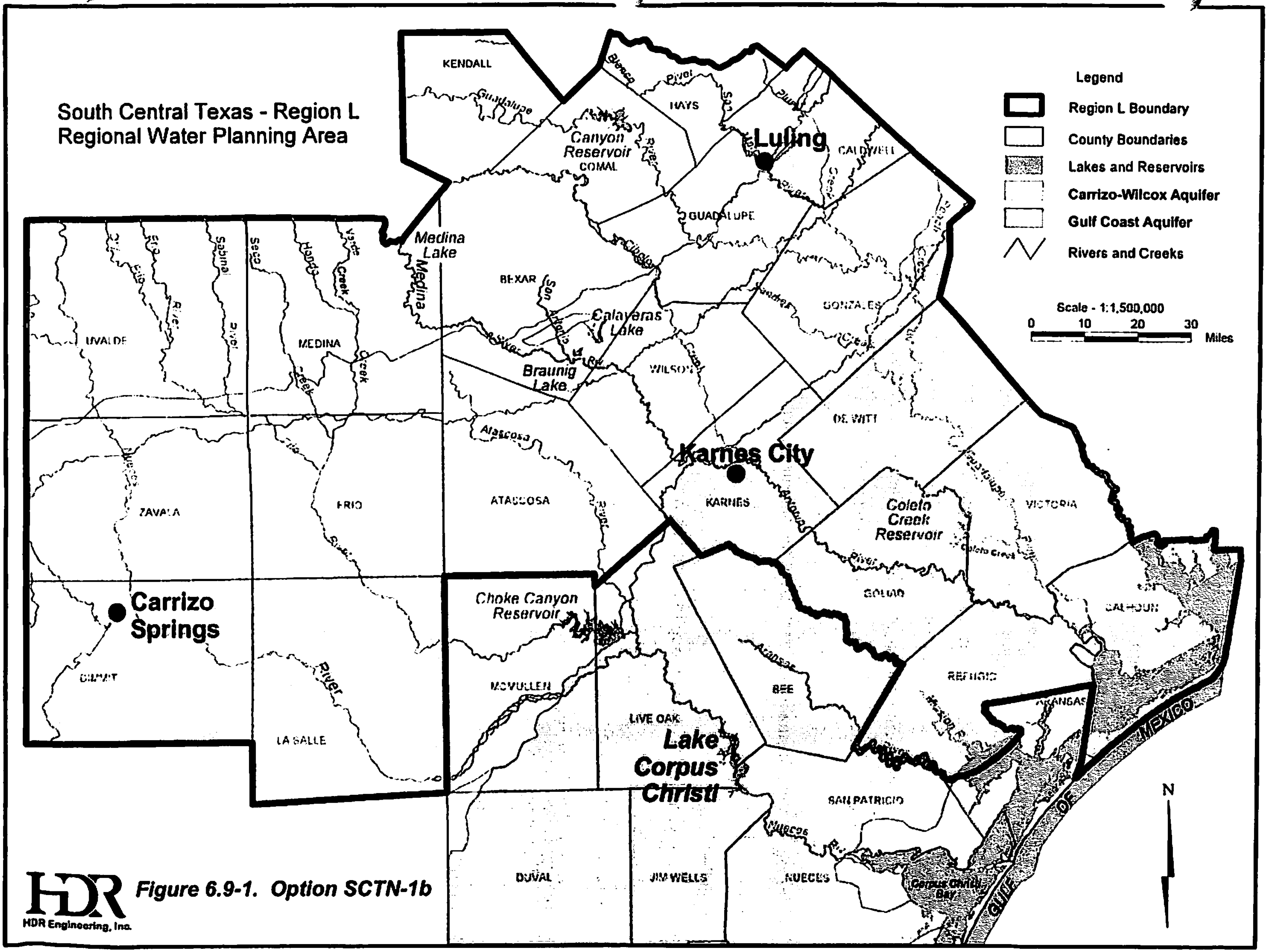


Figure 6.9-1. Option SCTN-1b

range from 200 to 300 gpm. For a 1.0-MGD facility, three to five wells would be required. The wells would be located within the city to maintain control of the stored water. They would be spaced about 0.5 miles apart.

6.9.2.2 City of Luling

The selected conceptual application of an ASR facility to serve the City of Luling uses the annual approach. In this case, the application assumes treated surface water from the Guadalupe River would be the water source. The water would be diverted and treated during the fall, winter, and spring and injected into the Carrizo Aquifer for storage. The water would be recovered during the summer months when water demands are high. This concept allows using the water treatment facilities at near capacity throughout the year and reduces demand on supplies in the Guadalupe River during the summer when demands are high. ASR wells would be in the injection cycle eight to nine months a year and in the recovery cycle three to four months.

A review of existing reports listed above and a county groundwater report[5] indicates that an ASR well field in the City of Luling would be satisfactory. In this location, the Carrizo Aquifer is sufficiently transmissive so that well capacities can range from 400 to 500 gpm. For a 1.0-MGD facility, two to three wells would be required, and locating the wells in the City of Luling provides a means of controlling who can pump the stored water.

6.9.2.3 Karnes City

The selected conceptual application of an ASR facility to serve Karnes City uses the annual approach. In this case, the candidate supply is treated surface water from a local stream or the San Antonio River. The water would be diverted and treated during the fall, winter, and spring and injected into the Catahoula Formation of the Gulf Coast Aquifer from which the city presently obtains a part of its water. The injected water could be recovered during the summer months when water demands are high. This concept would allow using the water treatment facilities at near capacity when a raw water supply is available. It would also provide emergency supplies when there is a malfunction of the existing system. ASR wells would be in the injection cycle eight to nine months a year and in the recovery cycle three to four months.

[5] Follett, C.R., "Ground-Water Resources of Caldwell County, Texas," TWDB, Report 12, 1966

In Karnes City, depth to the Catahoula Formation is about 100 feet; however, native water in the Catahoula Formation has total dissolved solids concentrations between 1,000 and 2,000 milligrams per liter. Water from the Carrizo Aquifer comes from a water-bearing zone over 3,000 feet deep and has total dissolved solids concentrations less than 1,000 milligrams per liter. However, the water temperature is over 150 degrees Fahrenheit. Thus, an ASR operation using the Catahoula Formation would be expected to improve the quality and increase the quantity of supply for Karnes City.

A review of existing reports listed above and other reports[6,7] indicates that an ASR well field in Karnes City would be satisfactory. In this location, the Catahoula Formation is sufficiently transmissive so that well capacities can range from 200 to 250 gpm. For a 1.0-MGD facility, three to four wells would be required, and locating the wells in Karnes City provides a means of controlling who can pump the stored water.

6.9.2.4 Coastal Area Water Suppliers of Calhoun County

The selected conceptual application of an ASR facility to serve the municipal and industrial suppliers of Calhoun County use the annual approach. In this case, groundwater from the Gulf Coast Aquifer in the northwestern part of Calhoun County about 12 miles from the Gulf Coast would be the water supply and would be pumped at a rather uniform rate throughout the year. During the fall, winter, and spring when water demands are low, the water in excess of demands would be injected into the Gulf Coast Aquifer for storage, which is slightly saline at about 10 miles inland. The water would be recovered during the summer months to meet water demands that exceed system capacity of the remote wells and pipeline. This concept allows using the remote wells and pipeline to operate at near capacity throughout the year and provides emergency supplies close to the demands. ASR wells would be in the injection cycle eight to nine months a year and in the recovery cycle 3 to 4 months.

[6] Wood, L. A., et al., "Reconnaissance Investigation of Ground-Water Resources of the Gulf Coast Region, Texas," Texas Water Commission Bulletin 6305, 1963.
[7] Anders, R.B., "Ground Water Geology of Karnes County, Texas," TWDB Bulletin 6007, 1960.

A review of existing reports listed above and other reports[8,9] indicates that an ASR well field in the vicinity of the City of Seadrift would be satisfactory.[10] In this location, the Gulf Coast Aquifer is sufficiently transmissive so that well capacities can range up to 500 gpm. For a 1.0-MGD facility, two to three wells would be required.

6.9.3 Environmental Issues

Option SCTN-1b involves the construction of well fields in the Carrizo-Wilcox and Gulf Coast Aquifers regions that would support local municipalities. These local scale facilities would store surplus groundwater or surface water in the aquifers and recover the water when demand exceeds ordinary supply. The facilities would have a capacity of 0.5 to 1 MGD.

In this option, the sources of water would probably be local stream or river systems and groundwater from aquifers. In the case of surface water sources, reduced streamflows would be a potential environmental concern. Reduced streamflow could affect species endemic to the water systems, terrestrial species that rely on the river or stream as a water supply, and the riparian zone along the river's course.

Data from well fields in the Carrizo Aquifer area show a variety of trends in groundwater levels over the past 30 years. The effects of ASR wells on groundwater levels would need to be considered when evaluating this option.

The injection of water into aquifers and the pumping of groundwater from aquifers where ASR is practiced would be expected to contribute to variations in aquifer levels, springflow, and temporary pools in these areas. Some species inhabit or use temporary pools as well as aquifers and springs. Possible negative effects on these species need to be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places,

[8] Marvin, R.F., et al., "Ground-Water Resources of Victoria and Calhoun Counties, Texas," Texas Board of Water Engineers Bulletin 6202, 1962.
[9] Carr, J.E., et al., "Digital Models for Simulation of Ground-Water Hydrology of the Chicot and Evangeline Aquifers Along the Gulf Coast of Texas," Texas Department of Water Resources Report 289, 1985.
[10] It is important to note that the City of Seadrift has recently installed a reverse-osmosis desalination plant to meet its needs. Thus, it may become advantageous to use desalted water as a source of water for ASR.

respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.9.4 Engineering and Costing

Securing a water supply for the aquifer storage and recovery option and transporting the water to the ASR facility is beyond the scope of this evaluation, which is to locate potential sites for ASR facilities and to calculate the costs of constructing and operating such facilities in case they are needed. The major facilities required for the ASR options described above are:

- Water Treatment Plant (if needed):
  - Conventional treatment of surface water (projected to be necessary).
  - Necessary treatment (if any for groundwater).
- Freshwater Supply Wells (Calhoun County).
- Transmission System to the ASR wells and to a central storage facility for blending:
  - Pipeline(s).
  - Pump Station(s).
- ASR Well Field(s):
  - ASR wells.
  - Injection controls.
  - Monitoring wells.
  - Pumps and motors.

The approximate locations of the ASR facilities for the four sites are shown in Figure 6.9-1.

Estimates were prepared for capital costs, annual debt service, operation and maintenance, water purchases, power, and land. These costs are summarized in Tables 6.9-1, 6.9-2, 6.9-3, and 6.9-4 for the cities of Carrizo Springs, Luling, Karnes City, and Calhoun County, respectively. As shown, the annual costs for a 1.0 MGD size facility, including debt service for a 30-year loan at 6 percent interest and operation and maintenance costs, including power, are estimated to be $763,000, $703,000, $756,000 and $111,000, respectively. The annual costs for the respective ASR facilities are estimated at $2,734/acft, $2,519/acft, $2,708/acft, and $396/acft, respectively. The costs are based on operating the facilities in the

Table 6.9-1.
Cost Estimate Summary
SCTN-1b: City of Carrizo Springs
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
ASR Wells (4 wells, 1 MGD total)	$1,044,000
Transmission Pipeline (12-inch dia., 4 miles)	950,000
Water Treatment Plant (1 MGD)	2,654,000
Total Capital Cost	**$4,648,000**
Engineering, Legal Costs and Contingencies	$1,453,000
Environmental & Archaeology Studies and Mitigation	31,000
Land Acquisition and Surveying (3 acres)	43,000
Interest During Construction (2 years)	466,000
Total Project Cost	**$6,806,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$495,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	10,000
Water Treatment Plant	249,000
Pumping Energy Costs (152,613 kWh @ $0.06 per kWh)	9,000
Total Annual Cost	**$763,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$2,734**
Annual Cost of ASR ($ per 1,000 gallons)	**$8.39**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.9-2. Cost Estimate Summary SCTN-1b: City of Luling (Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
ASR Wells (3 wells, 1 MGD total)	$783,000
Transmission Pipeline (12-inch dia., 3 miles)	713,000
Water Treatment Plant (1 MGD)	2,654,000
Total Capital Cost	**$4,150,000**
Engineering, Legal Costs and Contingencies	$1,417,000
Environmental & Archaeology Studies and Mitigation	17,000
Land Acquisition and Surveying (3 acres)	23,000
Interest During Construction (2 years)	449,000
Total Project Cost	**$6,056,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$440,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	7,000
Water Treatment Plant	249,000
Pumping Energy Costs (111,768 kWh @ $0.06 per kWh)	7,000
Total Annual Cost	**$703,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$2,519**
Annual Cost of ASR ($ per 1,000 gallons)	**$7.73**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.9-3.
Cost Estimate Summary
SCTN-1b: Karnes City
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
ASR Wells (4 wells, 1 MGD total)	$1,044,000
Transmission Pipeline (12-inch dia., 4 miles)	950,000
Water Treatment Plant (1 MGD)	2,654,000
Total Capital Cost	**$4,648,000**
Engineering, Legal Costs and Contingencies	$1,579,000
Environmental & Archaeology Studies and Mitigation	3,000
Land Acquisition and Surveying (3 acres)	4,000
Interest During Construction (2 years)	499,000
Total Project Cost	**$6,733,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$489,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	10,000
Water Treatment Plant	249,000
Pumping Energy Costs (132,333 kWh @ $0.06 per kWh)	8,000
Total Annual Cost	**$756,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$2,708**
Annual Cost of ASR ($ per 1,000 gallons)	**$8.31**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.9-4.
Cost Estimate Summary
SCTN-1b: Calhoun County near City of Seadrift
(Second Quarter 1999 Prices)

Item	*Estimated Costs for Facilities*
Capital Costs	
ASR Wells (2 wells, 1 MGD total)	$470,000
Transmission Pipeline (12-inch dia., 2 miles)	475,000
Total Capital Cost	**$945,000**
Engineering, Legal Costs and Contingencies	$307,000
Environmental & Archaeology Studies and Mitigation	1,000
Land Acquisition and Surveying (1 acre)	2,000
Interest During Construction (2 years)	101,000
Total Project Cost	**$1,356,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$99,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	5,000
Pumping Energy Costs (111,768 kWh @ $0.06 per kWh)	7,000
Total Annual Cost	**$111,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$396**
Annual Cost of ASR ($ per 1,000 gallons)	**$1.21**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

pumping cycle 3 months each year. It is reiterated that these cost estimates do not include the cost of securing a water supply nor the transportation of water to the ASR facility. The estimated cost of the ASR facility at the Calhoun County site is considerably less because no water treatment would be required.

6.9.5 Implementation Issues

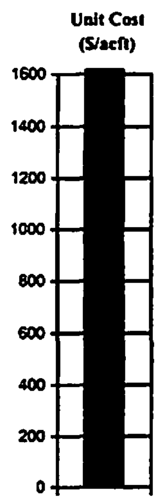
Implementation of the ASR concepts includes the following issues:

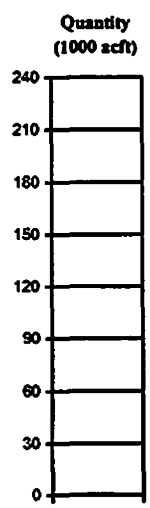
- Suitable supplies of water for injection;
- Rules and regulations of groundwater conservation districts where ASR facilities would be located;
- Water treatment prior to injection;
- Lack of experience to develop confidence in the ability to inject and recover water from an aquifer. This includes the uncertainty about the compatibility of the injected water with native groundwater and aquifer materials;
- Availability of access to local aquifers for an efficient application of ASR;
- Regulations by the TNRCC;
- Controlling the loss of injected water to neighboring groundwater users;
- Initial cost;
- Experience in operating the facilities; and/or
- Developing a management plan to efficiently use the ASR wells with balanced injection and recovery cycles.

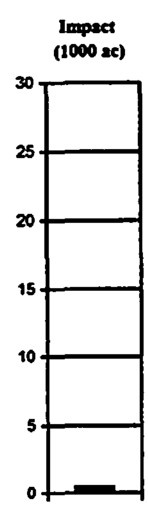
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

January 2001







OPTION NUMBER: SCTN-8
OPTION NAME: Trinity Aquifer Optimization

OPTION DESCRIPTION: *Recharge to the Trinity Aquifer in Kendall County would be enhanced through the operation of a system of one or more recharge reservoirs on tributaries of the Guadalupe River. Enhanced recharge could be available for local domestic needs or for transmission to a municipality. Representative costs include enhanced recharge to the Trinity Aquifer from a single recharge structure. Multiple structures could be constructed to maximize recharge at approximately the same unit cost.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	$1,886	per acft[1]	Raw Water in Aquifer
QUANTITY OF WATER:	390	acft/yr[2]	(Program of Five Structures)
LAND IMPACTED:	460	acres[3]	(Program of Five Structures)

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Representative cost for recharge dam and reservoir, including mitigation.

[2]**QUANTITY OF WATER:** Upstream and downstream water rights, size and number of recharge reservoirs.

[3]**LAND IMPACTED:** Reservoir sites.

ENVIRONMENTAL ISSUES: Inundation of about 92 acres (per site) of Guadalupe River tributary channel. Archaeological and cultural resource surveys should be conducted. The Guadalupe River in Kendall County is recommended for designation as an Ecologically Unique River Segment by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water high, primarily due to expected low infiltration rates and associated evaporation. Recharge rates could be much greater in areas where the aquifer formation is highly fractured. However, the likelihood of rapid losses to proximate springs is also greater in these areas.

ADDITIONAL FACTORS: Ability to obtain permits to use surface water from the Guadalupe River Basin.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-19, G-30, SCTN-2c, and/or SCTN-10.

6.10 Trinity Aquifer Optimization (SCTN-8)

6.10.1 Description of Option

Recharge to the Trinity Aquifer within the South Central Texas Region occurs primarily where the Lower Member of the Glen Rose Limestone outcrops in portions of Hays, Comal, Bexar, Kendall, Medina, and Uvalde Counties. The majority of Kendall County lies within this outcrop area, as indicated in Figure 6.10-1. Water recharged to the aquifer generally travels to the south and southeast.[1] The aquifer can be described as a generally "tight" formation, referring to a relatively low permeability. This low permeability limits the quantity of water that may be pumped by individual wells, and conversely, the quantity of water that can be recharged to the aquifer. Reported permeabilities range from 0.0012 to 0.108 feet per day for cores taken at depth, to 0.1 to 0.4 feet per day at the surface. This is extremely low in contrast to reported permeabilities of other aquifer formations investigated for water supply potential within the South Central Texas Region. For example, the Carrizo Aquifer has reported permeabilties ranging from 1.2 to 4 feet per day.

This option evaluates the potential for enhancing recharge of the Trinity Aquifer in Kendall County with available (unappropriated) water from tributaries of the Guadalupe River. With this option, available flows from these tributaries would be impounded in small- to medium-sized recharge reservoirs, and allowed to percolate into the underlying aquifer formation. Water recharged in this fashion would then be available for pumpage by wells in the surrounding area. However, due to the low permeability and other characteristics of the formation, water recharged in this fashion would likely be available for pumpage only in the immediate geographic vicinity of the recharge project.

Water recharged by implementation of this option would be available for local domestic needs, or for transmission to a nearby municipality. Only costs for enhanced recharge of the Trinity Aquifer are considered in this analysis.

[1] Texas Department of Water Resources, "Report 273: Ground-Water Availability of the Lower Cretaceous Formations in the Hill Country of South-Central Texas," January 1983.

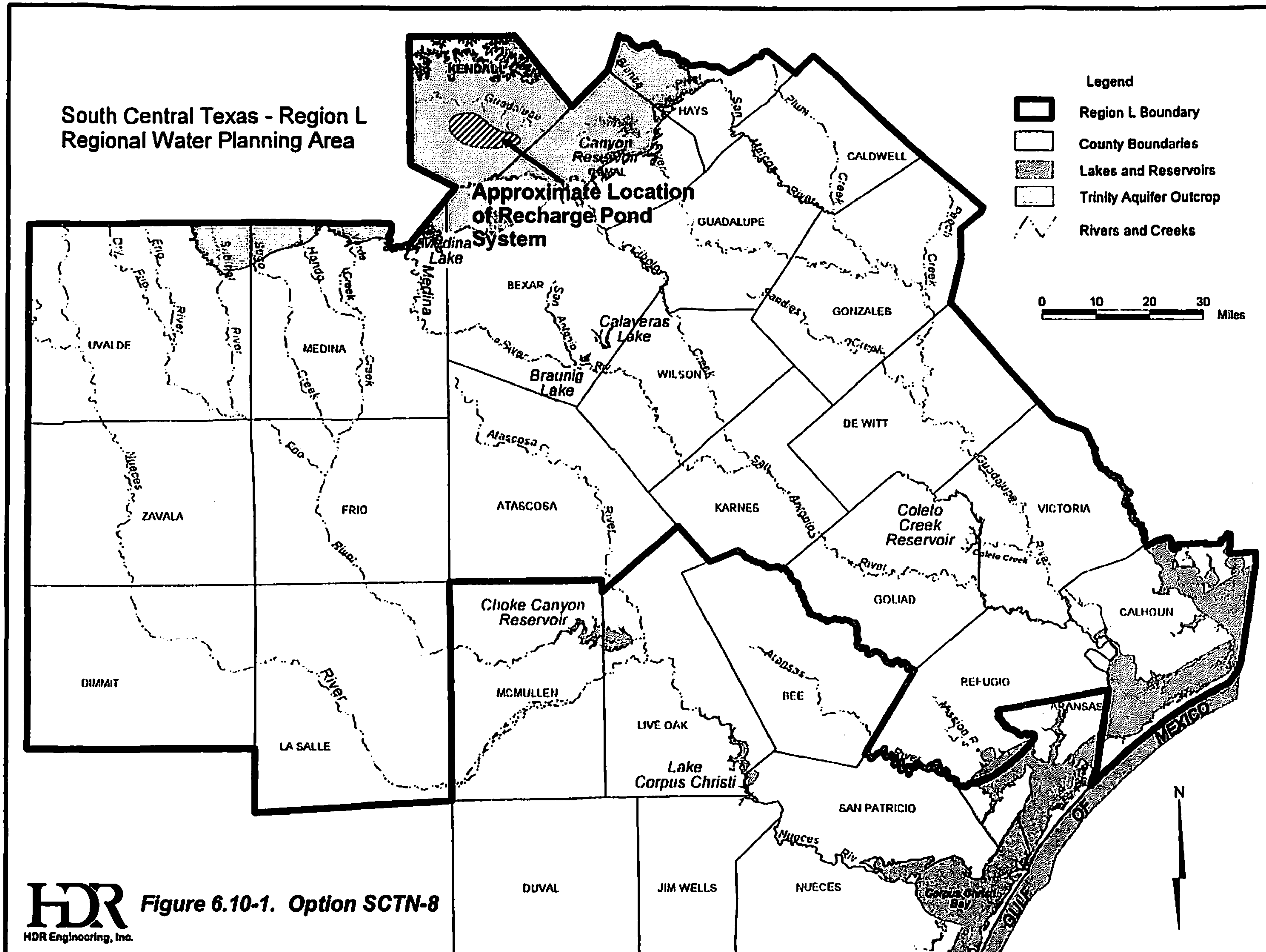


Figure 6.10-1. Option SCTN-8

6.10.2 Water Availability

Water available for recharge enhancement from tributaries of the Guadalupe River in Kendall County is limited by upstream and downstream water rights. Water would be available sporadically, during periods of high flow when existing water rights (including priority hydropower) are fully satisfied, and Canyon Reservoir is full. The availability of water for recharge enhancement was computed utilizing the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B). Monthly regulated streamflow and unappropriated streamflow available from the Guadalupe River Basin were estimated using the Guadalupe-San Antonio River Basin Water Availability Model (GSA WAM),[2] developed for TNRCC under the SB1 Water Availability Modeling Project. The current version of the GSA WAM includes the 1934 to 1989 historical period. Input data files for the GSA WAM were modified so as to match the general assumptions adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

Water availability was estimated for one representative site in central Kendall County. The drainage area of this site (15 square miles) is representative of other sites in this area at which small-to-medium-sized recharge reservoirs could be constructed. Figure 6.10-1 shows a general outline of the vicinity within which one or more of these structures might be constructed. Daily streamflow available for diversion at a representative site was estimated by distributing the monthly regulated and unappropriated streamflows computed by the GSA WAM to daily values using nearby gaged streamflow records.

A computer program was developed to simulate daily impoundment of available streamflow and subsequent recharge of the water to the Trinity Aquifer. Data inputs to the program include the monthly regulated and available streamflows estimated using the GSA WAM, monthly evaporation rates, daily gaged flows used to distribute the monthly flows to daily values, the Consensus Criteria pass-through requirements, the storage capacity of the reservoir, and the infiltration (recharge) rate estimated for the site. As gaged flows for this small watershed are not available, the streamflow statistics used to determine the monthly Consensus Criteria pass-through requirements were prorated by drainage area from those for the Guadalupe River near Comfort (USGS #08167000). Monthly unappropriated flows for the representative

[2] HDR, "Water Availability in the Guadalupe-San Antonio River Basin-Draft Report," Texas Natural Resource Conservation Commission, September 1999.

Criteria pass-through requirements were prorated by drainage area from those for the Guadalupe River near Comfort (USGS #08167000). Monthly unappropriated flows for the representative site are shown in Figure 6.10-2. As is apparent in the figure, available flows occur relatively infrequently. Note that additional water could be made available for impoundment (at additional cost) through negotiation of an hydropower subordination agreement with downstream water rights owners.

An infiltration rate of 0.01 feet per day was assumed. This rate is within the range reported by the Texas Department of Water Resources[4] for cores obtained from test wells, but is lower than permeability test data presented in a soil survey of Kendall County.[5] The lower rate would control recharge into the formation, and was adopted for this analysis. Recharge rates could be much greater in areas where the aquifer formation is highly fractured. However, the likelihood of rapid losses to proximate springs is also greater in these areas. A recharge reservoir capacity of 500 acft was assumed, based upon the area of land that might be controlled by the facility (15 square miles). Based upon a generalized area-capacity relationship for small reservoirs developed by Texas A&M University,[6] the land area within the recharge pool for this size reservoir would be approximately 92 acres. Estimated annual recharge over the 1934 through 1989 simulation period is shown in Figure 6.10-3. For the representative site, the long-term average (mean) annual recharge enhancement to the Trinity Aquifer is about 78 acft. Due to the relatively low rate of infiltration, such a reservoir would evaporate an average of 55 acft per year, a volume equal to 71 percent of the recharge enhancement.

Figure 6.10-4 illustrates simulated storage fluctuations in the representative recharge reservoir. The reservoir would be more than 50 percent full approximately 16 percent of the time, as most inflows must be passed to satisfy downstream senior water rights and instream flow requirements of the Consensus Criteria, only high flows would be affected by the reservoir, and no significant change in median and low streamflows would occur.

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[3] Ibid.
[4] Texas Department of Water Resources, Op. Cit., January 1983.
[5] U.S. Department of Agriculture, "Soil Survey of Kendall County, Texas," March 1981.
[6] Texas Water Resources Institute, "Hydrologic and Institutional Water Availability in the Brazos River Basin, TR-144," Texas A&M University, August 1988.

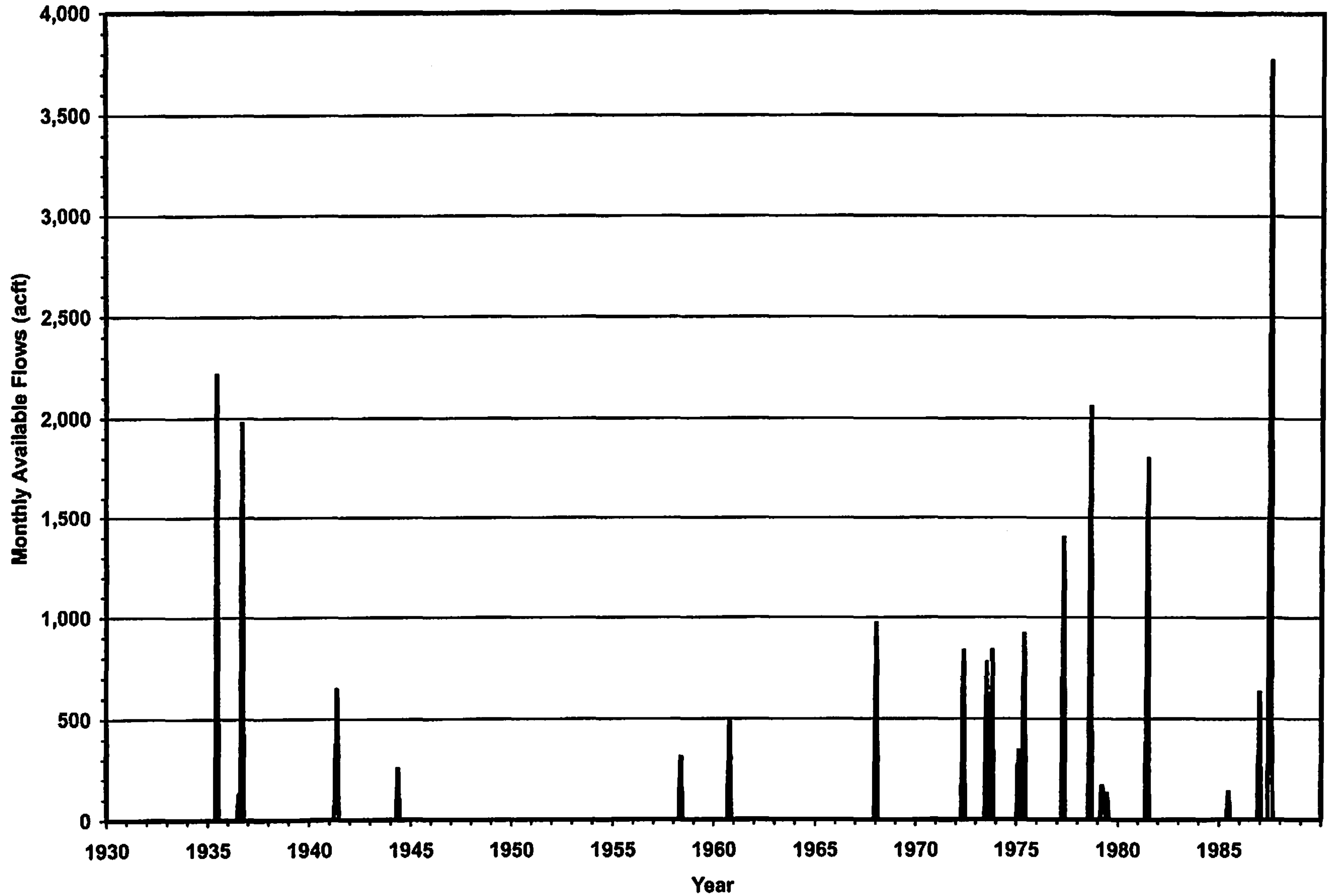


Figure 6.10-2. Monthly Available Flows for a Representative 15 Square Mile Watershed in Kendall County

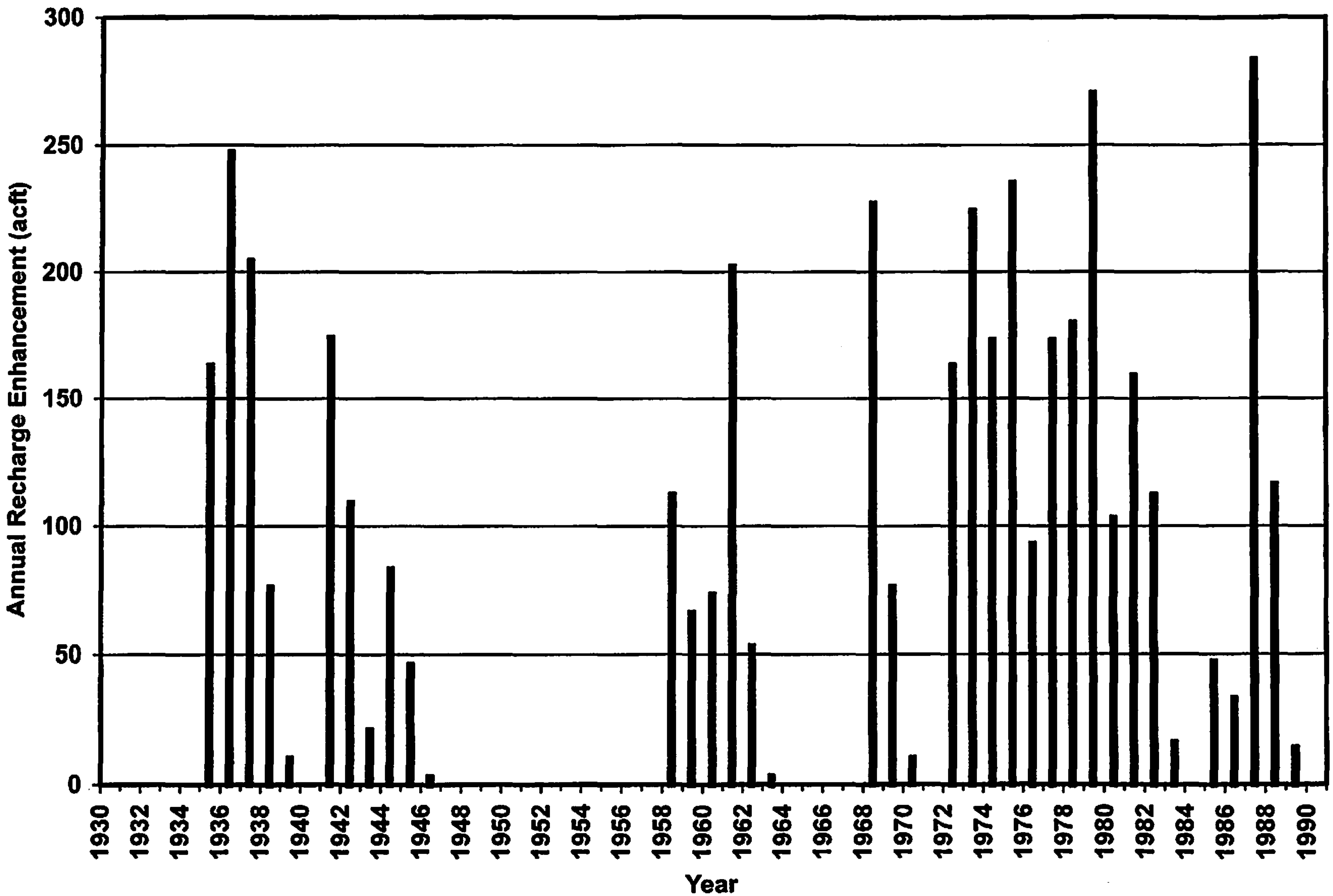
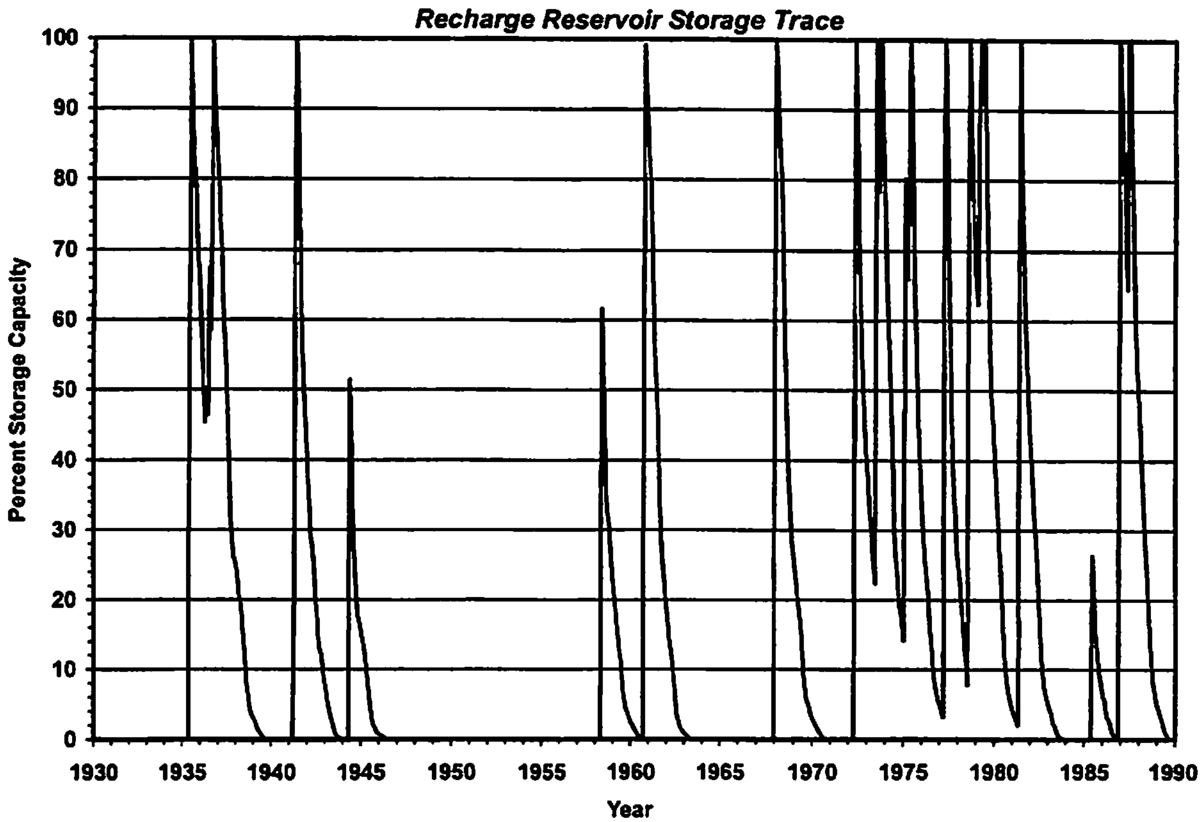


Figure 6.10-3. Trinity Aquifer Recharge Enhancement by a Representative Recharge Reservoir



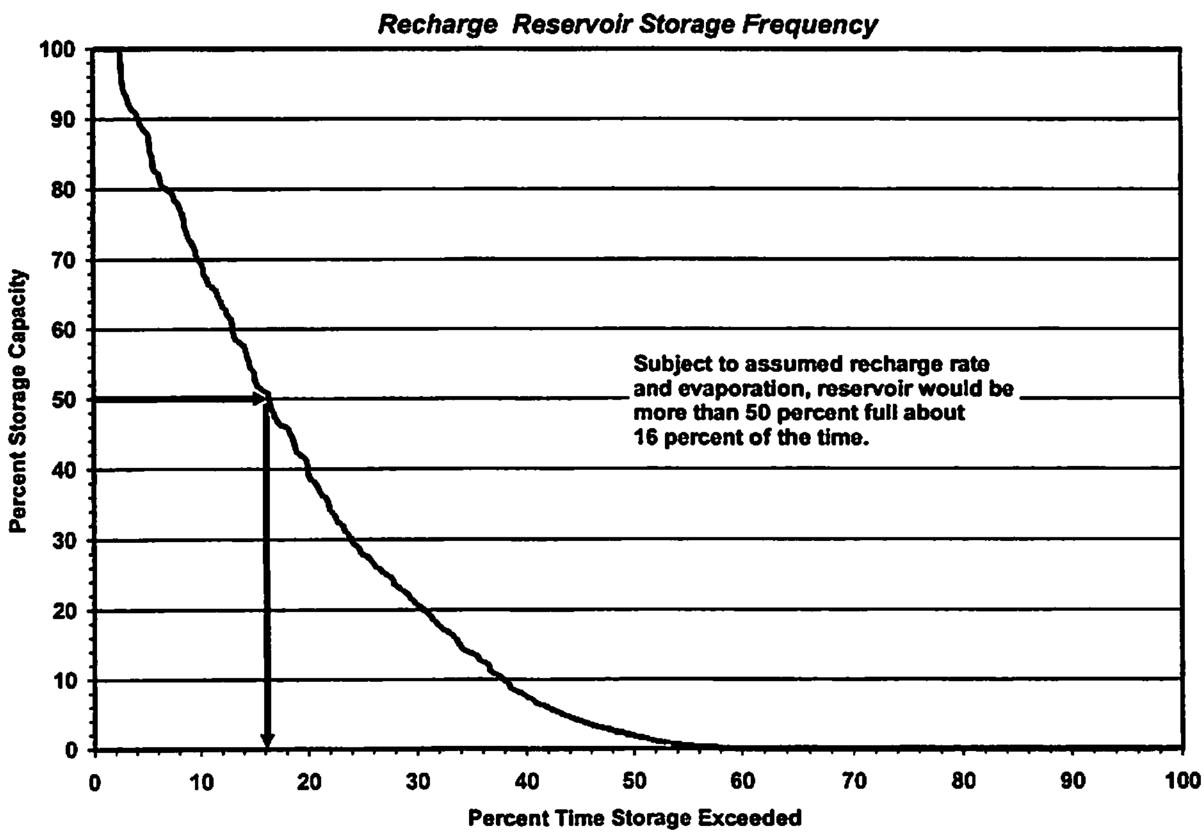


Figure 6.10-4. Recharge Reservoir Storage Considerations

Review of topographic mapping for the area of interest shown in Figure 6.10-1 indicates that five (or more) candidate sites for recharge enhancement reservoirs having drainage areas averaging about 15 square miles could be identified. The feasibility assessment of any specific site should include the evaluation of the potential for rapid loss to nearby springs. As water is available for impoundment only during high flow periods, it is reasonable to assume that recharge enhancement for multiple sites will be approximately additive. Hence, annual Trinity Aquifer average recharge enhancement associated with the development of five small- to medium-sized reservoirs is estimated to be 390 acft/yr.

6.10.3 Environmental Issues.

Option SCTN-8 takes available flows from tributaries of the Guadalupe River and impounds them within recharge reservoirs in Kendall County. The relatively low permeability of the Trinity formation will result in the recharge reservoirs holding water for significant periods. Evaporation from the reservoirs and the need to control vector species and nuisance growths should be considered in overall management plans. Overall, construction of the reservoir will enhance the aquifer by increasing the amount of water available for pumping. Potential concerns involved with construction of this option include destruction of species habitat.

Table 6.10-1 presents the protected plant and animal species which are listed for Kendall County by TPWD, USFWS, and TOES. Two protected bird species, which may have habitat within the study area, are the Golden-Cheeked Warbler (*Dendroica chrysoparia*) and Black-Capped Vireo (*Vireo atricapillus*). The Golden-Cheeked Warbler inhabits mature oak-Ashe juniper woods for nesting. It requires strips of Ashe juniper bark for nest material. The Black-Capped Vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories. Additional protected birds which may be found in the area are the American Peregrine Falcon, Arctic Peregrine Falcon, Bald Eagle, Black-Capped Vireo, Golden-Cheeked Warbler, Interior Least Tern and Whooping Crane. A survey of any potential reservoir site may be required prior to construction to determine whether populations of, or potential habitat for, species of concern occur in the area to be impacted.

The Guadalupe River in Kendall County is recommended for designation as an Ecologically Unique River Segment by TPWD.

Table 6.10-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Trinity Aquifer Optimization (SCTN-8)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Basin Bellflower	*Campanula reverchonii*	Dry gravels and shallow sandy soils; open slopes			WL	Resident
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black Bear	*Ursus americanus*	Mountains, broken country, woods, brushlands, forests		T	T	Resident
Black-Capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Blanco River Springs Salamander	*Eurycea pterophila*	Subaquatic; Springs and caves of the Blanco River				Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C			Resident
Canyon Mock-Orange	*Philadelphus ernestii*	Edwards Plateau			WL	Resident
Cascade Caverns Salamander	*Eurycea latitans*	Endemic; Subaquatic; Springs and caves		T	T	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau				Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Edge Falls Anemone	*Anemone edwardsiana var petraea*	Woodlands in mesic canyons			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau				Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Hill Country Wild-Mercury	*Argythamnia aphoroides*	Shallow to moderately deep clays; live oak woodlands			WL	Resident
Headwater Catfish	*Ictalurus lupus*	Clear streams			WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear				Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	*Philadelphus texensis*	Endemic; Limestone cliffs and boulders in mesic stream bottoms and canyons			WL	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999. Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
[5] Correll, Donovan S. and Marshall Johnston. 1979. Manual of the Vascular Plants of Texas. University of Texas at Dallas. Austin, Texas. pp 1201.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

6.10.4 Engineering and Costing

Construction costs for a representative 500-acft capacity recharge dam were estimated from detailed cost estimates for similarly sized recharge enhancement projects.[7, 8] Operation and maintenance costs were developed in accordance with the cost estimation procedure presented in Appendix A. Land was assumed to be purchased for the recharge reservoir pool. The cost estimate shown in Table 6.10-3 is for a single 500 acft capacity recharge enhancement reservoir.

Financing a single recharge enhancement reservoir under the Senate Bill 1 assumptions (40 years at 6 percent annual interest) results in an annual expense of $131,000. Annual operation and maintenance costs total $16,000. The annual cost, including debt service and operation and maintenance, totals $147,000. For an average annual recharge enhancement of 78 acft per site, the resulting annual cost of water recharged to the Trinity Aquifer from tributaries of the Guadalupe River in Kendall County is $1,886 per acft per reservoir site (Table 6.10-2).

With the development of a program of five reservoirs, average annual recharge of the Trinity Aquifer in Kendall County could be enhanced by about 390 acft at an estimated annual cost of $1,886/acft.

6.10.5 Implementation Issues

Implementation of this option for one or more sites could directly affect the feasibiltiy of other water supply options under consideration, including G-19, G-30, SCTN-ZC, and/or SCTN-10.

1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits.
   b. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. GLO Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel, and Marl permit.

[7] HDR, et al., "Nueces River Basin Edwards Aquifer Recharge Enhancement project, Phase IV A," Edwards Underground Water District, June 1994.
[8] HDR, et al., "Trans-Texas Water Program, West Central Study area, Edwards Aquifer Recharge Analyses," San Antonio River Authority, et al., march 1998.

Table 6.10-2.
Cost Estimate Summary for a Representative Recharge Enhancement Reservoir
Trinity Aquifer Optimization (SCTN-8)
Second Quarter 1999 Prices

Item	Estimated Costs for Facilities
Capital Costs	
Dam and Reservoir (500 acft, 92 acres)	$1,054,000
Total Capital Cost	**$1,054,000**
Engineering, Legal Costs and Contingencies	$369,000
Land Acquisition and Surveying (92 acres)	147,000
Interest During Construction (4 years)	272,000
Environmental & Archaeology Studies, Mitigation and Permitting	133,000
Total Project Cost	**$1,975,000**
Annual Costs	
Reservoir Debt Service (6 percent, 40 years)	$131,000
Operation and Maintenance	16,000
Total Annual Cost	**$147,000**
Available Annual Recharge Enhancement (acft)	**78**
Annual Cost of Water ($ per acft) Raw Water in Aquifer[1]	**$1,886**
Annual Cost of Water ($ per 1,000 gallons) Raw Water in Aquifer[1]	**$5.79**

[1] Reported Annual Cost of Water is for additional water supply in the Trinity Aquifer.

2. Permitting, at a minimum, will require these studies:
   a. Assessment of effects on instream flows.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.
3. Land or easements will need to be acquired through either negotiations or condemnation.
4. Recovery of the enhanced recharge would need to be coordinated and permitted through local groundwater conservation districts.

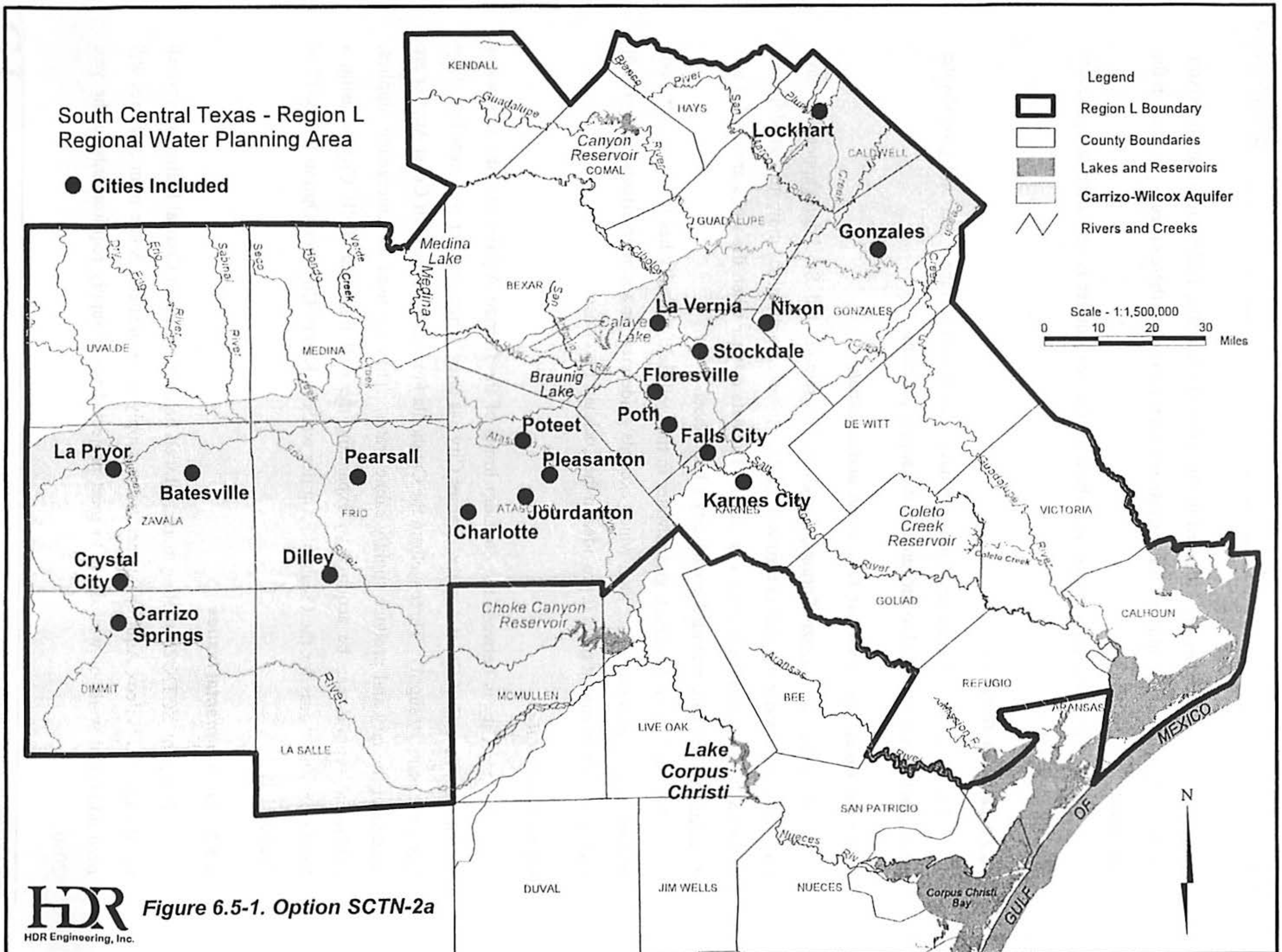


Figure 6.5-1. Option SCTN-2a

report that these guidelines are exceeded in the cities of Charlotte, Dilley, Jourdanton, Nixon, and Pearsall. The cost of adding a water treatment plant for each of these cities is provided in the Fact Sheet.

Some of the well fields are located where the Carrizo Aquifer is very deep and produces relatively hot water.

6.5.2.2 LaVernia, Gonzales

The cities of LaVernia and Gonzales have a combined surface water and groundwater supply, and are not expected to encounter water supply problems.

6.5.2.3 Carrizo Springs, Lockhart, Pleasanton, and Stockdale

The cities of Carrizo Springs, Lockhart, Pleasanton, and Stockdale appear to have sufficient groundwater supplies in their well fields. However, projections indicate that additional well(s) will be required before the year 2050. The date or year when the wells are needed and the estimated costs are provided in each city's Fact Sheet.

For the City of Lockhart, groundwater in the well field typically has iron concentrations greater than 0.3 milligrams per liter, which exceeds guidelines for aesthetic effects. The cost of adding a water treatment plant is provided in the Lockhart Fact Sheet.

6.5.2.4 Karnes City

Karnes City is between the downdip limits of the Carrizo Aquifer and the freshwater formations of the Gulf Coast Aquifer. Karnes City has one Carrizo Aquifer well near Falls City that is the primary supply. Three wells in the Catahoula Formation of the Gulf Coast Aquifer are located in the city and produce slightly saline water. They are used for emergency supplies. Additional supplies can be acquired by expanding the well field near Falls City or using a desalinization process for the Catahoula Aquifer wells in Karnes City (see Option SCTN-17 of Section 1.10).

6.5.3 Environmental Issues

In Option SCTN-2a existing municipal well fields in the upper Coastal Plains area, which use the Carrizo-Wilcox Aquifer for their water supply are evaluated. Some municipalities will need additional wells or well fields to meet projected water supply requirements to the year 2050.

Data from well fields in this area show declining trends in groundwater levels during the past 30 years. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels.

The pumping of groundwater from the Carrizo-Wilcox Aquifer could have a negative impact on springflow and temporary pools in these areas. Some species inhabit or use temporary pools as well as aquifers and springs. Possible negative effects on these species should be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primary pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.5.4 Engineering and Costing: See Individual City Fact Sheets

6.5.5 Implementation Issues

The development of additional wells and well fields in the Carrizo-Wilcox Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

- Detailed feasibility evaluation including test drilling and aquifer water quality testing.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Competition with others for groundwater in the area.
- Regulations by Underground Water conservation Districts, including the renewal of pumping permits at periodic intervals in counties where districts have been organized.

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ID: 1 | City: Batesville | TNRCC Survey Year: 1995

County: Zavala

Aquifer: Carrizo

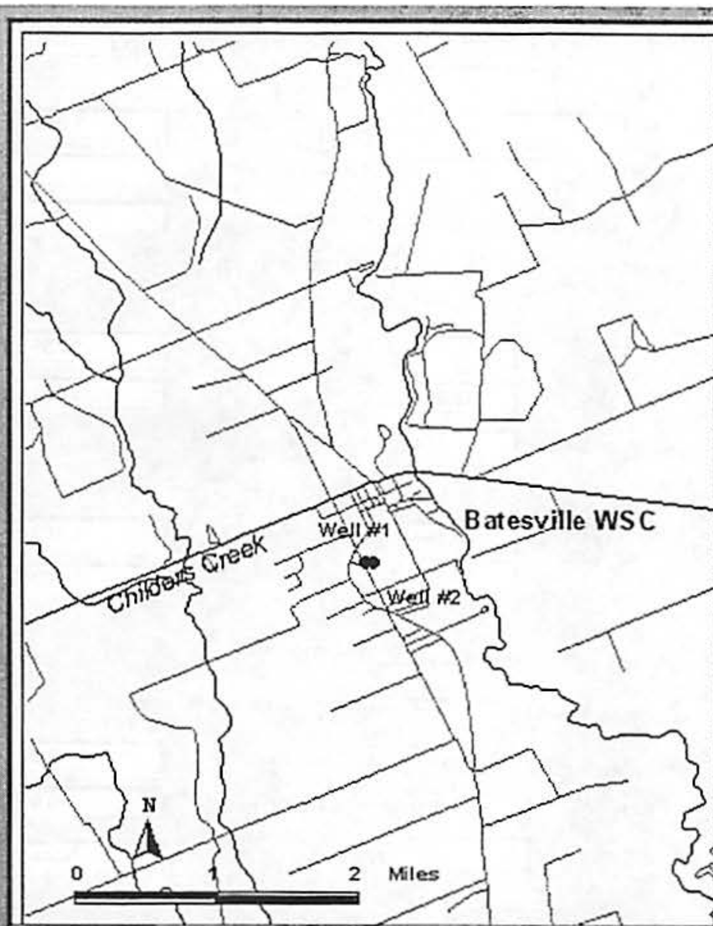
PWS_ID: 2540005

Connections

Retail: 360

Wholesale: 0

Outside Water Supply: No



Population

City

1996	1,303
2050	1,669
Growth (%)	28

Service Area

Survey Year	1,080
2050	1,383

Average Use (mgd)

City

Survey Year	0.209
2050	0.207

Service Area

Survey Year	N/A
2050	

Aquifer Information

Static Water Level (ft): 340

Water-bearing Zone (ft)

Top	700
Bottom	1,000

Trend in Groundwater Levels

Last Decade (ft/yr)	-2.3
Last 3 Decades (ft/yr)	-2.9
Water Quality Problems	None

Well Information

Total Well Capacity (gpm): 770

Total Well Capacity (mgd): 1.108

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	0.311
2050	0.399

Well	Depth (ft)	Yield (gpm)
1	807	400
2	807	370

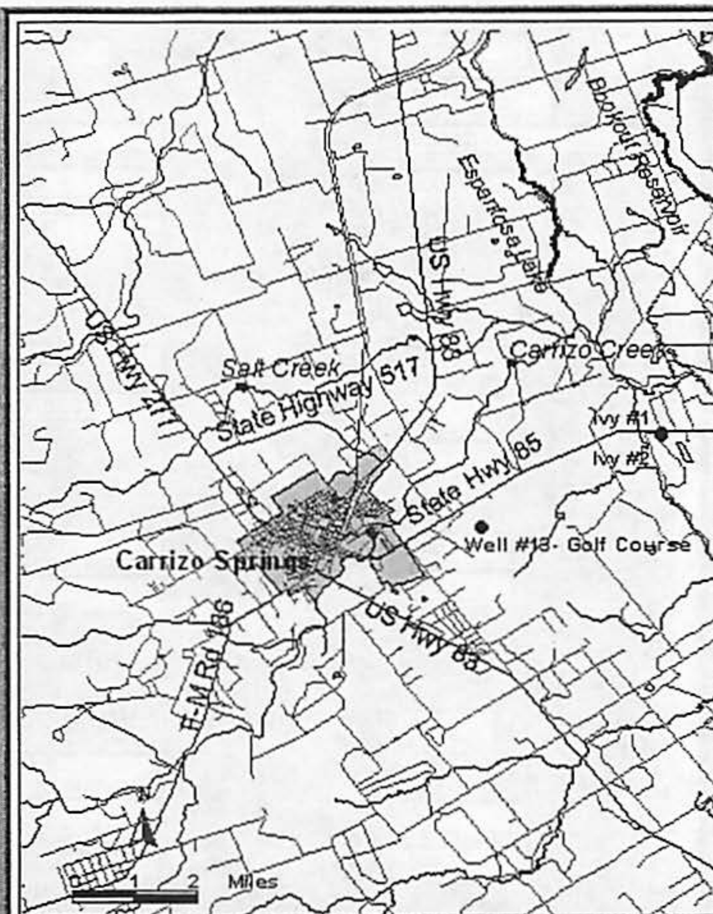
Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Batesville appear to be adequate to meet the Texas Water Development Board's projected demands for Batesville through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	2	City	Carrizo Sprs
County	Dimmit	TNRCC Survey Year	1998
Aquifer	Carrizo	Connections	
PWS_ID	0640002	Retail	1,948
		Wholesale	0
		Outside Water Supply	No

Population		**Average Use (mgd)**	
City		City	
1996	5,771	Survey Year	1.736
2050	15,262	2050	3.690
Growth (%)	164		
Service Area		Service Area	
Survey Year	5,844	Survey Year	1.460
2050	15,455	2050	3.103



Aquifer Information

Static Water Level (ft)	400	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	-0.2
Top	200	Last 3 Decades (ft/yr)	-0.9
Bottom	800	Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	2,700	**TNRCC Required Capacity (mgd)**	Survey Year	1.684
Total Well Capacity (mgd)	3.888	Peak day demand in Service Area	2050	4.444

Well	Ivy #1	Well	Ivy #2	Well	13	Well		Well	
Depth (ft)	800	Depth (ft)	800	Depth (ft)	514	Depth (ft)		Depth (ft)	
Yield (gpm)	1,150	Yield (gpm	1,250	Yield (gpm	300	Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Evaluation of Water Supply to Year 2050

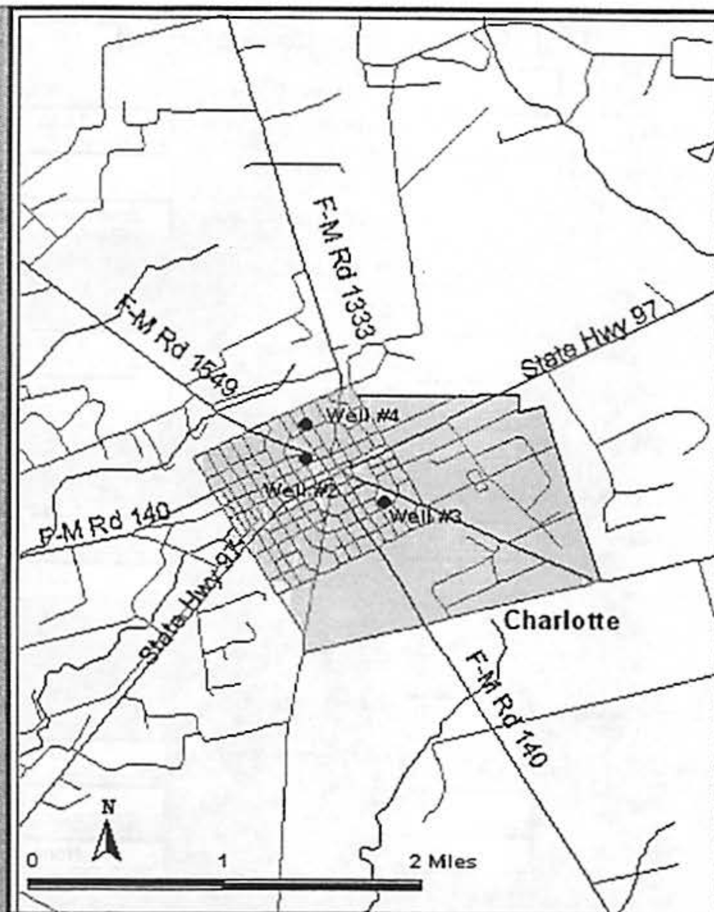
Groundwater supplies from the Carrizo Aquifer in the vicinity (within 5 miles toward the east) of Carrizo Springs appear to be adequate to meet the Texas Water Development Board's projected demands for Carrizo Springs through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

After year 2030, a new well will be needed. The estimated cost for a new well and half a mile of pipeline is $396,000.

ID	3	City	Charlotte
County	Atascosa		
Aquifer	Carrizo		
PWS_ID	0070016		

TNRCC Survey Year	1999
Connections	
Retail	581
Wholesale	0
Outside Water Supply	No



Population

City	
1996	1,604
2050	2,982
Growth (%)	86
Service Area	
Survey Year	1,743
2050	3,240

Average Use (mgd)

City	
Survey Year	0.285
2050	0.507
Service Area	
Survey Year	0.236
2050	0.420

Aquifer Information

Static Water Level (ft)	240
Water-bearing Zone (ft)	
Top	1,500
Bottom	2,300

Trend in Groundwater Levels	
Last Decade (ft/yr)	-1.8
Last 3 Decades (ft/yr)	-1.7
Water Quality Problems	Iron

Well Information

Total Well Capacity (gpm)	1,820
Total Well Capacity (mgd)	2.621

TNRCC Required Capacity (mgd)		
Peak day demand in Service Area	Survey Year	0.502
	2050	0.934

Well	2	Well	3	Well	4	Well		Well	
Depth (ft)	1,864	Depth (ft)	1,993	Depth (ft)	1,930	Depth (ft)		Depth (ft)	
Yield (gpm)	420	Yield (gpm	550	Yield (gpm	850	Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Charlotte appear to be adequate to meet the Texas Water Development Board's projected demands for Charlotte through the year 2050.

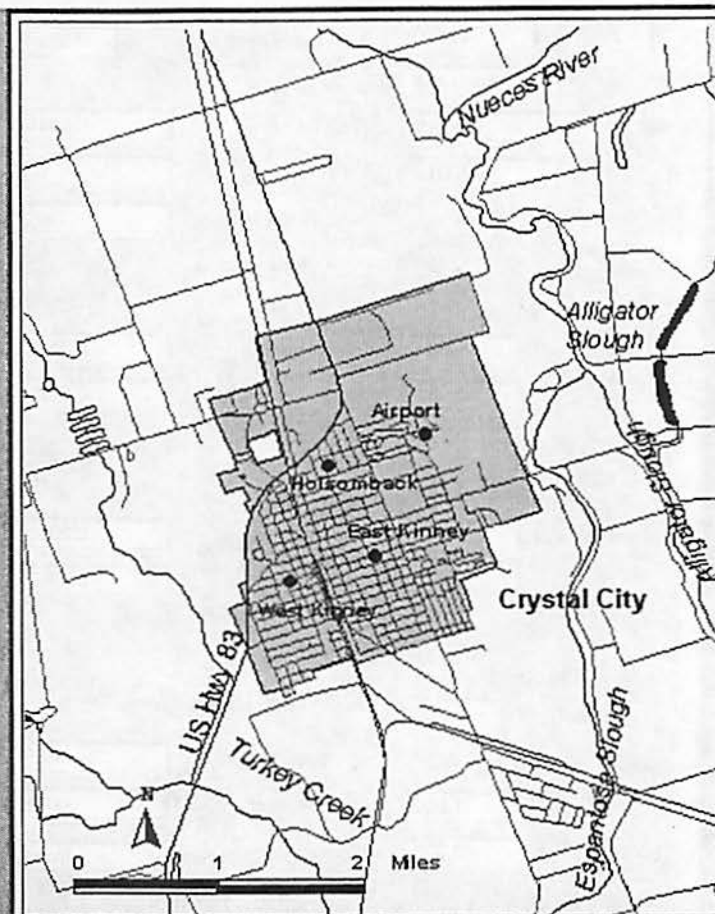
If needed, potential location of new well field and estimated cost to adding new supply to system

A 1.0 mgd water treatment plant to remove excessive iron concentrations is estimated to cost $2,596,000.

ID	4	City	Crystal City
TNRCC Survey Year	1997		
County	Zavala		
Aquifer	Carrizo		
PWS_ID	2540001		

Connections

Retail	2,049
Wholesale	0
Outside Water Supply	Emergency



Population

City	
1996	8,227
2050	10,140
Growth (%)	23

Service Area	
Survey Year	6,147
2050	7,576

Average Use (mgd)

City	
Survey Year	1.688
2050	1.704

Service Area	
Survey Year	1.907
2050	1.925

Aquifer Information

Static Water Level (ft)	270
Water-bearing Zone (ft) Top	700
Water-bearing Zone (ft) Bottom	900

Trend in Groundwater Levels	
Last Decade (ft/yr)	-0.2
Last 3 Decades (ft/yr)	2.4
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	4,820
Total Well Capacity (mgd)	6.941

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	1.771
2050	2.183

Well	West Kinney	Holsomback	Airport	East Kinney	
Depth (ft)	990	995	1,000	1,000	
Yield (gpm)	1220	1050	1230	1320	

Well					
Depth (ft)					
Yield (gpm					

Well					
Depth (ft)					
Yield (gpm					

Evaluation of Water Supply to Year 2050

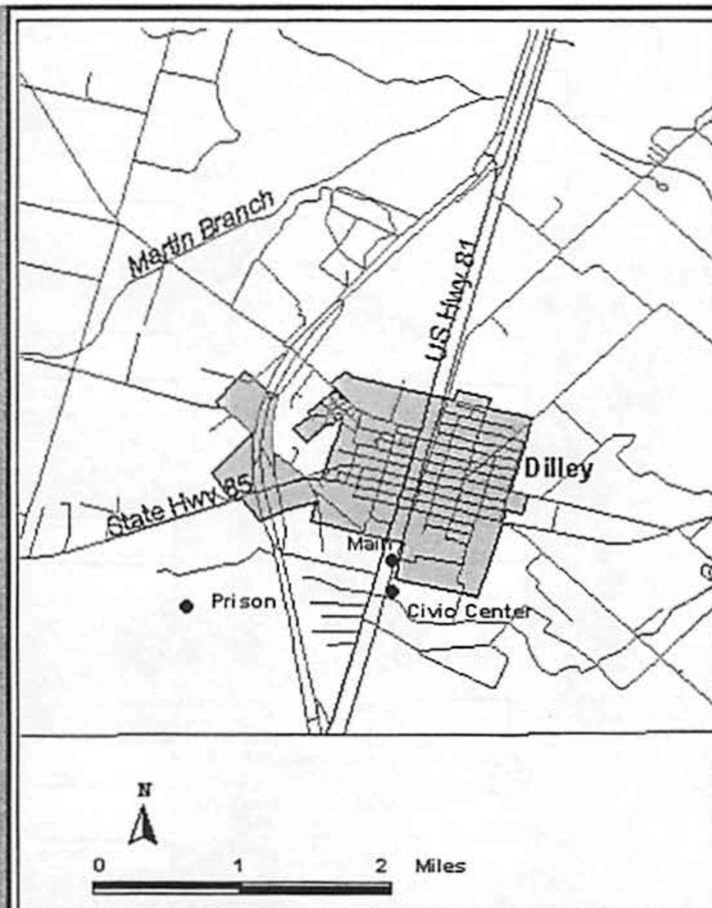
Groundwater supplies from the Carrizo Aquifer in the vicinity of Crystal City appear to be adequate to meet the Texas Water Development Board's projected demands for Crystal City through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	5	City	Dilley	TNRCC Survey Year	1998
County	Frio			Connections	
Aquifer	Carrizo			Retail	1,305
PWS_ID	0820001			Wholesale	0
				Outside Water Supply	No

Population

City		Average Use (mgd) City	
1996	2,952	Survey Year	0.643
2050	4,209	2050	0.859
Growth (%)	43		
Service Area		**Service Area**	
Survey Year	4,400	Survey Year	0.680
2050	6,274	2050	0.908



Aquifer Information

Static Water Level (ft)	280	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	6.5
Top	1,700	Last 3 Decades (ft/yr)	-2.7
Bottom	2,200	Water Quality Problems	Iron

Well Information

Total Well Capacity (gpm)	3,400	TNRCC Required Capacity (mgd)	Survey Year	1.128
Total Well Capacity (mgd)	4.896	Peak day demand in Service Area	2050	1.609

Well: Civic Center	Well: Main - op	Well: Prison	Well:	Well:
Depth (ft): 2,200	Depth (ft): 2,150	Depth (ft): 2,200	Depth (ft):	Depth (ft):
Yield (gpm): 1,100	Yield (gpm: 1,100	Yield (gpm: 1,200	Yield (gpm:	Yield (gpm:
Well:	Well:	Well:	Well:	Well:
Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):
Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:
Well:	Well:	Well:	Well:	Well:
Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):
Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Dilley appear to be adequate to meet the Texas Water Development Board's projected demands for Dilley through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

A 2.0 mgd water treatment plant to remove excessive iron concentrations is estimated to cost $3,063,000.

ID 6 City Falls City TNRCC Survey Year 1999

County Karnes

Aquifer Carrizo

PWS_ID 1280004

Connections

Retail 245

Wholesale 0

Outside Water Supply No

Population

City

1996	515
2050	676
Growth (%)	31

Service Area

Survey Year	735
2050	963

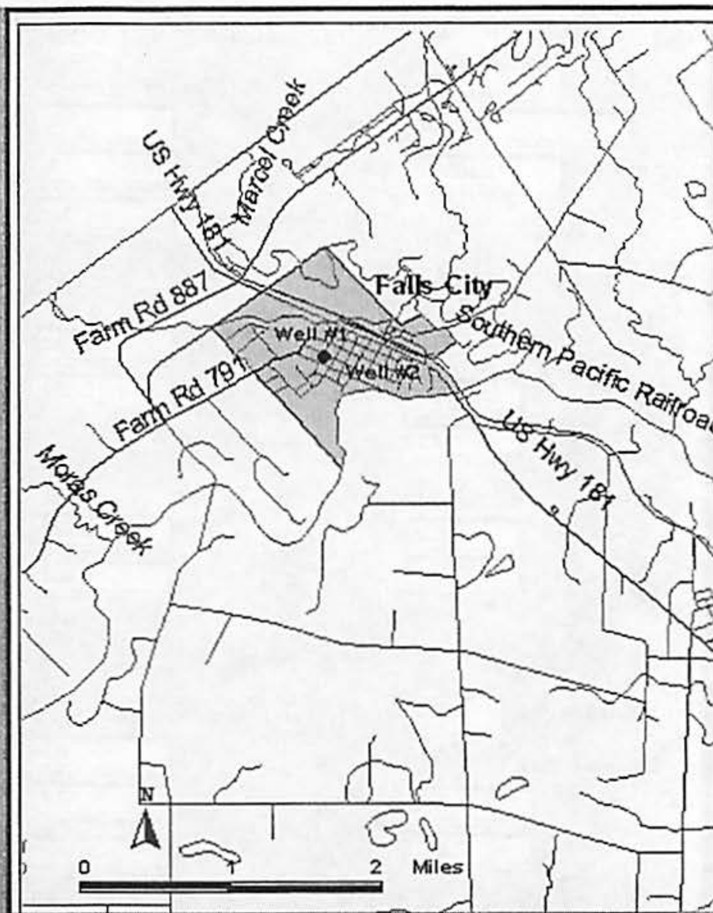
Average Use (mgd)

City

Survey Year	0.095
2050	0.103

Service Area

Survey Year	0.099
2050	0.130



Aquifer Information

Static Water Level (ft) 180

Water-bearing Zone (ft)

Top 2,700

Bottom 3,800

Trend in Groundwater Levels

Last Decade (ft/yr) -1

Last 3 Decades (ft/yr) -1.1

Water Quality Problems None

Well Information

Total Well Capacity (gpm) 625

Total Well Capacity (mgd) 0.900

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year 0.212

2050 0.278

Well	Depth (ft)	Yield (gpm)
1	3,564	325
2	3,607	300

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Falls City appear to be adequate to meet the Texas Water Development Board's projected demands for Falls City through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	7	City	Floresville
TNRCC Survey Year	1997		
County	Wilson		
Aquifer	Carrizo		
PWS_ID	2470001		

Connections

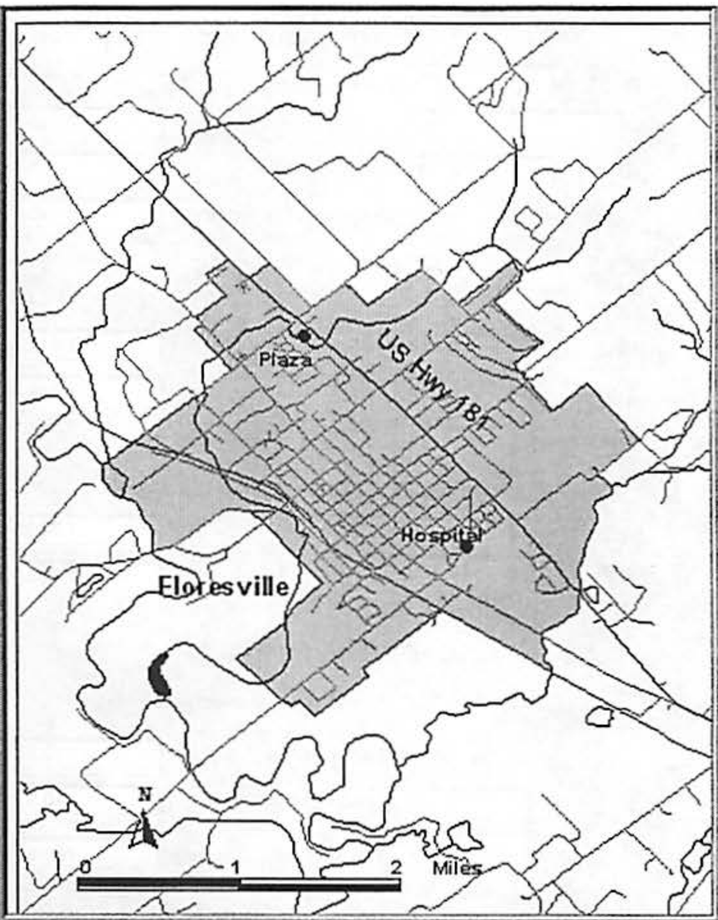
Retail	2,064
Wholesale	0
Outside Water Supply	No

Population

City	
1996	6,309
2050	9,112
Growth (%)	44
Service Area	
Survey Year	6,192
2050	8,943

Average Use (mgd)

City	
Survey Year	1.023
2050	1.440
Service Area	
Survey Year	1.149
2050	1.617



Aquifer Information

Static Water Level (ft)	40
Water-bearing Zone (ft)	
Top	700
Bottom	1,500

Trend in Groundwater Levels	
Last Decade (ft/yr)	-0.5
Last 3 Decades (ft/yr)	-0.3
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1,820
Total Well Capacity (mgd)	2.621

TNRCC Required Capacity (mgd)
Peak day demand in Service Area

Survey Year	1.784
2050	2.577

Well: Hospital	Well: Plaza	Well:	Well:	Well:
Depth (ft): 1,260	Depth (ft): 1,025	Depth (ft):	Depth (ft):	Depth (ft):
Yield (gpm): 720	Yield (gpm: 1100	Yield (gpm:	Yield (gpm:	Yield (gpm:
Well:	Well:	Well:	Well:	Well:
Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):
Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:
Well:	Well:	Well:	Well:	Well:
Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):
Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:

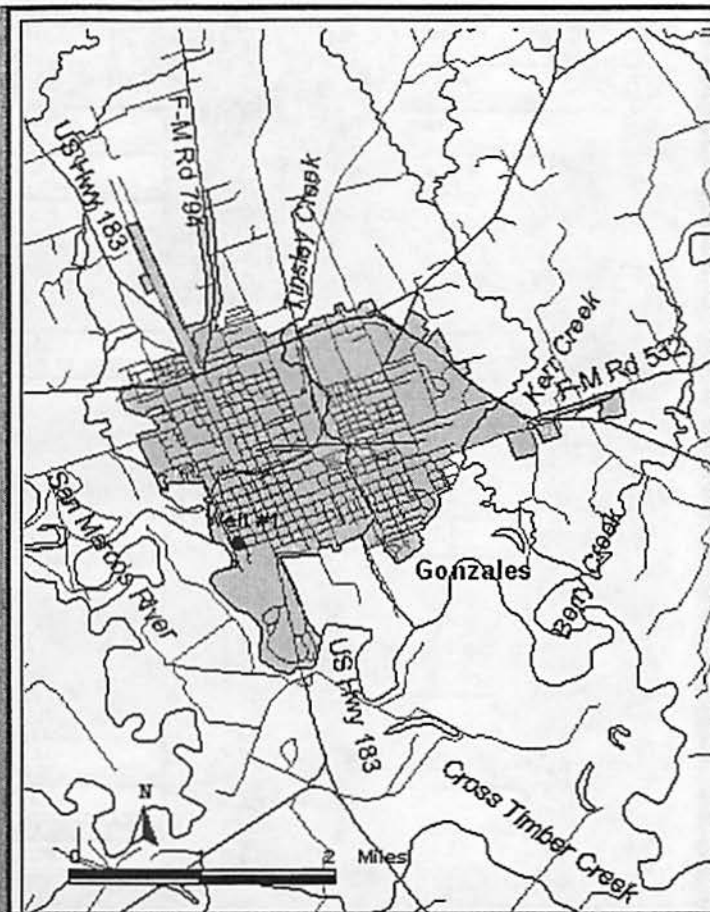
Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carizzo Aquifer in the vicinity of Floresville appear to be adequate to meet the Texas Water Development Board's projected demands for Floresville through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	8	City	Gonzales
County	Gonzales		
Aquifer	Carrizo		
PWS_ID	0890001		

TNRCC Survey Year	1998
Connections	
Retail	2,885
Wholesale	1
Outside Water Supply	No



Population

City	
1996	6,417
2050	8,232
Growth (%)	28
Service Area	
Survey Year	8,715
2050	11,180

Average Use (mgd)

City	
Survey Year	1.512
2050	1.449
Service Area	
Survey Year	1.740
2050	1.668

Aquifer Information

Static Water Level (ft)	40
Water-bearing Zone (ft)	
Top	1,400
Bottom	1,900

Trend in Groundwater Levels	
Last Decade (ft/yr)	-0.8
Last 3 Decades (ft/yr)	-0.5
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1,600
Total Well Capacity (mgd)	2.304

TNRCC Required Capacity (mgd) Peak day demand in Service Area	
Survey Year	2.510
2050	3.220

Well	# 1	Well	# 2	Well		Well		Well	
Depth (ft)	1,600	Depth (ft)	1,832	Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm)	400	Yield (gpm	1,200	Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Evaluation of Water Supply to Year 2050

Water supplies for Gonzales are a combination of surface water from the Guadalupe River and the Carrizo Aquifer and appear to be adequate to meet the Texas Water Development Board's projected demands for Gonzales through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	9	City	Jourdanton
County	Atascosa	TNRCC Survey Year	1997
Aquifer	Carrizo	Connections	
PWS_ID	0070002	Retail	1,280
		Wholesale	0
		Outside Water Supply	No

Population		**Average Use (mgd)**	
City		City	
1996	3,597	Survey Year	0.499
2050	6,313	2050	1.004
Growth (%)	76		
Service Area		Service Area	
Survey Year	3,840	Survey Year	0.922
2050	6,739	2050	1.855

Aquifer Information

Static Water Level (ft)	120	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	-6.4
Top	1,400	Last 3 Decades (ft/yr)	-2.3
Bottom	2,200	Water Quality Problems	Iron

Well Information

Total Well Capacity (gpm)	2,550	**TNRCC Required Capacity (mgd)**	Survey Year	1.107
Total Well Capacity (mgd)	3.672	Peak day demand in Service Area	2050	1.942

Well 3	Well 4	Well 5	Well	Well
Depth (ft) 2,000	Depth (ft) 2,200	Depth (ft) 1,960	Depth (ft)	Depth (ft)
Yield (gpm) 700	Yield (gpm 1,100	Yield (gpm 750	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Jourdanton appear to be adequate to meet the Texas Water Development Board's projected demands for Jourdanton through the year 2050.

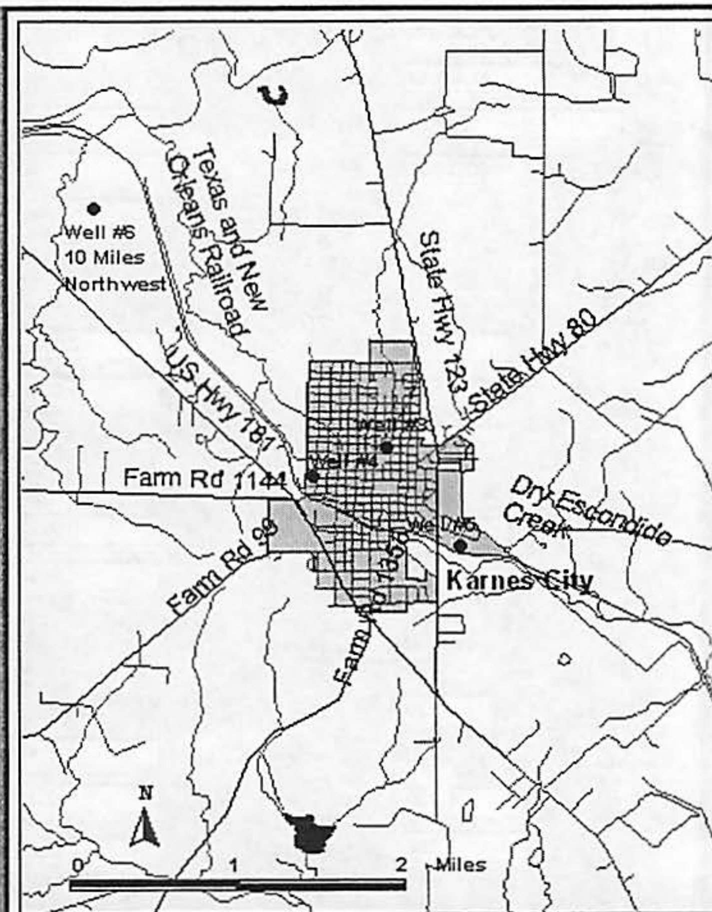
If needed, potential location of new well field and estimated cost to adding new supply to system

A 2.0 mgd water treatment plant to remove excessive iron concentrations is estimated to cost $3,063,000.

ID	10	City	Karnes City
TNRCC Survey Year	1999		
County	Karnes		
Aquifer	Catahoula & Carrizo		
PWS_ID	1280001		

Connections

Retail	1,209
Wholesale	0
Outside Water Supply	Emergency



Population

City	
1996	3,039
2050	4,793
Growth (%)	58

Service Area	
Survey Year	3,627
2050	5,720

Average Use (mgd)

City	
Survey Year	0.351
2050	0.460

Service Area	
Survey Year	0.326
2050	0.427

Aquifer Information

Static Water Level (ft)	180
Water-bearing Zone (ft)	
Top	<100
Bottom	4,000

Trend in Groundwater Levels	
Last Decade (ft/yr)	2.2
Last 3 Decades (ft/yr)	3.2
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1,270
Total Well Capacity (mgd)	1.829

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	1.045
2050	1.649

Well 3	Well 4	Well 5	Well 6	Well
Depth (ft) 872	Depth (ft) 1,000	Depth (ft) 905	Depth (ft) 3,818	Depth (ft)
Yield (gpm) 120	Yield (gpm 250	Yield (gpm 250	Yield (gpm 650	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm

Evaluation of Water Supply to Year 2050

Groundwater supplies in the vicinity of Karnes City are difficult to obtain. The Carrizo Aquifer is very deep and the water is hot and water bearing zones in the Catahoula Formation have limited production. Additional supplies may be needed.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID: 11 | City: La Pryor | TNRCC Survey Year: 1998

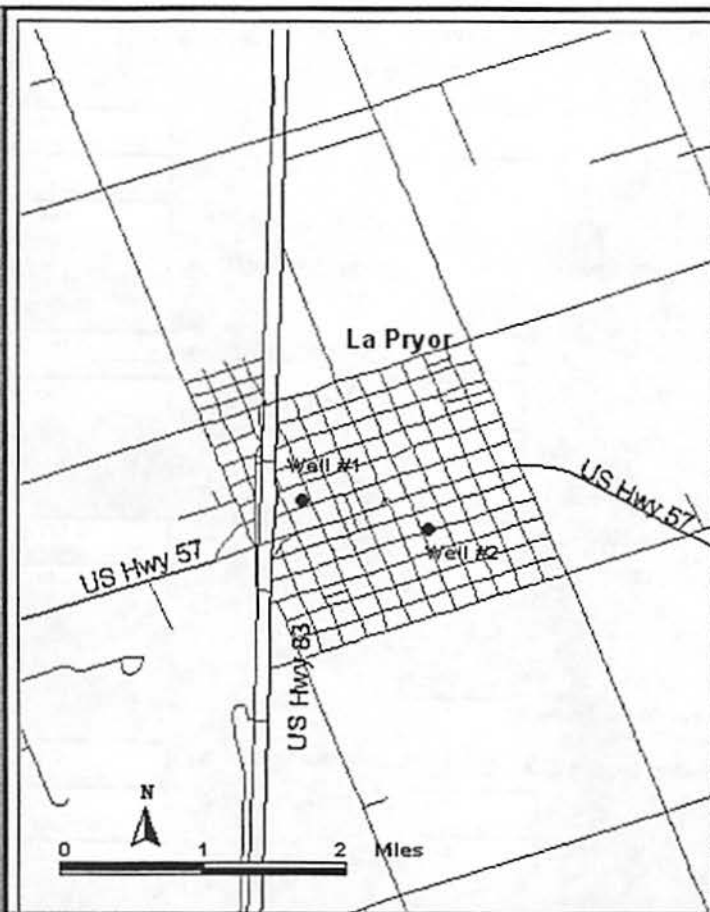
County: Zavala

Aquifer: Carrizo

PWS_ID: 2540003

Connections

- Retail: 522
- Wholesale: 0
- Outside Water Supply: No



Population

City

1996	1,269
2050	938
Growth (%)	-26

Service Area

Survey Year	1,566
2050	1,158

Average Use (mgd)

City

Survey Year	0.300
2050	0.142

Service Area

Survey Year	0.317
2050	0.150

Aquifer Information

Static Water Level (ft): 330

Water-bearing Zone (ft)

- Top: 400
- Bottom: 700

Trend in Groundwater Levels

- Last Decade (ft/yr): -0.4
- Last 3 Decades (ft/yr): -1.6

Water Quality Problems: Radium

Well Information

Total Well Capacity (gpm): 1,040

Total Well Capacity (mgd): 1.498

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

- Survey Year: 0.451
- 2050: 0.334

Well	Depth (ft)	Yield (gpm)
1	547	700
2	580	500

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of La Pryor appear to be adequate to meet the Texas Water Development Board's projected demands for La Pryor through the year 2050.

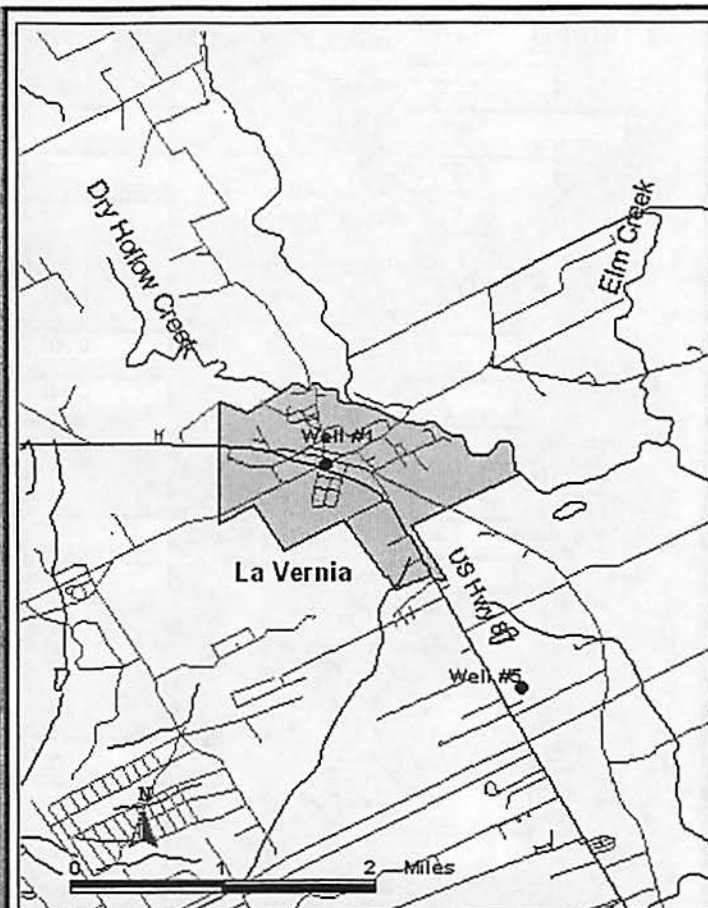
If needed, potential location of new well field and estimated cost to adding new supply to system

ID 12 | City LaVernia | TNRCC Survey Year 1997

County: Wilson
Aquifer: Wilcox
PWS_ID: 2470004

Connections

Retail: 475
Wholesale: 0
Outside Water Supply: Yes



Population

City

1996	860
2050	1,297
Growth (%)	51

Service Area

Survey Year	1,425
2050	2,149

Average Use (mgd)

City

Survey Year	0.181
2050	0.255

Service Area

Survey Year	0.177
2050	0.249

Aquifer Information

Static Water Level (ft): 170

Water-bearing Zone (ft)
Top: <100
Bottom: 600

Trend in Groundwater Levels
Last Decade (ft/yr): -0.6
Last 3 Decades (ft/yr): -0.1
Water Quality Problems: TDS

Well Information

Total Well Capacity (gpm): 490
Total Well Capacity (mgd): 0.706

TNRCC Required Capacity (mgd)
Peak day demand in Service Area
Survey Year: 0.411
2050: 0.619

Well	Depth (ft)	Yield (gpm)
1	525	240
5	520	250

Evaluation of Water Supply to Year 2050

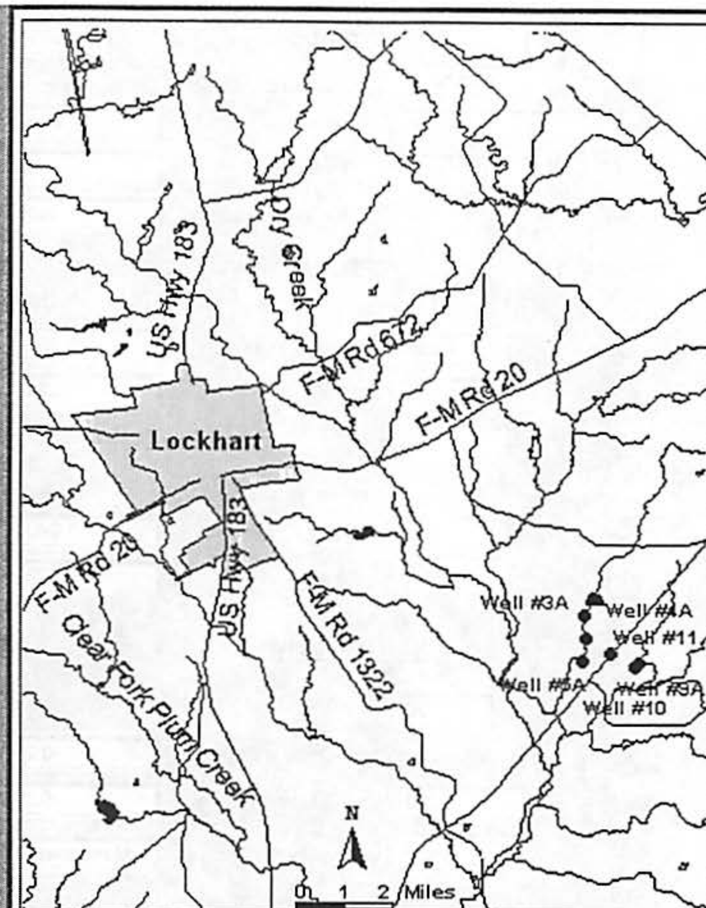
Groundwater supplies from the Wilcox Aquifer in the vicinity of LaVernia and from Canyon Regional Water Authority. Supplies appear to be adequate to meet the Texas Water Development Board's projected demands for LaVernia through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	13
City	Lockhart
TNRCC Survey Year	1998
County	Caldwell
Aquifer	Wilcox
PWS_ID	0280001

Connections

Retail	3,257
Wholesale	15
Outside Water Supply	Emergency



Population

City	
1996	9,769
2050	20,605
Growth (%)	111

Service Area	
Survey Year	9,945
2050	20,984

Average Use (mgd)

City	
Survey Year	1.815
2050	2.718

Service Area	
Survey Year	1.562
2050	2.342

Aquifer Information

Static Water Level (ft)	40
Water-bearing Zone (ft) Top	<100
Bottom	700

Trend in Groundwater Levels	
Last Decade (ft/yr)	-0.4
Last 3 Decades (ft/yr)	-0.5
Water Quality Problems	Iron

Well Information

Total Well Capacity (gpm)	2,864
Total Well Capacity (mgd)	4.124

TNRCC Required Capacity (mgd)

Peak day demand in Service Area	
Survey Year	2.829
2050	5.967

Well	3-A	4-A	5-A	9-A	10
Depth (ft)	420	320	365	608	622
Yield (gpm)	400	300	405	600	480

Well	11				
Depth (ft)	635				
Yield (gpm	680				

Well					
Depth (ft)					
Yield (gpm					

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Wilcox Aquifer in the vicinity of Lockhart appear to be adequate to meet the Texas Water Development Board's projected demands for Lockhart through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

Four new wells will be required; one before 2010, and three between 2010 and 2020. The estimated cost for each well and half mile of pipeline is $272,000. A water treatment plant to remove excessive iron is estimated to cost $4,932,000.

ID 14 City Nixon

TNRCC Survey Year 1999

County Gonzales

Aquifer Carrizo

PWS_ID 0890002

Connections

Retail	820
Wholesale	0
Outside Water Supply	No

Population

City

1996	2,056
2050	2,511
Growth (%)	22

Service Area

Survey Year	2,460
2050	3,004

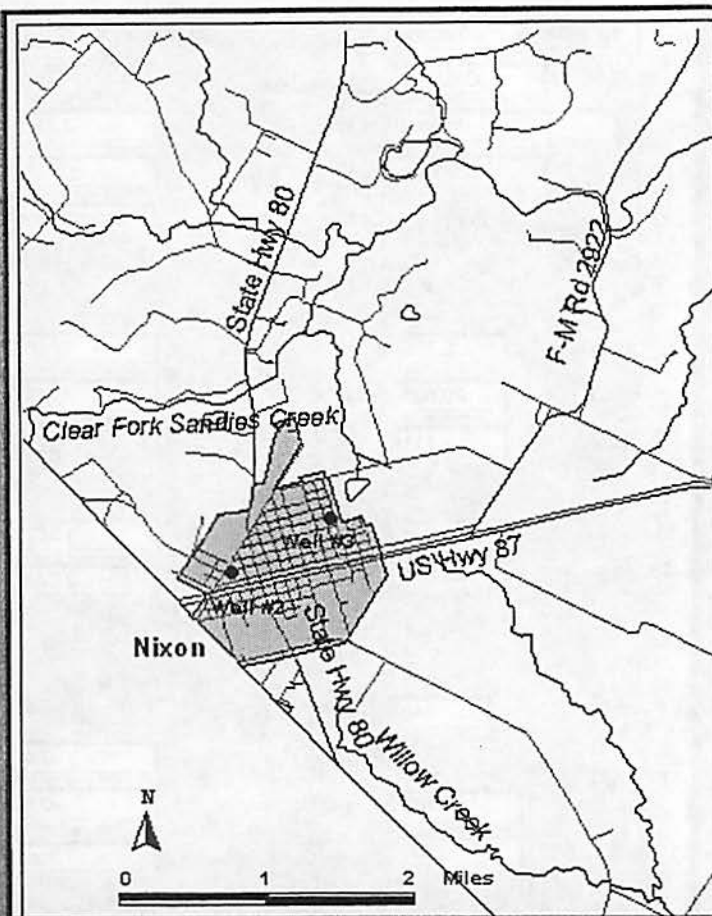
Average Use (mgd)

City

Survey Year	0.363
2050	0.324

Service Area

Survey Year	1.040
2050	0.928



Aquifer Information

Static Water Level (ft) 20

Water-bearing Zone (ft)

Top	1,200
Bottom	1,900

Trend in Groundwater Levels

Last Decade (ft/yr)	-0.2
Last 3 Decades (ft/yr)	-0.2
Water Quality Problems	Manganese

Well Information

Total Well Capacity (gpm)	1,870
Total Well Capacity (mgd)	2.692

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	0.709
2050	0.866

Well	3	Well	2	Well		Well		Well	
Depth (ft)	1,645	Depth (ft)	1,396	Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm)	1,320	Yield (gpm	550	Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Nixon appear to be adequate to meet the Texas Water Development Board's projected demands for Nixon through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

A 1.0 mgd water treatment plant to remove excessive concentrations of manganese is estimated to cost $2,596,000.

ID: 15 | City: Pearsall | TNRCC Survey Year: 1997

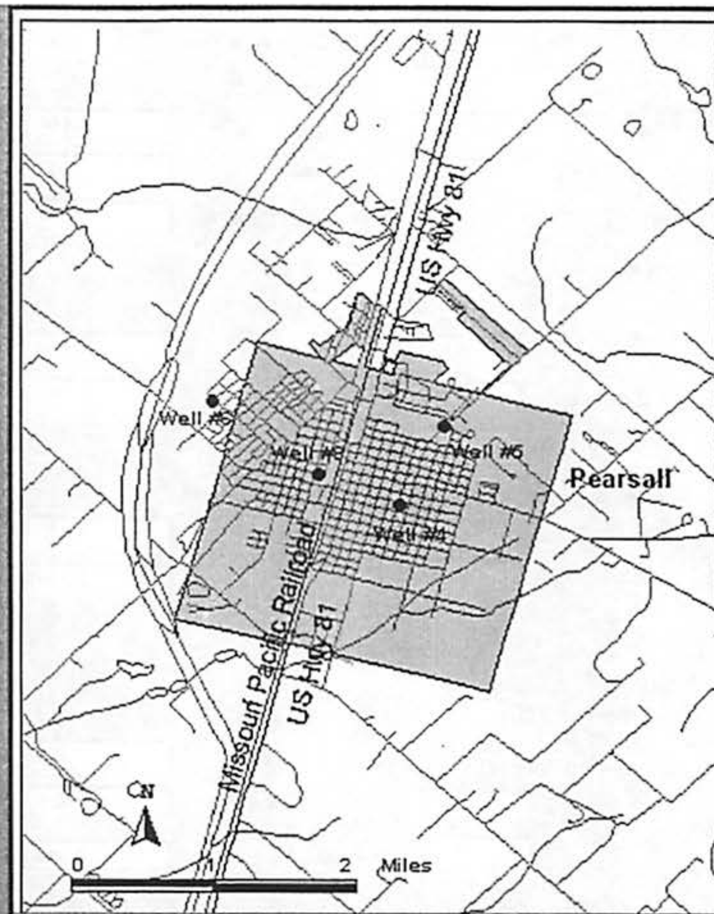
County: Frio

Connections

Aquifer: Carrizo | Retail: 2,682

PWS_ID: 0820002 | Wholesale: 0

Outside Water Supply: N/A



Population		Average Use (mgd)	
City		City	
1996	7,821	Survey Year	1.291
2050	10,979	2050	2.021
Growth (%)	40		
Service Area		Service Area	
Survey Year	8,046	Survey Year	1.320
2050	11,295	2050	2.066

Aquifer Information

Static Water Level (ft)	300	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	-2.2
Top	1,200	Last 3 Decades (ft/yr)	-2.1
Bottom	1,900	Water Quality Problems	Iron

Well Information

Total Well Capacity (gpm)	4,180	TNRCC Required Capacity (mgd)	Survey Year	2.319
Total Well Capacity (mgd)	6.019	Peak day demand in Service Area	2050	3.255

Well	4	Well	5	Well	6	Well	8	Well	
Depth (ft)	1,290	Depth (ft)	1,400	Depth (ft)	1,541	Depth (ft)	1,500	Depth (ft)	
Yield (gpm)	580	Yield (gpm	1,200	Yield (gpm	1,100	Yield (gpm	1,300	Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Pearsall appear to be adequate to meet the Texas Water Development Board's projected demands for Pearsall through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

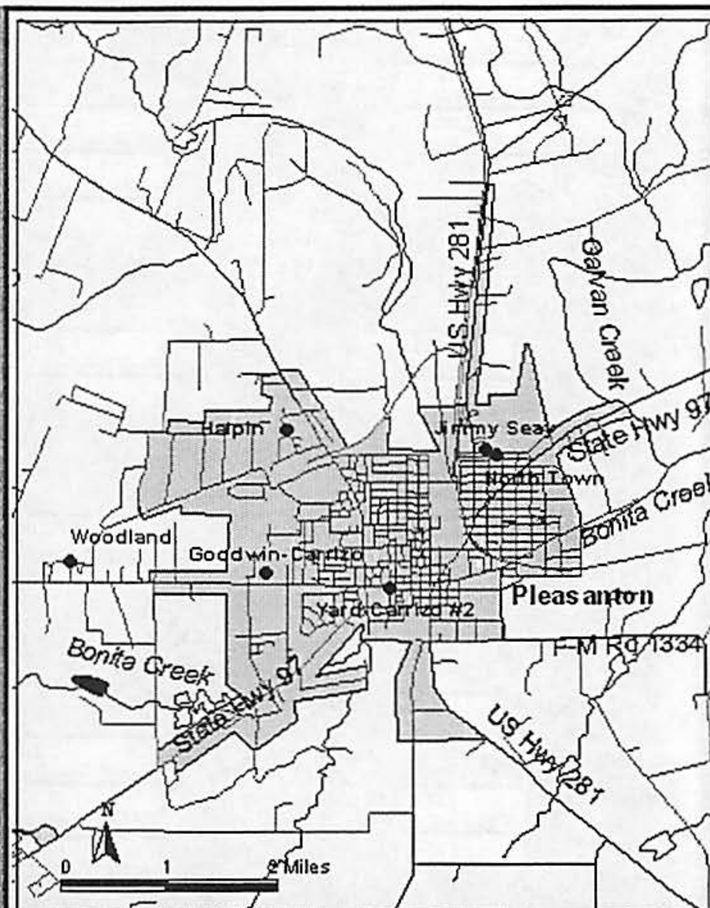
A 3.0 mgd water treatment plant to remove excessive concentrations of iron is estimated to cost $3,531,000.

ID	16	City	Pleasanton
County	Atascosa	TNRCC Survey Year	1998
Aquifer	Queen City & Carrizo		
PWS_ID	0070003		

Connections

Retail	3,444
Wholesale	302
Outside Water Supply	No

Population		Average Use (mgd)	
City		City	
1996	8,611	Survey Year	1.710
2050	17,092	2050	3.143
Growth (%)	98		
Service Area		Service Area	
Survey Year	9,681	Survey Year	1.826
2050	19,168	2050	3.359



Aquifer Information

Static Water Level (ft)	50	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	-0.5
Top	100	Last 3 Decades (ft/yr)	-0.8
Bottom	2,000	Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	4,370	TNRCC Required Capacity (mgd)	Survey Year	3.237
Total Well Capacity (mgd)	6.292	Peak day demand in Service Area	2050	6.409

Well	Woodland	North Town	Jimmy Seay	Halpin	Goodwin-Carri
Depth (ft)	750	790	763	723	1,700
Yield (gpm)	400	500	400	370	1,500

Well	Yard-Carr #2				
Depth (ft)	1,710				
Yield (gpm	1,200				

Well					
Depth (ft)					
Yield (gpm					

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Queen City and Carrizo Aquifers in the vicinity of Pleasanton appear to be adequate to meet the Texas Water Development Board's projected demands for Pleasanton through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

After year 2040, a new well will be needed. The estimated cost for a Carrizo well and a half mile of pipeline is $525,000.

ID 17 City Poteet TNRCC Survey Year 1999

County Atascosa

Aquifer Carrizo

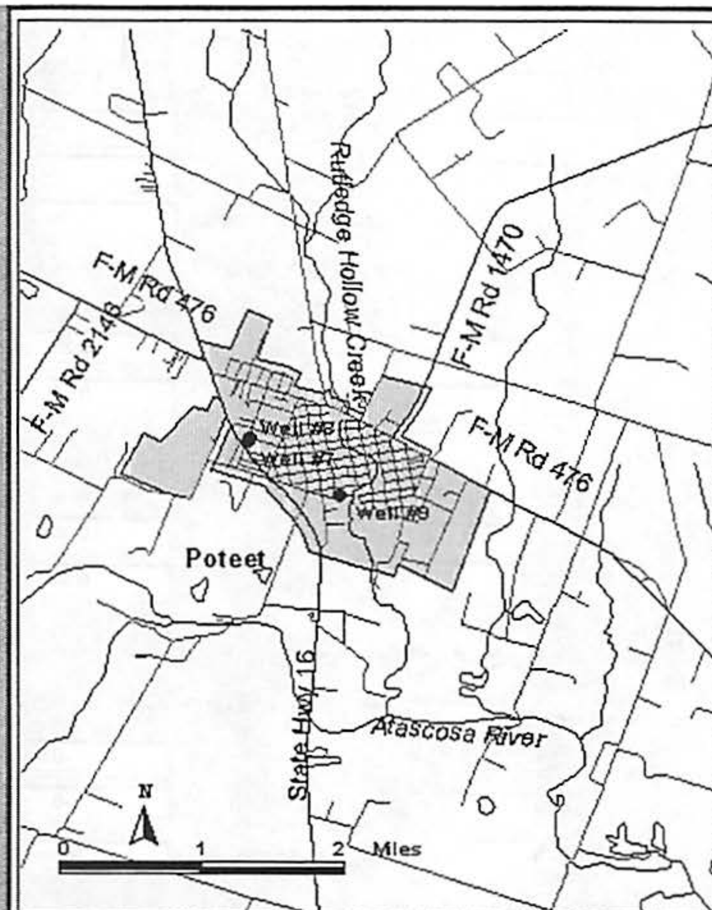
PWS_ID 0070005

Connections

Retail 1,024

Wholesale 66

Outside Water Supply No



Population

City

1996	3,663
2050	5,887
Growth (%)	61

Service Area

Survey Year	3,270
2050	5,265

Average Use (mgd)

City

Survey Year	0.663
2050	1.454

Service Area

Survey Year	0.533
2050	1.169

Aquifer Information

Static Water Level (ft) 120

Water-bearing Zone (ft)

Top	700
Bottom	1,400

Trend in Groundwater Levels

Last Decade (ft/yr)	-1.5
Last 3 Decades (ft/yr)	-1.6
Water Quality Problems	Iron

Well Information

Total Well Capacity (gpm) 2,490

Total Well Capacity (mgd) 3.586

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	0.942
2050	1.515

Well 7	Well 8	Well 9	Well	Well
Depth (ft) 925	Depth (ft) 925	Depth (ft) 1,100	Depth (ft)	Depth (ft)
Yield (gpm) 430	Yield (gpm 1,000	Yield (gpm 1,060	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm
Well	Well	Well	Well	Well
Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)	Depth (ft)
Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm	Yield (gpm

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Poteet appear to be adequate to meet the Texas Water Development Board's projected demands for Poteet through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

A 1.5 mgd water treatment plant to remove excessive concentrations of iron is estimated to cost $2,830,000.

ID 18 City Poth TNRCC Survey Year 1997

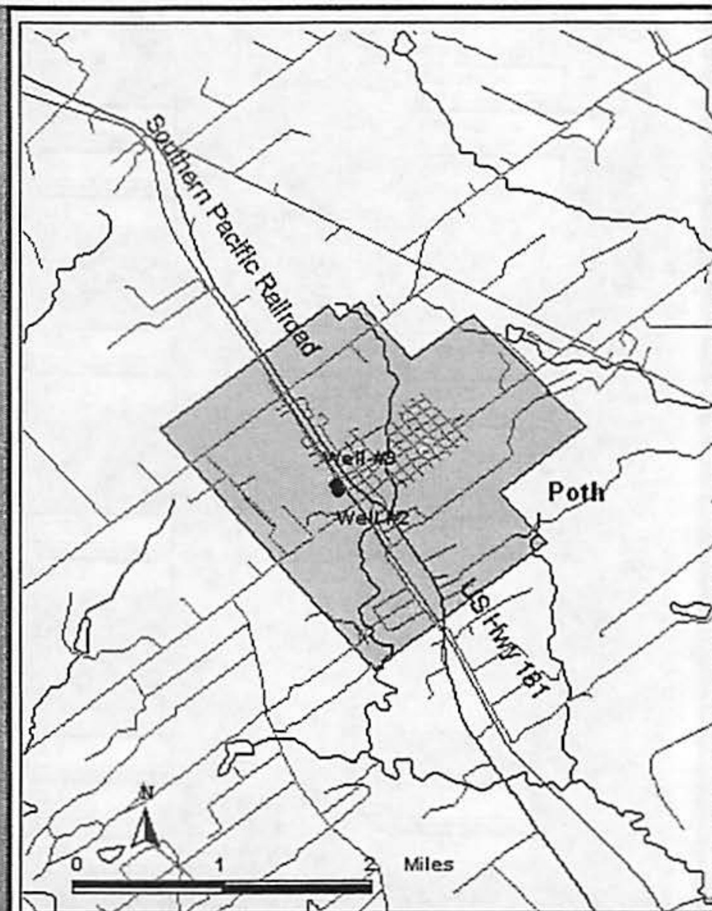
County Wilson

Connections

Aquifer Carrizo Retail 700

PWS_ID 2470002 Wholesale 0

Outside Water Supply No



Population

City	
1996	1,970
2050	3,114
Growth (%)	58

Service Area	
Survey Year	2,100
2050	3,319

Average Use (mgd)

City	
Survey Year	0.290
2050	0.536

Service Area	
Survey Year	0.305
2050	0.564

Aquifer Information

Static Water Level (ft) 40

Water-bearing Zone (ft)

Top 1300

Bottom 2,100

Trend in Groundwater Levels

Last Decade (ft/yr) -0.6

Last 3 Decades (ft/yr) -0.8

Water Quality Problems None

Well Information

Total Well Capacity (gpm) 2500

Total Well Capacity (mgd) 3601

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year 0.605

2050 0.957

Well	Depth (ft)	Yield (gpm)
2	2,012	400
3	2,031	600
4	2035	1500

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo Aquifer in the vicinity of Poth appear to be adequate to meet the Texas Water Development Board's projected demands for Poth through the year 2050. Well #4 is under contract.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID 19 City Stockdale TNRCC Survey Year 1999

County Wilson

Aquifer Queen City & Carrizo

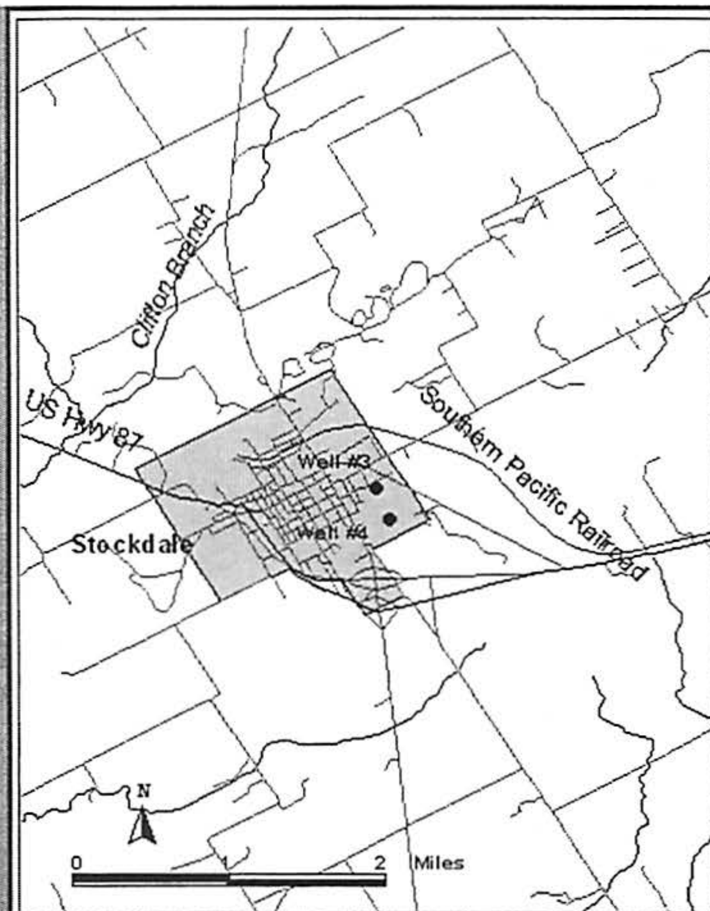
PWS_ID 2470003

Connections

Retail 593

Wholesale 0

Outside Water Supply Emergency



Population

City

1996	1,426
2050	2,378
Growth (%)	67

Service Area

Survey Year	1,779
2050	2,967

Average Use (mgd)

City

Survey Year	0.283
2050	0.400

Service Area

Survey Year	0.268
2050	0.379

Aquifer Information

Static Water Level (ft) 100

Water-bearing Zone (ft)

Top 400

Bottom 1,100

Trend in Groundwater Levels

Last Decade (ft/yr) -1.1

Last 3 Decades (ft/yr) -0.5

Water Quality Problems None

Well Information

Total Well Capacity (gpm) 1700

Total Well Capacity (mgd) 2.45

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year 0.513

2050 0.855

Well	Depth (ft)	Yield (gpm)
3	916	500
4	900	1200

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Carrizo and Queen City Aquifers in the vicinity of Stockdalle appear to be adequate to meet the Texas Water Development Board's projected demands for Stockdale through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

In late 1999 or early 2000 will drill new Well #4 into the Carrizo, and pump at 1200 gpm.

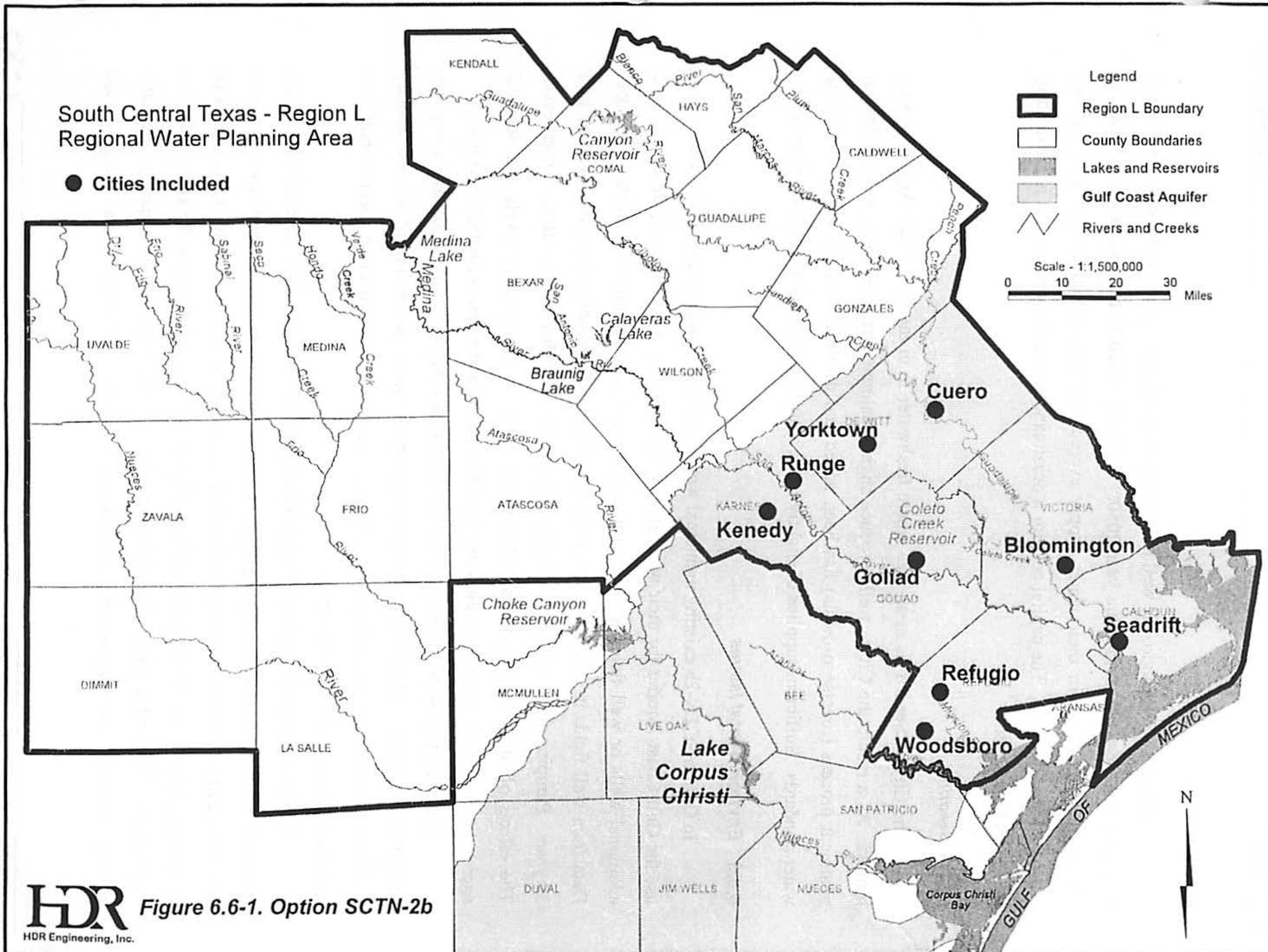


Figure 6.6-1. Option SCTN-2b

6.6.2.3 Refugio

For the City of Refugio, the well field is not expected to encounter water supply problems or a need for expansion before the year 2050. However, TNRCC field survey notes that the chloride concentrations in their water supply exceeds the 250 milligrams per liter primary drinking water standard. The capital cost for a desalination water treatment plant is provided in the City's Fact Sheet.

6.6.2.4 Seadrift

The City of Seadrift is in an area where freshwater from the Gulf Coast Aquifer is very limited. As a result, the City's wells produce slightly saline water. Recently, a desalinization treatment process (reverse osmosis) has been added and demineralizes the water to drinking water standards. Sufficient supplies of slightly saline water are available through the year 2050.

6.6.3 Environmental Issues

In Option SCTN-2b existing municipal well fields in the lower Coastal Plains area, which use the Gulf Coast Aquifer for their water supply are evaluated. Some municipalities will need additional wells or well fields to meet projected water supply requirements to the year 2050. Data from well fields in this area show a variety of trends in groundwater levels over the past 30 years. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels. The effects of these existing wells and any new wells on groundwater levels and potential encroachment of poor quality groundwater should be considered when evaluating this option.

The pumping of groundwater from the Gulf Coast Aquifer could also have a negative impact on springflow and temporary pools in these areas. Some species inhabit or use temporary pools, as well as aquifers and springs. Possible negative effects in these species should be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegeration procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.6.4 Engineering and Costing: See Individual City Fact Sheets

6.6.5 Implementation Issues

The development of additional wells and well fields in the Gulf Coast Water Planning Region must address several issues. Major issues include:

- Detailed feasibility evaluations including test drilling, and aquifer and water quality testing.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands
- Competition with others for groundwater in the area.
- Regulations by Underground Water Conservation Districts, including the renewal of pumping permits at periodic intervals in counties where districts have been organized.

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ID 20 | City Bloomington | TNRCC Survey Year 1997

County: Victoria

Aquifer: Gulf Coast

PWS_ID: 2350001

Connections

Retail: 850

Wholesale: 0

Outside Water Supply: No

Population

City	
1996	2,055
2050	4,442
Growth (%)	116

Service Area	
Survey Year	1,800
2050	3,891

Average Use (mgd)

City	
Survey Year	0.230
2050	0.374

Service Area	
Survey Year	0.225
2050	0.366

Aquifer Information

Static Water Level (ft): 50

Water-bearing Zone (ft)

Top: <100

Bottom: 1,400

Trend in Groundwater Levels

Last Decade (ft/yr): 0.4

Last 3 Decades (ft/yr): 0

Water Quality Problems: None

Well Information

Total Well Capacity (gpm): 700

Total Well Capacity (mgd): 1.008

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year: 0.735

2050: 1.588

Well	Depth (ft)	Yield (gpm)
4	1,010	350
5	1,002	350

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Bloomington appear to be adequate to meet the Texas Water Development Board's projected demands for Bloomington through the year 2050.

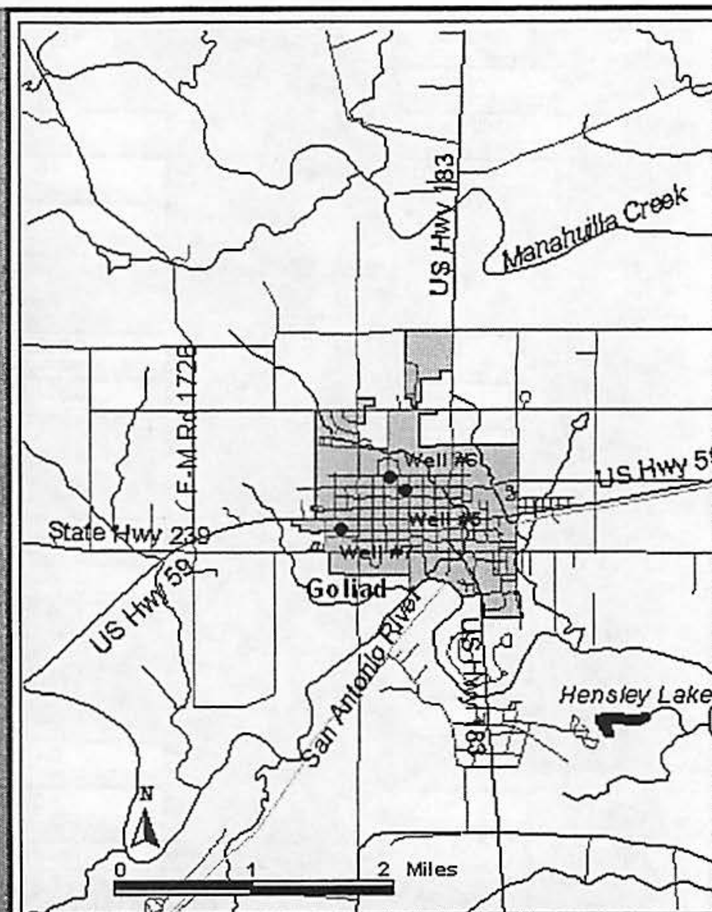
If needed, potential location of new well field and estimated cost to adding new supply to system

One new well will be needed after year 2010 and another after year 2040. The estimated cost for one new well and a half mile of pipeline is $319,000.

ID	21	City	Goliad
County	Goliad	TNRCC Survey Year	1999
Aquifer	Gulf Coast		
PWS_ID	0880001		

Connections

Retail	985
Wholesale	0
Outside Water Supply	No



Population

City

1996	2,221
2050	2,636
Growth (%)	19

Service Area

Survey Year	1,998
2050	2,371

Average Use (mgd)

City

Survey Year	0.370
2050	0.393

Service Area

Survey Year	0.367
2050	0.390

Aquifer Information

Static Water Level (ft)	40
Water-bearing Zone (ft)	
Top	<100
Bottom	900

Trend in Groundwater Levels

Last Decade (ft/yr)	0.7
Last 3 Decades (ft/yr)	0.3
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1,680
Total Well Capacity (mgd)	2.419

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	0.852
2050	1.010

Well	5	Well	6	Well	7	Well		Well	
Depth (ft)	557	Depth (ft)	575	Depth (ft)	550	Depth (ft)		Depth (ft)	
Yield (gpm)	460	Yield (gpm	650	Yield (gpm	570	Yield (gpm		Yield (gpm	

Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Evaluation of Water Supply to Year 2050

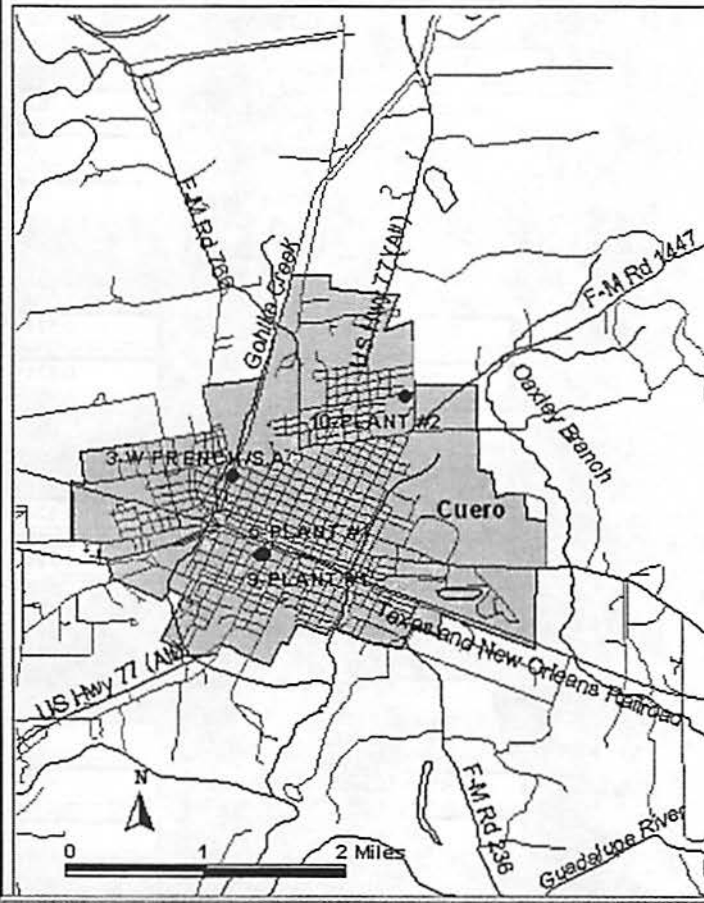
Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Goliad appear to be adequate to meet the Texas Water Development Board's projected demands for Goliad through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	22	City	Cuero
TNRCC Survey Year	1999		
County	DeWitt		
Aquifer	Gulf Coast		
PWS_ID	0620001		

Connections

Retail	2,804
Wholesale	0
Outside Water Supply	No



Population

City	
1996	6,932
2050	9,074
Growth (%)	31
Service Area	
Survey Year	8,412
2050	11,011

Average Use (mgd)

City	
Survey Year	1.305
2050	1.688
Service Area	
Survey Year	1.43
2050	1.87

Aquifer Information

Static Water Level (ft)	10
Water-bearing Zone (ft)	
Top	<100
Bottom	1,500
Trend in Groundwater Levels	
Last Decade (ft/yr)	1.5
Last 3 Decades (ft/yr)	0.4
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	3,425
Total Well Capacity (mgd)	4.932

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	2.422
2050	3.170

Well: Plant #1	Well: Plant #1	Well: Plant #2	Well: Plant #3	Well:
Depth (ft): 1,173	Depth (ft): 1,150	Depth (ft): 1,422	Depth (ft): 870	Depth (ft):
Yield (gpm): 850	Yield (gpm: 400	Yield (gpm: 1,050	Yield (gpm: 1,125	Yield (gpm:
Well:	Well:	Well:	Well:	Well:
Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):
Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:
Well:	Well:	Well:	Well:	Well:
Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):	Depth (ft):
Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:	Yield (gpm:

Evaluation of Water Supply to Year 2050

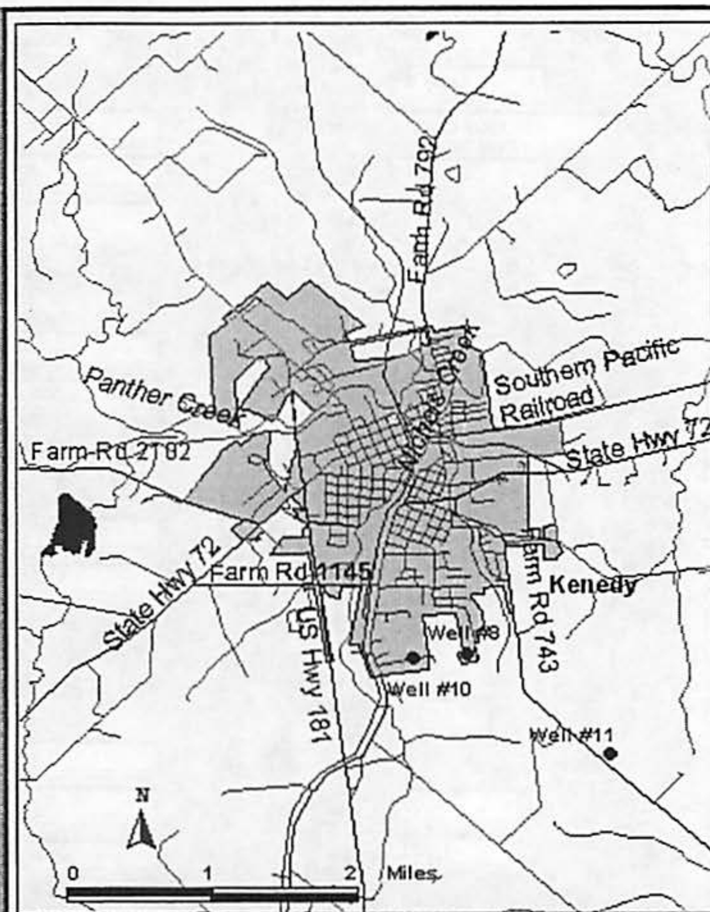
Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Cuero appear to be adequate to meet the Texas Water Development Board's projected demands for Cuero through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	23	City	Kenedy
County	Karnes	TNRCC Survey Year	1998
Aquifer	Catahoula		
PWS_ID	1280002		

Connections

Retail	1,782
Wholesale	0
Outside Water Supply	No



Population

City	
1996	6,463
2050	6,155
Growth (%)	-5

Service Area	
Survey Year	7,341
2050	6,991

Average Use (mgd)

City	
Survey Year	0.524
2050	0.831

Service Area	
Survey Year	1.134
2050	1.798

Aquifer Information

Static Water Level (ft)	130
Water-bearing Zone (ft) Top	<100
Bottom	600

Trend in Groundwater Levels

Last Decade (ft/yr)	2.7
Last 3 Decades (ft/yr)	-0.3
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1,450
Total Well Capacity (mgd)	2.172

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	1.541
2050	1.467

	Well	Well	Well	Well	Well
Well	8	10	11		
Depth (ft)	650	650	320		
Yield (gpm)	570	540	340		

	Well	Well	Well	Well	Well
Well					
Depth (ft)					
Yield (gpm					

	Well	Well	Well	Well	Well
Well					
Depth (ft)					
Yield (gpm					

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Catahoula formation in the vicinity of Kenedy appear to be adequate to meet the TWDB's projected demands for Kenedy through the year 2050. Water treatment includes reverse osmosis to reduce TDS concentrations.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID: 24 | City: Refugio | TNRCC Survey Year: 1999

County: Refugio

Aquifer: Gulf Coast

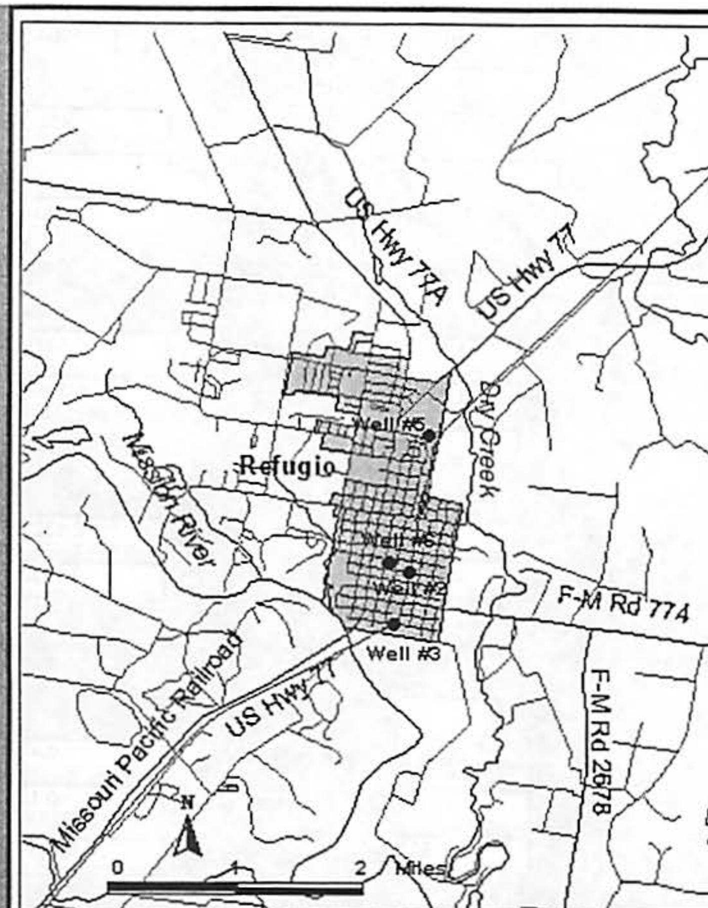
PWS_ID: 1960001

Connections

Retail: 1,353

Wholesale: 0

Outside Water Supply: No



Population

City	
1996	3,153
2050	3,732
Growth (%)	18

Service Area	
Survey Year	3,156
2050	3,736

Average Use (mgd)

City	
Survey Year	0.550
2050	0.526

Service Area	
Survey Year	0.560
2050	0.536

Aquifer Information

Static Water Level (ft): 20

Water-bearing Zone (ft)

Top: <100

Bottom: 1,200

Trend in Groundwater Levels

Last Decade (ft/yr): -0.4

Last 3 Decades (ft/yr): -0.4

Water Quality Problems: Chloride

Well Information

Total Well Capacity (gpm): 2,350

Total Well Capacity (mgd): 3.384

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year: 1.170

2050: 1.385

Well	Depth (ft)	Yield (gpm)
2	835	450
3	835	500
5	900	700
6	900	700

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Refugio appear to be adequate to meet the TWDB's projected demands for Refugio through the year 2050. TNRCC surveys indicate chloride concentrations exceed drinking water standards.

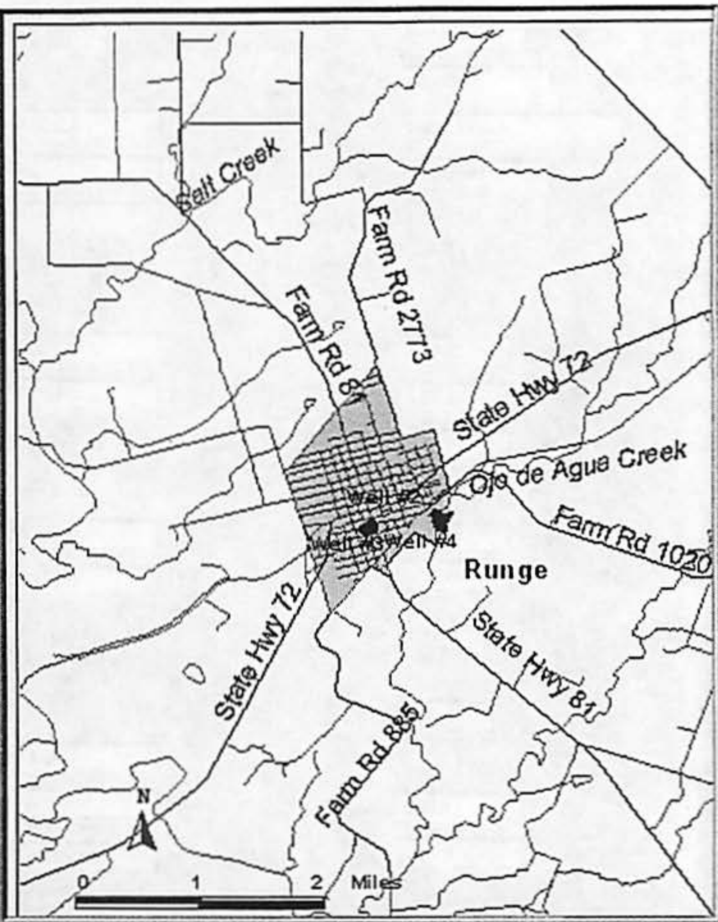
If needed, potential location of new well field and estimated cost to adding new supply to system

The installation of a desalinization unit that uses reverse osmosis technology is estimated to cost $587,000.

ID	25	City	Runge
County	Karnes	TNRCC Survey Year	1999
Aquifer	Gulf Coast		
PWS_ID	1280003		

Connections

Retail	460
Wholesale	0
Outside Water Supply	No



Population

City	
1996	1,197
2050	1,845
Growth (%)	54

Service Area	
Survey Year	1,380
2050	2,127

Average Use (mgd)

City	
Survey Year	0.137
2050	0.190

Service Area	
Survey Year	0.132
2050	0.183

Aquifer Information

Static Water Level (ft)	30
Water-bearing Zone (ft) Top	<100
Bottom	750

Trend in Groundwater Levels	
Last Decade (ft/yr)	-0.4
Last 3 Decades (ft/yr)	-0.1
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	580
Total Well Capacity (mgd)	0.835

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	0.398
2050	0.613

Well	2	3	4		
Depth (ft)	212	210	710		
Yield (gpm)	120	100	360		
Well					
Depth (ft)					
Yield (gpm					
Well					
Depth (ft)					
Yield (gpm					

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Runge appear to be adequate to meet the Texas Water Development Board's projected demands for Runge through the year 2050.

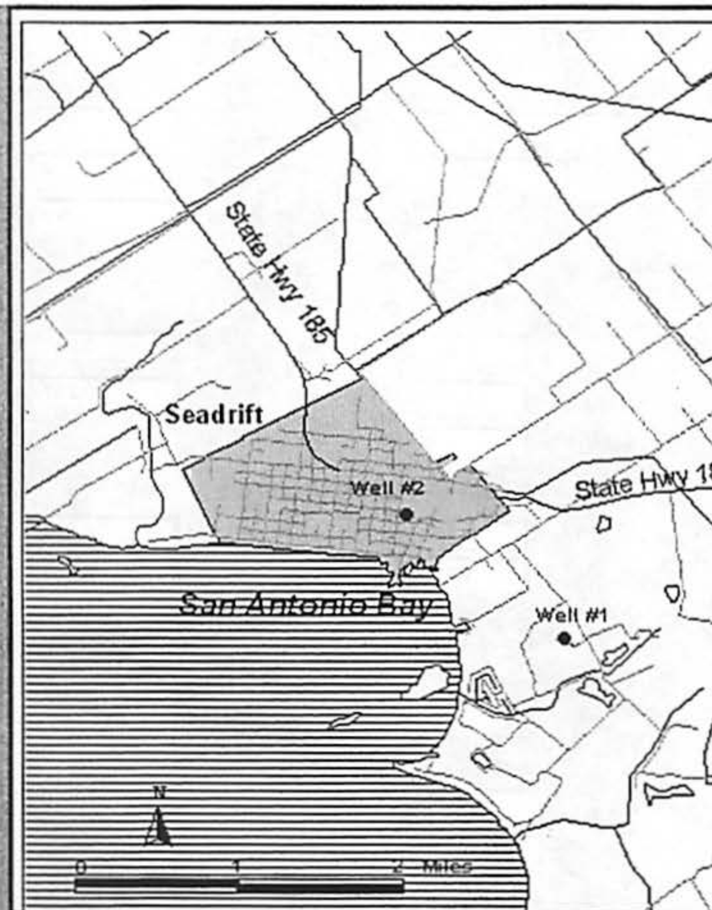
If needed, potential location of new well field and estimated cost to adding new supply to system

ID	26	City	Seadrift
County	Calhoun	TNRCC Survey Year	1999
Aquifer	Gulf Coast		
PWS_ID	0290004		

Connections

Retail	650
Wholesale	0
Outside Water Supply	No

Population		Average Use (mgd)	
City		City	
1996	1,516	Survey Year	0.171
2050	3,012	2050	0.250
Growth (%)	99		
Service Area		Service Area	
Survey Year	1,950	Survey Year	0.190
2050	3,874	2050	0.278



Aquifer Information

Static Water Level (ft)	10	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	0.5
Top	<100	Last 3 Decades (ft/yr)	0.2
Bottom	300	Water Quality Problems	Salinity

Well Information

Total Well Capacity (gpm)	505	**TNRCC Required Capacity (mgd)**	Survey Year	0.562
Total Well Capacity (mgd)	0.727	Peak day demand in Service Area	2050	1.117

Well	1	Well	2	Well		Well		Well	
Depth (ft)	268	Depth (ft)	285	Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm)	295	Yield (gpm	210	Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	
Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Evaluation of Water Supply to Year 2050

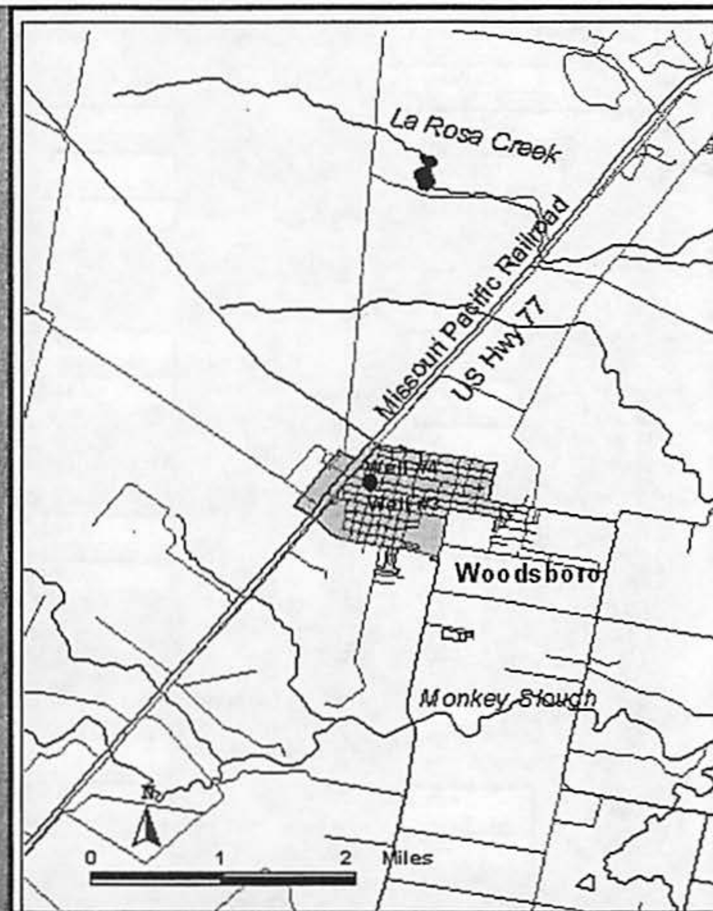
Groundwater from the Gulf Coast Aquifer in the vicinity of Seadrift is naturally slightly saline and does not meet public drinking water standards. The salinity problem is corrected with a desalinization unit that use reverse osmosis technology.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID	27	City	Woodsboro
TNRCC Survey Year	1999		
County	Refugio		
Aquifer	Gulf Coast		
PWS_ID	1960003		

Connections

Retail	753
Wholesale	0
Outside Water Supply	No



Population

City	
1996	1,857
2050	1,922
Growth (%)	4

Service Area	
Survey Year	1,750
2050	1,811

Average Use (mgd)

City	
Survey Year	0.233
2050	0.257

Service Area	
Survey Year	0.291
2050	0.321

Aquifer Information

Static Water Level (ft)	20
Water-bearing Zone (ft) Top	<100
Water-bearing Zone (ft) Bottom	1,200
Trend in Groundwater Levels: Last Decade (ft/yr)	0
Trend in Groundwater Levels: Last 3 Decades (ft/yr)	0
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	580
Total Well Capacity (mgd)	0.836

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	0.651
2050	0.674

Well	Depth (ft)	Yield (gpm)
3	279	330
4	170	250

Evaluation of Water Supply to Year 2050

Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Woodsboro appear to be adequate to meet the Texas Water Development Board's projected demands for Woodsboro through the year 2050.

If needed, potential location of new well field and estimated cost to adding new supply to system

ID: 28 | City: Yorktown | TNRCC Survey Year: 1999

County: DeWitt

Aquifer: Gulf Coast

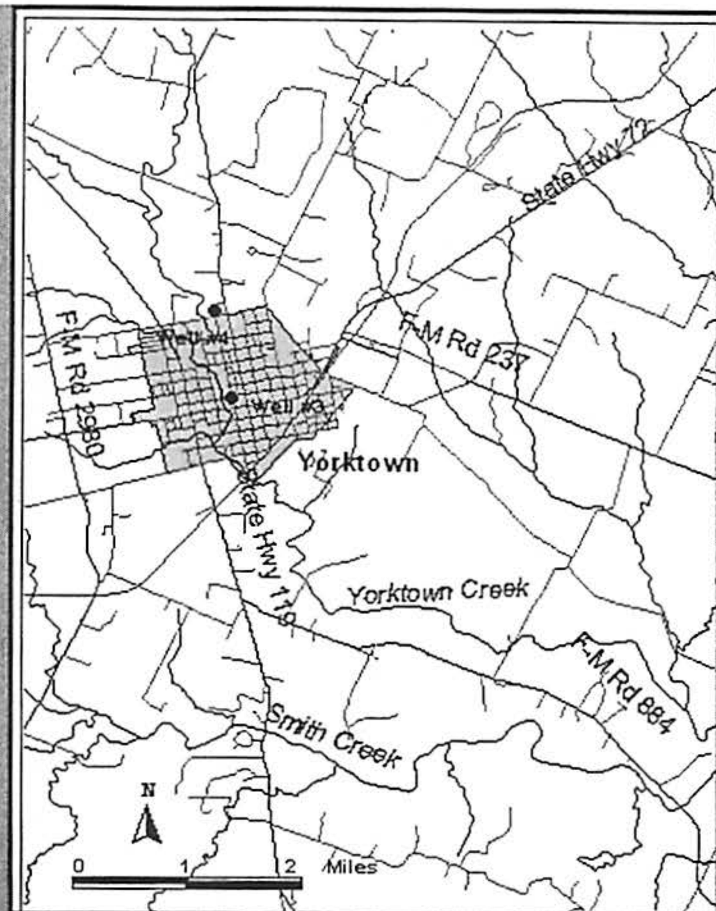
PWS_ID: 0620004

Connections

Retail: 1,147

Wholesale: 0

Outside Water Supply: No



Population

City	
1996	2,334
2050	3,450
Growth (%)	48

Service Area	
Survey Year	2,206
2050	3,261

Average Use (mgd)

City	
Survey Year	0.363
2050	0.455

Service Area	
Survey Year	0.330
2050	0.414

Aquifer Information

Static Water Level (ft): 20

Water-bearing Zone (ft)

Top: <100

Bottom: 1,100

Trend in Groundwater Levels

Last Decade (ft/yr): 0.3

Last 3 Decades (ft/yr): 0.1

Water Quality Problems: None

Well Information

Total Well Capacity (gpm): 1,500

Total Well Capacity (mgd): 2.160

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year: 0.992

2050: 1.466

Well	3	Well	4	Well		Well		Well	
Depth (ft)	963	Depth (ft)	955	Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm)	650	Yield (gpm	850	Yield (gpm		Yield (gpm		Yield (gpm	

Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Well		Well		Well		Well		Well	
Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)		Depth (ft)	
Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm		Yield (gpm	

Evaluation of Water Supply to Year 2050

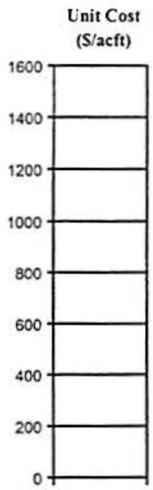
Groundwater supplies from the Gulf Coast Aquifer in the vicinity of Yorktown appear to be adequate to meet the Texas Water Development Board's projected demands for Yorktown through the year 2050.

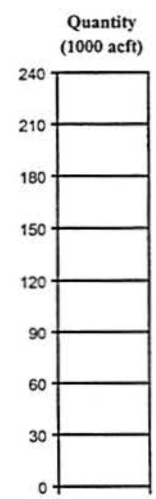
If needed, potential location of new well field and estimated cost to adding new supply to system

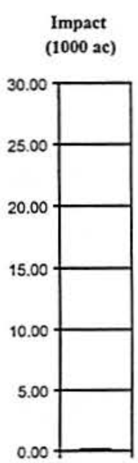
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

January 2001







OPTION NUMBER: **SCTN-2c**

OPTION NAME: **Groundwater Supplies for Municipal Water Systems in the Trinity Aquifer**

OPTION DESCRIPTION: *Municipal water systems in the Hill Country area of the South Central Texas Water Planning Region commonly use the Trinity Aquifer for their supply. This source is a strong preference because the water is usually conveniently located, although limited in quantities, inexpensive, and often suitable for public water supplies with minimal treatment. The purposes of this option are to (1) evaluate existing aquifers and well field(s) of each municipality as to ability to meet projected water supply requirements through the year 2050; and (2) if additional supplies are needed, generally locate suitable new well fields and estimate the cost to add the additional supply to the municipal water system.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yr.** ☐ **5-15 yr.** ☐ **> 15 yr.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF WATER:	N/A	per acft[1]
QUANTITY OF WATER:	N/A	acft/yr[2]
LAND IMPACTED:	N/A	acres[3]

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** See Individual City Fact Sheets.

[2]**QUANTITY OF WATER:** Not Applicable.

[3]**LAND IMPACTED:** Not Applicable.

ENVIRONMENTAL ISSUES: Not Applicable.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Not Applicable.

ADDITIONAL FACTORS: Not Applicable.

6.7 Groundwater Supplies for Municipal Water Systems in the Trinity Aquifer, South Central Texas Water Planning Region (SCTN-2c)

6.7.1 Description of Municipal Water Demands and Groundwater Supplies

Municipal water systems in the Hill Country area of the South Central Texas Water Planning Region commonly use the Trinity Aquifer for their supply. This source is a strong preference because the water is usually conveniently located, although limited in quantity, inexpensive, and suitable for public water supplies with minimal treatment. However, a very rapid growth of population in the cities as well as the development of rural areas is clashing with the rather modest supply of groundwater. Two ongoing efforts to address the water supply issue are (1) the formation of the Cow Creek Groundwater Conservation District (Kendall County), and (2) the planned construction of the West Comal Water Supply Project by GBRA.

The purposes of this option are to:

- Evaluate aquifers and existing well field(s) of each municipality as to ability to meet projected water supply requirements through the year 2050;
- If additional supplies are needed, identify a suitable area for a new well field(s); and
- If additional wells are needed or if the water needs to be treated, estimate when the expansion is needed and how much the facilities will cost.

The evaluation of individual municipal water systems is at a reconnaissance level and does not include:

- An engineering analysis of the water system as to the condition or adequacy of the wells, transmission system, and storage facilities;
- A projection of maintenance or replacement costs of existing wells and facilities;
- The potential interference of new wells installed by others near the city's wells or at locations identified for new well fields;
- Impact of potential changes in groundwater use patterns in the vicinity of the city's well field and the county;
- Rules and regulations that may be developed and implemented by a groundwater conservation district or the State; nor
- Consideration of additional wells or water treatment for local purposes such as reliability, water pressure, peaking capacity, and localized growth.

The evaluation of each municipal water system consisted of the following steps:

1. Compiled information prepared for the South Central Texas Regional Water Planning Group on current (1996) and TWDB's projected populations and water demands for each of the municipalities;

2. Estimated the TNRCC required system capacity in the year 2050 for each water system;
3. Compiled and summarized publicly available information for each municipal water system from TNRCC and TWDB;
4. Analyzed aquifer information from TWDB and U.S. Geological Survey (USGS) reports as to availability of groundwater from major and minor aquifers in the vicinity of each municipality;
5. Compiled groundwater level data from the TWDB database and analyzed for short-term and long-term trends;
6. When trends showed a decline in groundwater levels, made an adjustment for an estimated decrease in well yields and groundwater availability. Considered the position of the static water level in relation to the top and bottom of the producing formation(s) and well spacing. Compared the long-term groundwater availability within the city's well field(s) with the estimated required system capacity in the year 2050;
7. If the estimated groundwater supply after adjustments was greater than the estimated required capacity in the year 2050, the evaluation concludes that the existing water supply is adequate;
8. If the estimated supply after adjustments was less than the estimated required capacity in the year 2050, the evaluation concluded that an additional water supply would be needed; and
9. If a new well field is a reasonable option, estimated when it is needed and the capital cost of adding the well field to the water system.

6.7.2 Evaluation of Municipal Water Systems

A summary description of each municipality and their well field(s) is presented in the following Fact Sheets. The Fact Sheet provides information about the current and future water demands, current well capacities, aquifer characteristics and conditions, and the conclusion of the adequacy of the water supply through the year 2050.

A discussion on the evaluation of the systems (Figure 6.7-1) that are having difficulties or will be expected to have difficulties before the year 2050 is provided below.

6.7.2.1 Boerne

Groundwater supplies from the Trinity Aquifer are inadequate and have been for many years. Consequently, Boerne has been drawing over 800 acre-feet/year from Cibolo Creek. In the near future these combined supplies will not be adequate. Consequently, Boerne has plans to connect to GBRA's West Comal Water Supply Project that draws water from Canyon Lake.

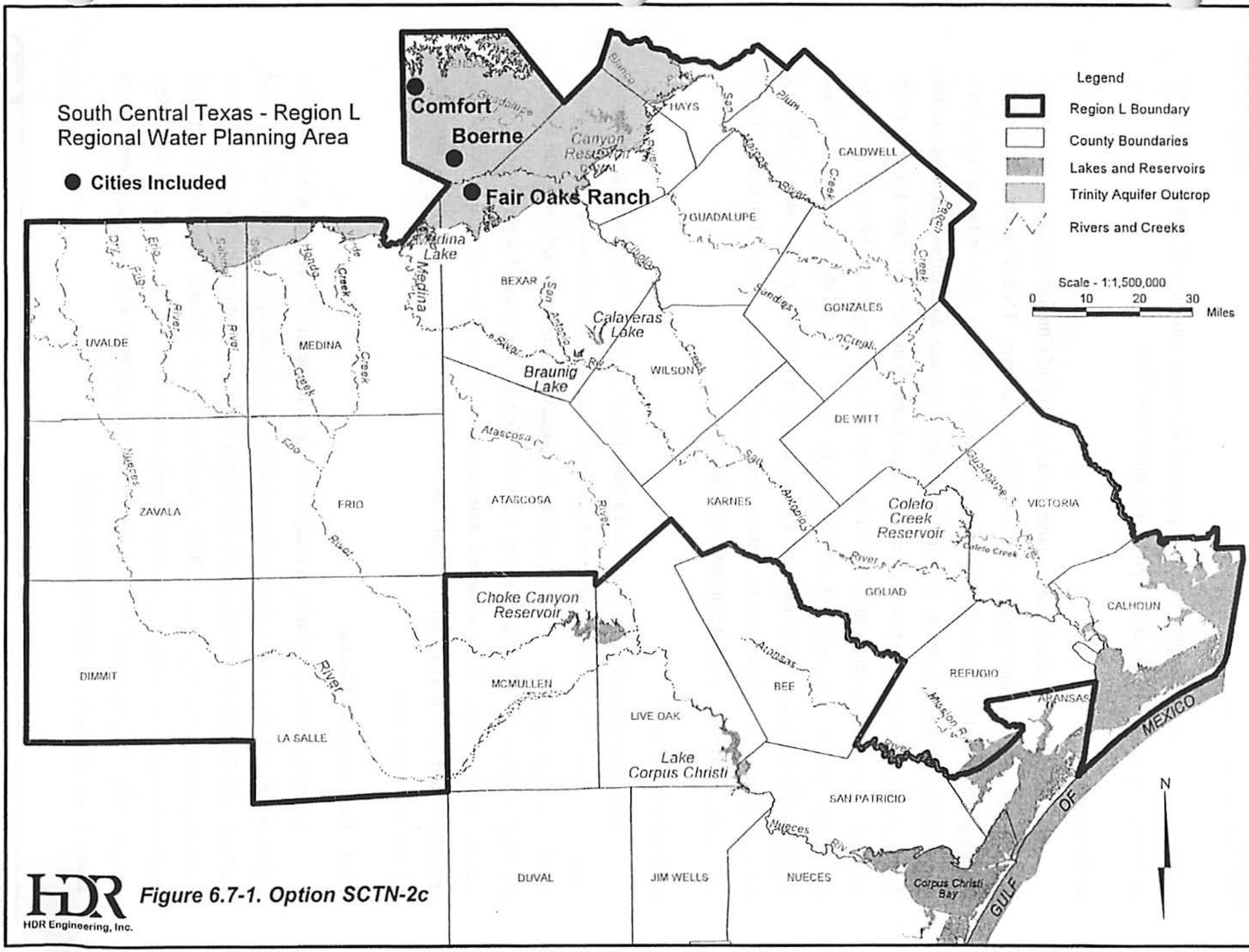


Figure 6.7-1. Option SCTN-2c

Given these sources of supply, Boerne's projected demands can be met through 2040, but additional supplies will be needed for projected growth after 2040.

6.7.2.2 Comfort

Groundwater from the Trinity Aquifer in the vicinity of Comfort appears to be adequate to meet projected demands through the year 2050. However, TNRCC notes a Secondary Drinking Water violation for chlorides and total dissolved solids. One or two of Comfort's deeper wells probably are causing the salinity problem. Because the shallow formations of the Trinity Aquifer typically produces water somewhat better than the secondary drinking water standards, the salinity problem probably can be corrected by taking the problem well(s) out of service and replacing them with new, shallower wells. The new wells should be located at least .5 miles from the nearest large capacity well producing from the same formation. Another option is to add a desalinization water treatment process to the water system. The estimated cost for a replacement well is provided in the City's Fact Sheet.

6.7.2.3 Fair Oaks Ranch

With rapid growth in demands in and around Fair Oaks Ranch and decreasing well yields caused by declining water levels, more and more wells and/or well fields will be required. As a result, and given the fact that suitable supplies of groundwater are not readily available locally, the City of Fair Oaks is participating in GBRA's West Comal Water Supply Project for an outside water supply. With advanced water conservation, and use of small quantities of reclaimed water (less than 25 acft/yr), Fair Oaks would not need additional supplies during the 50-year planning horizon.

6.7.3 Environmental Issues

In Option SCTN-2c existing municipal well fields in the Hill Country area, which use the Trinity Aquifer for their water supply, are evaluated. Some municipalities will need additional wells or well fields or a supplemental water supply from other aquifers or surface sources to meet projected water supply needs to 2050. Data from wells in this area show a declining trend in groundwater levels. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels. The effects of these existing wells and any new wells on groundwater levels should be considered when evaluating this option.

The pumping of groundwater from the Trinity Group of aquifers could also have a negative impact on springflow in these areas. Some species inhabit or use the aquifers and springs of the area. Possible negative effects on these species should be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.7.4 Engineering and Costing: See Individual City Fact Sheet

6.7.5 Implementation Issues

The development of additional wells in the Trinity Aquifer in the South Texas Water Planning Region must address several issues. Major issues include:

- Detailed feasibility evaluation including test drilling, and aquifer and water quality testing.
- Impact on:
  - Endangered and other wildlife species,
  - Water levels in the aquifer,
  - Baseflow in streams, and
  - Wetlands.
- Competition with others for groundwater in the area,
- Regulations by Underground Water Conservation Districts, including the renewal of pumping permits at periodic intervals in counties where underground water conservation districts have been organized.

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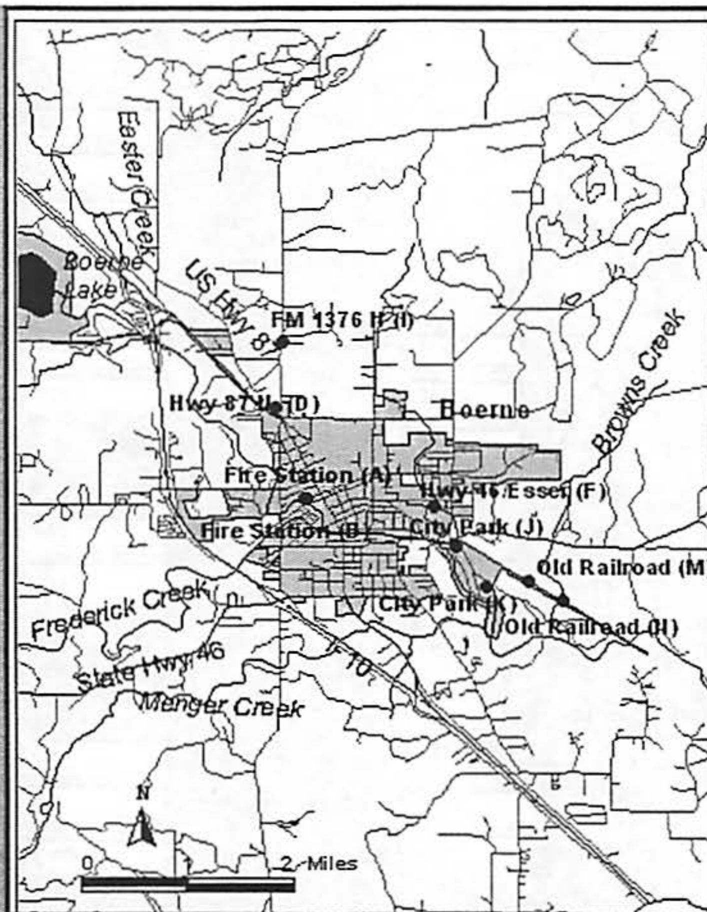
ID	29	City	Boerne
County	Kendall		
Aquifer	Trinity		
PWS_ID	1300001		

TNRCC Survey Year	1999
Connections	
Retail	2,437
Wholesale	0
Outside Water Supply	No



Population

City	
1996	5,754
2050	22,302
Growth (%)	288
Service Area	
Survey Year	7,311
2050	28,337

Average Use (mgd)

City	
Survey Year	0.967
2050	3.213
Service Area	
Survey Year	0.980
2050	3.323

Aquifer Information

Static Water Level (ft)	210
Water-bearing Zone (ft)	
Top	20
Bottom	600

Trend in Groundwater Levels	
Last Decade (ft/yr)	-0.2
Last 3 Decades (ft/yr)	0.1
Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	1744
Total Well Capacity (mgd)	2.512

TNRCC Required Capacity (mgd)		
Peak day demand in Service Area	Survey Year	2.107
	2050	8.160

Well	A	B	D	F	I
Depth (ft)	42	42	522	580	580
Yield (gpm)	200	200	140	250	100

Well	J	K	M	N	
Depth (ft)	420	418	420	430	
Yield (gpm	169	215	220	250	

Well					
Depth (ft)					
Yield (gpm					

Evaluation of Water Supply to Year 2050

Boerne draws water supplies from the Edwards - Trinity Aquifer and Cibolo Creek. These sources are adequate for current demands. In the future, supplies will be supplemented from the GBRA West Comal Water Supply Project.

If needed, potential location of new well field and estimated cost to adding new supply to system

See text for discussion.

ID: 30 | City: Comfort | TNRCC Survey Year: 1997

County: Kendall

Aquifer: Edwards-Trinity

PWS_ID: 1300002

Connections

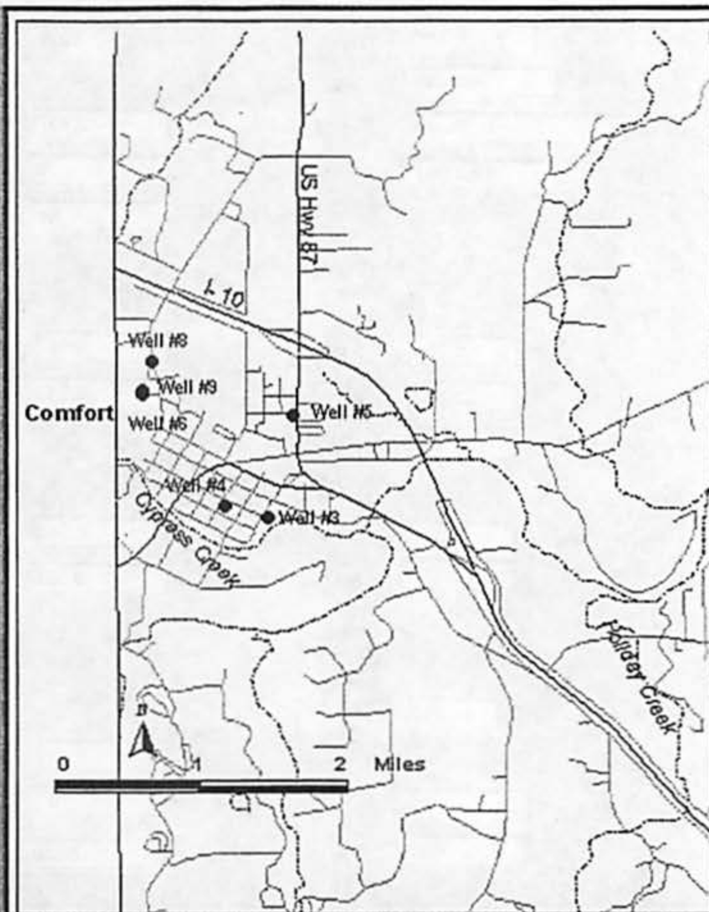
Retail	725
Wholesale	0
Outside Water Supply	No

Population

City	
1996	1,729
2050	2,359
Growth (%)	36
Service Area	
Survey Year	2,175
2050	2,967

Average Use (mgd)

City	
Survey Year	0.261
2050	0.254
Service Area	
Survey Year	0.244
2050	0.238



Aquifer Information

Static Water Level (ft)	90
Water-bearing Zone (ft) Top	<100
Water-bearing Zone (ft) Bottom	>650

Trend in Groundwater Levels

Last Decade (ft/yr)	-1.5
Last 3 Decades (ft/yr)	-0.5
Water Quality Problems	Salinity

Well Information

Total Well Capacity (gpm)	795
Total Well Capacity (mgd)	1.145

TNRCC Required Capacity (mgd)

Peak day demand in Service Area

Survey Year	0.626
2050	0.854

Well	Depth (ft)	Yield (gpm)
3	360	70
4	640	120
5	315	110
6	310	85
8	493	190
9	490	220

Evaluation of Water Supply to Year 2050

Groundwater from the Edwards-Trinity Aquifer in the vicinity of Comfort appears to be adequate for TWDB projections to the year 2050. However, TNRCC's survey indicates salinity concentrations greater than secondary drinking water standards.

If needed, potential location of new well field and estimated cost to adding new supply to system

Replace the well that is producing the slightly saline water. A replacement well and pipe is expected to cost $258,000.

ID: 32 | City: Fair Oaks Rh | TNRCC Survey Year: 1998

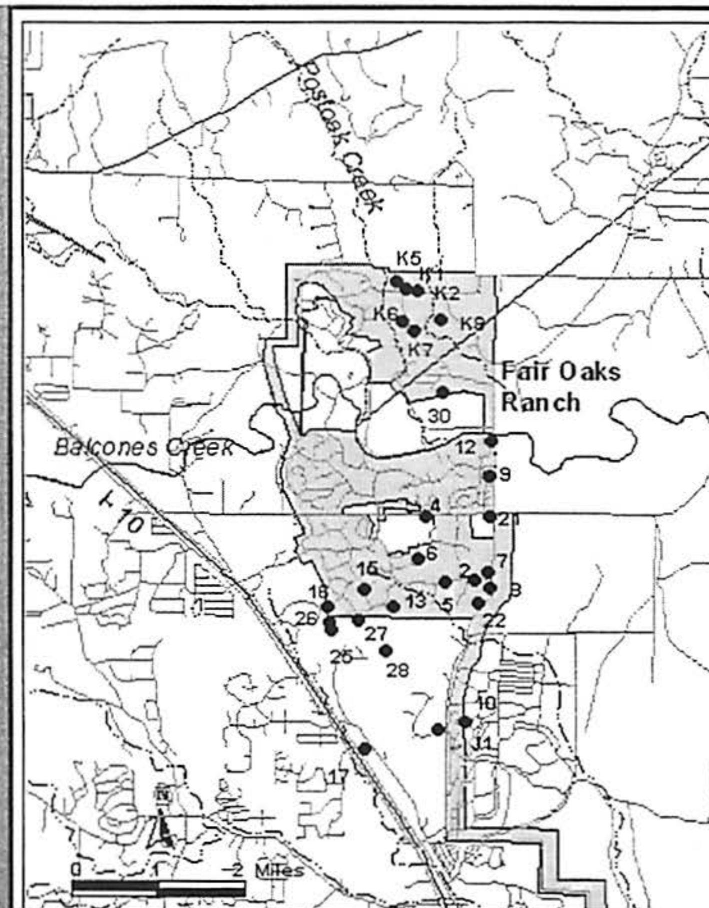
County: Bexar

Connections

Aquifer: Edwards-Trinity | Retail: 1664

PWS_ID: 0150216 | Wholesale: 0

Outside Water Supply: No



Population		**Average Use (mgd)**	
City		City	
1996	3101	Survey Year	1071
2050	4833	2050	1213
Growth (%)	56		
Service Area		Service Area	
Survey Year	4492	Survey Year	1095
2050	6985	2050	1240

Aquifer Information

Static Water Level (ft)	~450	Trend in Groundwater Levels	
Water-bearing Zone (ft)		Last Decade (ft/yr)	-4.4
Top	300	Last 3 Decades (ft/yr)	-3.2
Bottom	800	Water Quality Problems	None

Well Information

Total Well Capacity (gpm)	2515	**TNRCC Required Capacity (mgd)**	Survey Year	1438
Total Well Capacity (mgd)	3.62	Peak day demand in Service Area	2050	2.243

Well	2,5,7,8 & 22	4 & 6	9,12, & 21	10	30
Depth (ft)	505-552	613-625	435-500	419	660
Yield (gpm)	418	220	249	47	92

Well	,15,16,27& 28	J-1	25	26	K-1 & K-2
Depth (ft)	525-650	500	485	660	330-332
Yield (gpm	346	95	88	43	227

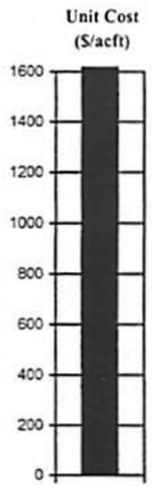
Well	K-5, K-6 & K-7	K-8	K-3		
Depth (ft)	360-380	395	340		
Yield (gpm	290	95	95		

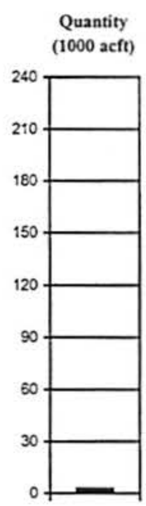
Evaluation of Water Supply to Year 2050

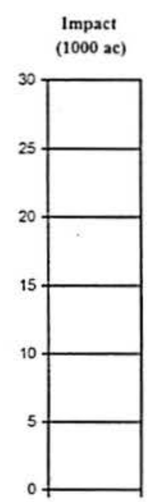
Substantial water level declines and a continued increase in groundwater use in the area indicate that groundwater supplies from the Edwards - Trinity Aquifer will not be adequate in 2050. Future supplies will be supplemented from the GBRA West Comal WSP.

If needed, potential location of new well field and estimated cost to adding new supply to system

SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS
OPTION DATA SHEET
January 2001







OPTION NUMBER: **SCTN-1a**
OPTION NAME: **Aquifer Storage and Recovery (ASR) – Regional Option**

OPTION DESCRIPTION: *Option SCTN-1a evaluates regional scale municipal and industrial utilities that would benefit from storing surplus groundwater or surface water in the Carrizo and Gulf Coast Aquifers and recovering the water when demand exceeds supply or system capacity. A regional scale facility is considered to have a capacity of 10 to 20 million gallons per day. For this option, two facilities are evaluated. One of the facilities would use the Carrizo-Wilcox Aquifer to support water suppliers in the major municipal and industrial demand center. The other one would support utilities in the Victoria area and would use the Gulf Coast Aquifer.*

TIME NEEDED TO IMPLEMENT: ☒ **1-5 yrs.** ☐ **5-15 yrs.** ☐ **> 15 yrs.**

COST, QUANTITY OF WATER, AND LAND IMPACTED		
UNIT COST OF CAPACITY (average):	**$2,428 and $1,009**	**per acft[1]**
QUANTITY OF CAPACITY (each facility):	**2,792**	**acft/yr[2] (Capacity only)**
LAND IMPACTED (average):	**286**	**acres[3]**

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	**of**	(1=lowest unit)
QUANTITY OF WATER:	**of**	(1=highest volume)
LAND IMPACTED:	**of**	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Water treatment, transmission system from water treatment plant to ASR wells and from wells to central storage for blending, and ASR wells. Costs of a water supply and a transmission system to get raw water to the water treatment plant and to the ASR facility are not included. Costs presented here are for installation and operation of an ASR facility.

[2]**QUANTITY OF WATER:** ASR facilities are sized at 10 million gallons per day and would operate in a pumping cycle for three months each year. The facilities do not produce any new water supplies, rather, they provide storage to better manage existing supplies and facilities.

[3]**LAND IMPACTED:** Land impacts will be well sites and transmission facilities. The facility for the major municipal and industrial demand center would impact about 278 acres in rural areas while the Victoria facility would impact about 8 acres of urban area.

ENVIRONMENTAL ISSUES: Considered to be minimal – well field sites and pipeline rights-of-way.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing a supply of ASR water, suitability of local aquifer conditions, control of potential water losses to other users of local groundwater, and balancing the operation of injection and recovery.

ADDITIONAL FACTORS: Lack of experience with ASR technology and in operating the facilities, permits from groundwater conservation districts, and TNRCC regulations.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: Cannot be determined until ASR water source is specified.

6.8 Aquifer Storage and Recovery (ASR) – Regional Option (SCTN-1a)

6.8.1 Description of Option

For purposes of this evaluation, Aquifer Storage and Recovery (ASR) is defined as the use of dual-purpose well(s) to inject available water into an aquifer for storage, with recovery of the water using the well(s)' pumping systems. This management strategy would be useful to water suppliers that have quantities surplus to immediate needs but do not have storage for such quantities. In addition, ASR can be used to store treated water during off-peak seasons, thereby eliminating the need (part or all) for treatment plant capacity to meet peak day and peak season demands. In other words, ASR is a way to store water in aquifers during times when water is available and recovering the water when it is needed. If the water management issue is meeting high summer demands, water would be injected into the aquifer during the fall, winter, and spring and pumped during the summer. This strategy more fully utilizes the available capacities of the water treatment plant and, possibly, the availability of the supply. If the water management issue is a supply for emergencies or drought, water could be stored in the aquifer for several years before it is recovered. ASR wells would be designed to accommodate the injection of water as well as pumping water. However, the water utility operating plan must be designed to balance the injection and recovery cycles.

Option SCTN-1a evaluates regional scale ASR facilities for municipal and industrial water supply management. A regional scale facility is considered to have a capacity of 10 to 20 MGD (11,201 to 22,402 acft/yr), if operated continuously. For this option, three facilities are evaluated. Two of the facilities would support municipal and industrial utilities located in the major municipal and industrial demand center of the South Central Texas Region and would use nearby sites located over the Carrizo-Wilcox Aquifer. The other facility would support municipal and industrial water suppliers in the Victoria area and would use the Gulf Coast Aquifer. It is emphasized, however, that this is a strategy for use in management of existing or new water supplies and is not a water supply in and of itself.

The following report section provides a listing and description of characteristics of the important elements involved in determining the feasibility of adding ASR wells to a water supply system. These guidelines or considerations are intended for screening purposes only and not to be criteria for suitability.

6.8.1.1 Source Water

Quality of Source Water to be Injected: When injecting water into an aquifer that is being used for drinking water supplies, TNRCC regulations require that the injected water be at least as good in quality as the water already in the aquifer (native water). This generally means that the injected water has to meet Drinking Water Standards (e.g., for surface water sources, the water will most likely need to be treated).

Availability of Water: Water for recharge must be available in sufficient quantities, durations, and frequencies for development of viable ASR projects. Each project will have to be sized and designed to consider the hydrology of the source water and the storage characteristics of aquifers, as well as the recovery requirements. In addition, the water demand parameters and technical features of supply sources have to be incorporated into the optimization analyses.

Location of Facilities: ASR wells should be near the water treatment and distribution system in order to reduce the cost of constructing new pipelines and pumping the water to and from the ASR wells, however, each project must be evaluated on its own merits, including location and suitability of aquifer materials.

6.8.1.2 Aquifer System

Productivity of the Aquifer: The water yielding characteristics of an aquifer typically should allow the construction of wells producing 700 gpm (about 1 MGD) or more to improve the prospects of being able to make the project cost effective. Both the Carrizo and Gulf Coast Aquifers possess this characteristic. The lowest yield of an ASR well that is documented in the literature is about 200 gpm.

Aquifer Conditions: A confined water-bearing zone is preferable to a shallow water table aquifer.

Aquifer Thickness: The most suitable thickness of a target water-bearing zone is generally between 50 and 200 feet.

Depth to Water-Bearing Zone: The most suitable depths are from 200 to 500 feet. However, depth to water-bearing zones up to 2,500 feet may prove to be cost-effective.

Aquifer Material: A formation having a strong resistance to dissolution, such as sand, gravel, limestone, and sandstone is preferable. In any case, geochemical analyses are necessary to determine if any negative water quality issues are evident that could affect operation of an

ASR facility, such as cation exchange or mineral precipitation, which would result from a reaction with clay in the aquifer.

Water Quality: The most desirable aquifers have water quality that is at or near drinking water standards. However, successful ASR operations have been developed in aquifers with saline water in which the injection of freshwater would displace saline water and create a "freshwater" bubble. In fact, aquifers with saline water may be preferable because of few or no other users of the aquifer, but the well design must consider the fact that freshwater is lighter than saline water, since the freshwater would float to the top of water-bearing zones. Potential adverse geochemical processes such as precipitation, bacterial activity, ion exchange, and adsorption are possible and require a geochemical analysis to determine the expected reactions between the native water and injected water. On the positive side, ASR may improve water quality through reductions in disinfection byproducts, iron and manganese, and hydrogen sulfides.

Aquifer Water Levels and Wellhead Pressures: The desirable range in depth to water depends on the productivity of the aquifer. In aquifers with a high productivity, water levels can be near the land surface. For moderately transmissive water bearing zones, depth to water should be in the range of 100 to 300 feet below land surface. An existing cone of depression is desirable but not necessary. However, the formation of a water level mound that has a potentiometric surface that is above the land surface would increase springflows and cause uncapped wells to flow, which, in turn, would cause a waste of water and could damage existing facilities.[1] In any event, well design and operational requirements must consider expected wellhead pressures of the project.

Data Availability: Existing and reliable geophysical logs, geologic characteristics, water quality data, aquifer properties data, hydrogeologic reports, and groundwater models are very helpful.

Wells: Existing wells are often used, but many are unsuitable or would require modifications and more maintenance during operation. New wells, especially if constructed with PVC casing, are the most trouble free. Well screens should be stainless steel or PVC.

Other Groundwater Users: Natural or regulatory restrictions are needed to prohibit unauthorized withdrawals of stored surface water.

[1] The potentiometric surface is the level to which water of an artesian aquifer will rise if the confining layers are punctured. The Carrizo-Wilcox and the Gulf Coast Aquifers are artesian (confined) in the proposed well fields.

Regulations: The TNRCC regulates artificial recharge of aquifers. Local groundwater conservation districts may regulate artificial recharge and groundwater withdrawals.

6.8.2 Available Capacity

For purposes of evaluating this option, regional size water supply facilities are considered in order to be useful to major municipal and industrial water utilities in the major municipal and industrial demand center of the South Central Texas Region and in the vicinity of Victoria. The Carrizo Aquifer, from northern Atascosa to southwestern Gonzales Counties, offers suitable characteristics for an ASR facility to serve the major municipal and industrial demand center in Bexar County. The Gulf Coast Aquifer is suitable for the City of Victoria. The locations are shown in Figure 6.8-1.

The development of an ASR facility requires use of water to sufficiently flush the formation and to create a bubble of injected water. This quantity of water used to flush the formation is lost, and varies from site to site. However, once the site of the projects identified in this option become fully operational, it is estimated that 90 to 95 percent of the injected water can be recovered.

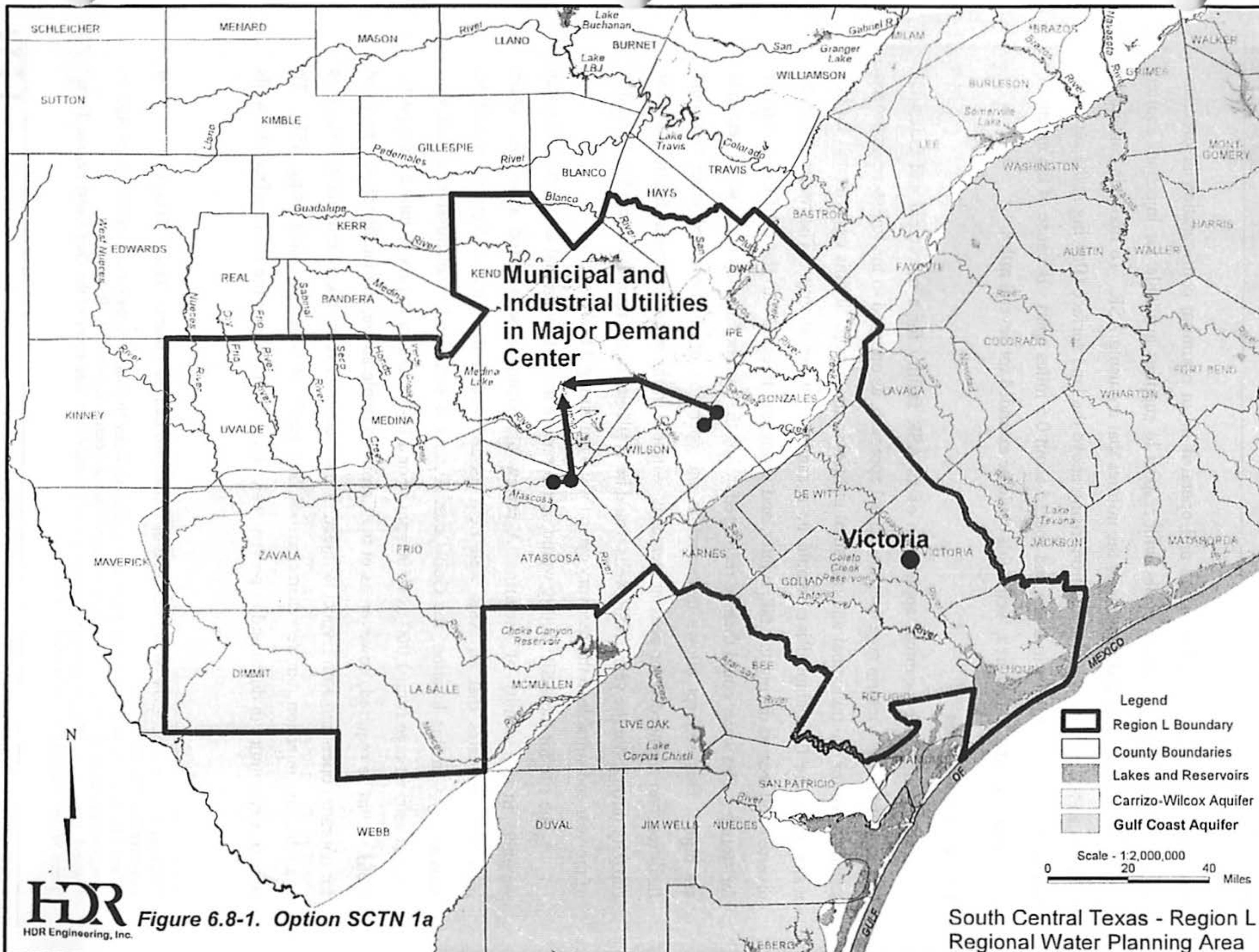
6.8.2.1 Municipal and Industrial Utilities in Region

The selected conceptual application of an ASR facility to serve the major municipal and industrial demand center is based upon the long-term ASR approach. In this case, excess supplies form the Edwards Aquifer and treated surface water, either from local watersheds or the Guadalupe River, would be candidate water supplies. The location for the potential ASR facility is a section of the Carrizo where all or most all the guidelines listed above can be met (Figure 6.8-1). The ASR well fields should parallel the outcrop of the Carrizo Formation and be located about 5 to 7 miles southeast of the downdip limit of the outcrop.[2,3,4] In these locations, the Carrizo Sands are sufficiently permeable and thick so that well capacities can range from 1,000 to 2,000 gpm. For a 10-MGD facility, five to eight high capacity wells would be required,

[2] Klemt, W.B., et al., "Ground-Water Resources of the Carrizo Aquifer in the Winter Garden Area of Texas," Texas Water Development Board (TWDB) Report 210, Vols. 1 and 2, 1976.

[3] HDR Engineering, Inc and LBG-Guyton Associates, "Interaction Between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," TWDB, 1998.

[4] Ryder, P.D. and Ardis, A.F., "Hydrology of the Texas Gulf Coast Aquifer System." U.S. Geological Survey Open-File Report 91-64, 1991.



HDR Engineering, Inc.

Figure 6.8-1. Option SCTN 1a

however, the facility should be sized and operated in an optimum configuration in order to balance injection and recovery cycles with respect to supplies available for injection, aquifer characteristics, and demand patterns of the utilities that are using ASR. To maintain continuity in depth and to prevent water levels from rising above the land surface (flowing at the surface), the wells would need to be in a line and spaced about 0.5 miles apart. Because of the extent of the Carrizo Aquifer in this area, well fields could be extended for several miles.

6.8.2.2 Victoria Area

The selected conceptual application of an ASR facility for a municipal and industrial water utility in the Victoria area uses the annual approach, as opposed to the long-term approach stated above for the municipal and industrial utilities in the region. In this case, treated surface water from the Guadalupe River would be a candidate water supply. The water could be diverted and treated during the fall, winter, and spring and injected into the Gulf Coast Aquifer for storage. The water could then be recovered during the summer months when water demands are high. This concept allows the selection and operation of smaller-sized water treatment facilities than are needed for peaking demands, with use of the water treatment facilities at near capacity throughout the year. ASR wells would be available for the injection cycle 8 to 9 months of the year and suitable to the recovery cycle for the remaining 3 to 4 months.

The site for the ASR facility would be the service area of municipal and industrial water suppliers in the vicinity of Victoria. A review of existing reports listed above and other reports[5,6,7] indicates that an ASR well field located within the City of Victoria would be satisfactory. In this location, the Gulf Coast Aquifer is sufficiently transmissive so that well capacities can range from 1,000 to 1,500 gpm. For a 10-MGD facility, six to nine high capacity wells would be required, however, as in the Carrizo example above, the facility should be sized for optimum operation with respect to injection and recovery cycles, taking into account supplies available for injection, aquifer characteristics, and needs of water suppliers using ASR. To maintain continuity in depth and to prevent water levels rising above the land surface, the wells

[5] Marvin, R.F., et al., "Ground-Water Resources of Victoria and Calhoun Counties, Texas," Texas Board of Water Engineers Bulletin 6202, 1962.
[6] Carr, J.E., et al., "Digital Models for Simulation of Ground-Water Hydrology of the Chicot and Evangeline Aquifers along the Gulf Coast of Texas," Texas Department of Water Resources Report 289, 1985.
[7] Wood, L.A., et al., "Reconnaissance Investigation of Ground-Water Resources of the Gulf Coast Region, Texas," Texas Water Commission Bulletin 6305, 1963.

would need to be distributed throughout the city and spaced about 0.5 mile apart. Locating the wells in the city of Victoria provides a means of controlling who can pump the stored water.

6.8.3 Environmental Issues

Option SCTN-1a involves the construction of well fields in the Carrizo-Wilcox and Gulf Coast Aquifers regions that would support municipal and industrial utilities in the major demand center, and utilities in the Victoria area, respectively. These regional scale facilities would store surplus groundwater or surface water in the aquifers and recover the water when demand exceeds ordinary supply. The facilities would have a capacity of 10 to 20 MGD.

Well fields in this option that use local stream or river systems as the water supply would result in reduced streamflows, which would be a potential environmental concern. Reduced streamflow could affect species endemic to the water systems, terrestrial species that rely on the river or stream as a water supply, and the riparian zone along the river's course.

Data from well fields in the ASR location area show a variety of trends in groundwater levels over the past 30 years. Pumping for water supply, amount of rainfall, and other factors affect aquifer levels. The effects of these new wells on groundwater levels would need to be considered when evaluating this option.

The injection of water into aquifers and the pumping of groundwater from aquifers where ASR is practiced would be expected to contributed to variations in aquifer levels, spring flow, and temporary pools in these areas. Some species inhabit or use temporary pools as well as aquifers and springs. Possible negative effects on these species need to be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places, respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.8.4 Engineering and Costing

Securing a water supply for the ASR option is beyond the scope of this option, which is to locate potential sites for ASR facilities and to calculate the costs of constructing and operating such facilities, in case water supplies can be obtained and delivered to the sites. The major facilities required for the ASR options described above are:

- Water Treatment Plant (if needed):
  - Conventional treatment of surface water (projected to be necessary).
  - Necessary treatment (if any of groundwater).
- Transmission System from water treatment plant or Edwards wells (for major demand center) to ASR wells and to a central storage facility for blending:
  - Pipeline(s).
  - Pump Station(s).
- ASR Well Field(s):
  - ASR wells.
  - Injection controls.
  - Monitoring wells.
  - Pumps and motors.

The approximate locations of the well fields, pipelines, and water treatment plants for the two areas are shown in Figure 6.8-1.

Estimates were prepared for capital costs, annual debt service, operation and maintenance, power, and land. The costs are based on operating the facilities in the injection cycle 9 months per year and the pumping cycle 3 months per year. These costs are summarized in Tables 6.8-1 and 6.8-2. As shown, the annual costs for a 10 MGD facility, including debt service for a 30-year loan at 6 percent interest and operation and maintenance costs, including power, are estimated to be $6,778,000 and $2,817,000 for the major municipal and industrial demand center and the Victoria area, respectively. The annual cost for storing and recovering the water is estimated at $2,428/acft, and $1,009/acft, respectively. It is reiterated, however, that these cost estimates do not include the cost of securing a water supply nor the transportation of water to the water treatment plant or the ASR facility. The ASR facility at Victoria is considerably less expensive per unit of capacity because of the shorter distance from the ASR wells to the distribution system than is the case for the major demand center. It is important to note, however, that neither the Carrizo nor the Gulf Coast cases presented are necessarily optimum in size nor injection/recovery cycles. Detailed optimization analyses will be required in order to consider ASR as a part of any water supply system.

Table 6.8-1
Cost Estimate Summary
Municipal and Industrial Users in
Major Demand Center in the Region (SCTN 1a)
(Second Quarter 1999 Prices)

Item	*Estimated Costs for Facilities*
Capital Costs	
ASR Wells (8 wells, 10 MGD total)	$4,248,000
Transmission Pump Stations (3)	3,987,000
Transmission Pipeline (24 in dia., 48.9 miles)	14,272,000
Water Treatment Plant (10 MGD)	10,303,000
Distribution Connections	12,880,000
Total Capital Cost	**$45,690,000**
Engineering, Legal Costs and Contingencies	$15,079,000
Environmental & Archaeology Studies and Mitigation	2,303,000
Land Acquisition and Surveying (278 acres)	3,167,000
Interest During Construction (2 years)	5,300,000
Total Project Cost	**$71,539,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$5,197,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	225,000
Water Treatment Plant	973,000
Pumping Energy Costs (6,391,324 kWh @ $0.06 per kWh)	383,000
Total Annual Cost	$6,778,000
Project Capacity (acft/yr) (for 3 months of operation)*	**2,792**
Annual Cost of ASR ($ per acft)	**$2,428**
Annual Cost of ASR ($ per 1,000 gallons)	**$7.45**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.8-2
Cost Estimate Summary
Municipal and Industrial Users
in Victoria Area (SCTN 1a)
(Second Quarter 1999 Prices)

Item	*Estimated Costs for Facilities*
Capital Costs	
ASR Wells (8 wells, 10 MGD total)	$4,432,000
Transmission Pipeline (24 in dia., 6 miles)	2,408,000
Water Treatment Plant (10 MGD)	10,303,000
Total Capital Cost	**$17,143,000**
Engineering, Legal Costs and Contingencies	$5,880,000
Environmental & Archaeology Studies and Mitigation	11,000
Land Acquisition and Surveying (8 acres)	15,000
Interest During Construction (2 years)	922,000
Total Project Cost	**$23,971,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$1,741,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	24,000
Water Treatment Plant	973,000
Pumping Energy Costs (1,321,333 kWh @ $0.06 per kWh)	79,000
Total Annual Cost	$2,817,000
Project Capacity (acft/yr)*	**2,792**
Annual Cost of ASR ($ per acft)	**$1,009**
Annual Cost of ASR ($ per 1,000 gallons)	**$3.10**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

6.8.5 Implementation Issues

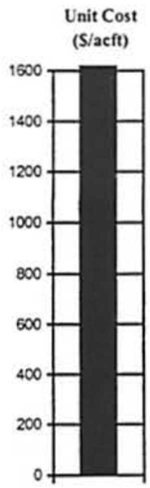
Implementation of the ASR concepts includes the following issues:

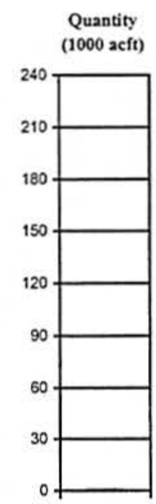
- Suitable supplies of water for injection;
- Rules and regulations of groundwater conservation districts where ASR facilities would be located;
- Water treatment prior to injection;
- Lack of experience to develop confidence in the ability to inject and recover water from an aquifer. This includes the uncertainty about the compatibility of the injected water with native groundwater and aquifer materials;
- Availability of access to local aquifers for an efficient application of ASR;
- Regulations by the TNRCC;
- Controlling the loss of injected water to neighboring groundwater users;
- Initial cost;
- Experience in operating the facilities; and/or
- Developing a management plan to efficiently use the ASR wells with balanced injection and recovery cycles.

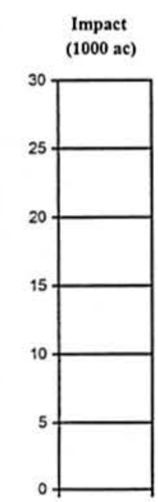
SOUTH CENTRAL TEXAS REGION WATER SUPPLY OPTIONS

OPTION DATA SHEET

January 2001







OPTION NUMBER: SCTN-1b
OPTION NAME: Aquifer Storage and Recovery (ASR) — Local Option

OPTION DESCRIPTION: *Option SCTN-1b evaluates local-scale municipal and industrial water supply facilities that would benefit by storing surplus groundwater or surface water in the Carrizo and Gulf Coast Aquifers and recovering the water when needed. A local-scale facility is considered to have a capacity of 0.5 to 1.0 million gallons per day. For this option, four facilities are evaluated. Two use the Carrizo-Wilcox Aquifer (Cities of Carrizo Springs and Luling) and the other two use the Gulf Coast Aquifer (Karnes City and City of Seadrift.*

TIME NEEDED TO IMPLEMENT: ☒ 1-5 yrs. ☐ 5-15 yrs. ☐ > 15 yrs.

COST, QUANTITY OF WATER, AND LAND IMPACTED

UNIT COST OF WATER (average):	$2,089	per acft[1]
QUANTITY OF WATER (each facility):	279	acft/yr [2]
LAND IMPACTED (average)	3	acres[3]

POSITION RELATIVE TO ALL OPTIONS

UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED

[1]**COST:** Water treatment, transmission system from water treatment plant to ASR wells and from wells to central storage for blending, and ASR wells. Costs of a water supply and a transmission system to get the raw water to the water treatment plant and not included.

[2]**QUANTITY OF WATER:** ASR facilities are sized at 1.0 million gallons per day and would operate in a pumping cycle for three months each year. The facilities do not produce additional water supplies, rather, they provide storage to better manage existing supplies and facilities.

[3]**LAND IMPACTED:** Land impacts would be for water treatment plant, well sites, and transmission facilities within urban areas. Waterlines are considered to be located on city easements and are not included.

ENVIRONMENTAL ISSUES: Considered to be minimal—well field sites and pipeline rights-of-way.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Securing a supply of water, water treatment, suitability of local aquifer conditions, control of water losses to other users of local groundwater, and balancing the operation of injection and recovery.

ADDITIONAL FACTORS: Lack of experience with ASR technology and in operating the facilities, permits from groundwater conservation districts, and TNRCC regulations.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: Cannot be determined until ASR water source is specified.

6.9 Aquifer Storage and Recovery (ASR) – Local Option (SCTN-1b)

6.9.1 Description of Option

For purposes of this evaluation, Aquifer Storage and Recovery (ASR) is defined as the use of dual-purpose well(s) to inject available water into an aquifer for storage, with recovery of the water using the well(s)' pumping systems. This management strategy would be useful to water suppliers that have quantities surplus to immediate needs but do not have storage for such quantities. In addition, ASR can be used to store treated water during off-peak seasons, thereby eliminating the need (part or all) for treatment plant capacity to meet peak day and peak season demands. In other words, ASR is a way to store water in aquifers during times when water is available and recovering the water when it is needed. If the water management issue is meeting high summer demands, water would be injected into the aquifer during the fall, winter, and spring and pumped during the summer. This strategy more fully utilizes the available capacities of the water treatment plant and, possibly, the availability of the supply. If the water management issue is a supply for emergencies or drought, water could be stored in the aquifer for several years before it is recovered. ASR wells would be designed to accommodate the injection of water as well as pumping water. However, the water utility operating plan must be designed to balance the injection and recovery cycles.

Option SCTN-1b evaluates local scale ASR facilities for municipal and industrial water supply management. A local scale facility is considered to have a capacity of 0.5 to 1.0 MGD (560 to 1,120 acft/yr), if operated continuously. For this option, four facilities are evaluated. Two of the facilities (Cities of Carrizo Springs and Luling) would use nearby sites located over the Carrizo-Wilcox Aquifer. The other two facilities (Karnes City and coastal area municipal and industrial water suppliers in Calhoun County) would use the Gulf Coast Aquifer. It is emphasized, however, that this is a strategy for use in management of existing or new water supplies and is not a water supply in and of itself.

The following report section provides a listing and description of characteristics of the important elements involved in determining the feasibility of adding ASR wells to a water supply system. These guidelines or considerations are intended for screening purposes only and not to be criteria for suitability.

6.9.1.1 Source Water

Quality of Source Water to be Injected: When injecting water into an aquifer that is being used for drinking water supplies, TNRCC regulations require that the injected water be at least as good in quality as the water already in the aquifer (native water). This generally means that the injected water has to meet Drinking Water Standards (e.g., for surface water sources, the water will most likely need to be treated).

Availability of Water: Water for recharge must be available in sufficient quantities, durations, and frequencies for development of viable ASR projects. Each project will have to be sized and designed to consider the hydrology of the source water and the storage characteristics of aquifers, as well as the recovery requirements. In addition, the water demand parameters and technical features of supply sources have to be incorporated into the optimization analyses.

Location of Facilities: ASR wells should be near the water treatment and distribution system in order to reduce the cost of constructing new pipelines and pumping the water to and from the ASR wells, however, each project must be evaluated on its own merits, including location and suitability of aquifer materials.

6.9.1.2 Aquifer System

Productivity of the Aquifer: The water yielding characteristics of an aquifer typically should allow the construction of wells producing 700 gpm (about 1 MGD) or more to improve the prospects of being able to make the project cost effective. Both the Carrizo and Gulf Coast Aquifers possess this characteristic. The lowest yield of an ASR well that is documented in the literature is about 200 gpm.

Aquifer Conditions: A confined water-bearing zone is preferable to a shallow water table aquifer.

Aquifer Thickness: The most suitable thickness of a target water-bearing zone is generally between 50 and 200 feet.

Depth to Water-Bearing Zone: The most suitable depths are from 200 to 500 feet. However, depth to water-bearing zones up to 2,500 feet may prove to be cost-effective.

Aquifer Material: A formation having a strong resistance to dissolution, such as sand, gravel, limestone, and sandstone is preferable. In any case, geochemical analyses are necessary to determine if any negative water quality issues are evident that could affect operation of an

ASR facility, such as cation exchange or mineral precipitation, which would result from a reaction with clay in the aquifer.

Water Quality: The most desirable aquifers have water quality that is at or near drinking water standards. However, successful ASR operations have been developed in aquifers with saline water in which the injection of freshwater would displace saline water and create a "freshwater" bubble. In fact, aquifers with saline water may be preferable because of few or no other users of the aquifer, but the well design must consider the fact that freshwater is lighter than saline water, since the freshwater would float to the top of water-bearing zones. Potential adverse geochemical processes such as precipitation, bacterial activity, ion exchange, and adsorption are possible and require a geochemical analysis to determine the expected reactions between the native water and injected water. On the positive side, ASR may improve water quality through reductions in disinfection byproducts, iron and manganese, and hydrogen sulfides.

Aquifer Water Levels and Wellhead Pressures: The desirable range in depth to water depends on the productivity of the aquifer. In aquifers with a high productivity, water levels can be near the land surface. For moderately transmissive water bearing zones, depth to water should be in the range of 100 to 300 feet below land surface. An existing cone of depression is desirable but not necessary. However, the formation of a water level mound that has a potentiometric surface that is above the land surface would increase springflows and cause uncapped wells to flow, which, in turn, would cause a waste of water and could damage existing facilities.[1] In any event, well design and operational requirements must consider expected wellhead pressures of the project.

Data Availability: Existing and reliable geophysical logs, geologic characteristics, water quality data, aquifer properties data, hydrogeologic reports, and groundwater models are very helpful.

Wells: Existing wells are often used, but many are unsuitable or would require modifications and more maintenance during operation. New wells, especially if constructed with PVC casing, are the most trouble free. Well screens should be stainless steel or PVC.

[1] The potentiometric surface is the level to which water of an artesian aquifer will rise if the confining layers are punctured. The Carrizo-Wilcox and the gulf Coast Aquifers are artesian (confined) in the proposed well fields.

Other Groundwater Users: Natural or regulatory restrictions are needed to prohibit unauthorized withdrawals of stored surface water.

Regulations: The TNRCC regulates artificial recharge of aquifers. Local groundwater conservation districts may regulate artificial recharge and groundwater withdrawals.

6.9.2 Available Capacity

For purposes of evaluating this option, local size water supply facilities are considered to be typical of communities with less than 2,500 connections. The cities selected for evaluation include Carrizo Springs and Luling in the Carrizo-Wilcox Aquifer and Karnes City and coastal water suppliers in Calhoun County in the Gulf Coast Aquifer. The locations are shown in Figure 6.9-1.

6.9.2.1 City of Carrizo Springs

The selected conceptual application of an ASR facility to serve Carrizo Springs combines the annual and long-term ASR approach. In this case, a long-term basis refers to the injection of water from a supply that is considered to be available on an intermittent basis over the long-term, but not on an annual basis or during selected seasons. Candidate sources are a local watershed or the Nueces River. The annual basis refers to the recovery cycle to meet summer peak demands. This scenario is based on injecting water over many months, and perhaps years, and withdrawing some of the water each summer, as needed. Considering the variability in the availability of surface water and the peak demands, it is estimated that four wells would be needed for the injection and recovery cycle.

In the vicinity of the City of Carrizo Springs, the Carrizo Aquifer meets most all the guidelines listed above. A review of existing reports[2,3,4] and the extent of other groundwater users in the area indicates that an ASR well field could be located on the eastern side of the city. In this location, the Carrizo Sands are sufficiently permeable and thick so that well capacities can

[2] Klemt, W.B., et al., "Ground-Water Resources of the Carrizo Aquifer in the Winter Garden Area of Texas," Texas Water Development Board (TWDB) Report 210, Vols. 1 and 2, 1976.

[3] HDR Engineering, Inc and LBG-Guyton Associates, "Interaction between Ground Water and Surface Water in the Carrizo-Wilcox Aquifer," TWDB, 1998

[4] Ryder, P.D. and Ardis, A.F., "Hydrology of the Texas Gulf Coast Aquifer System." U.S. Geological Survey Open-File Report 91-64, 1991.

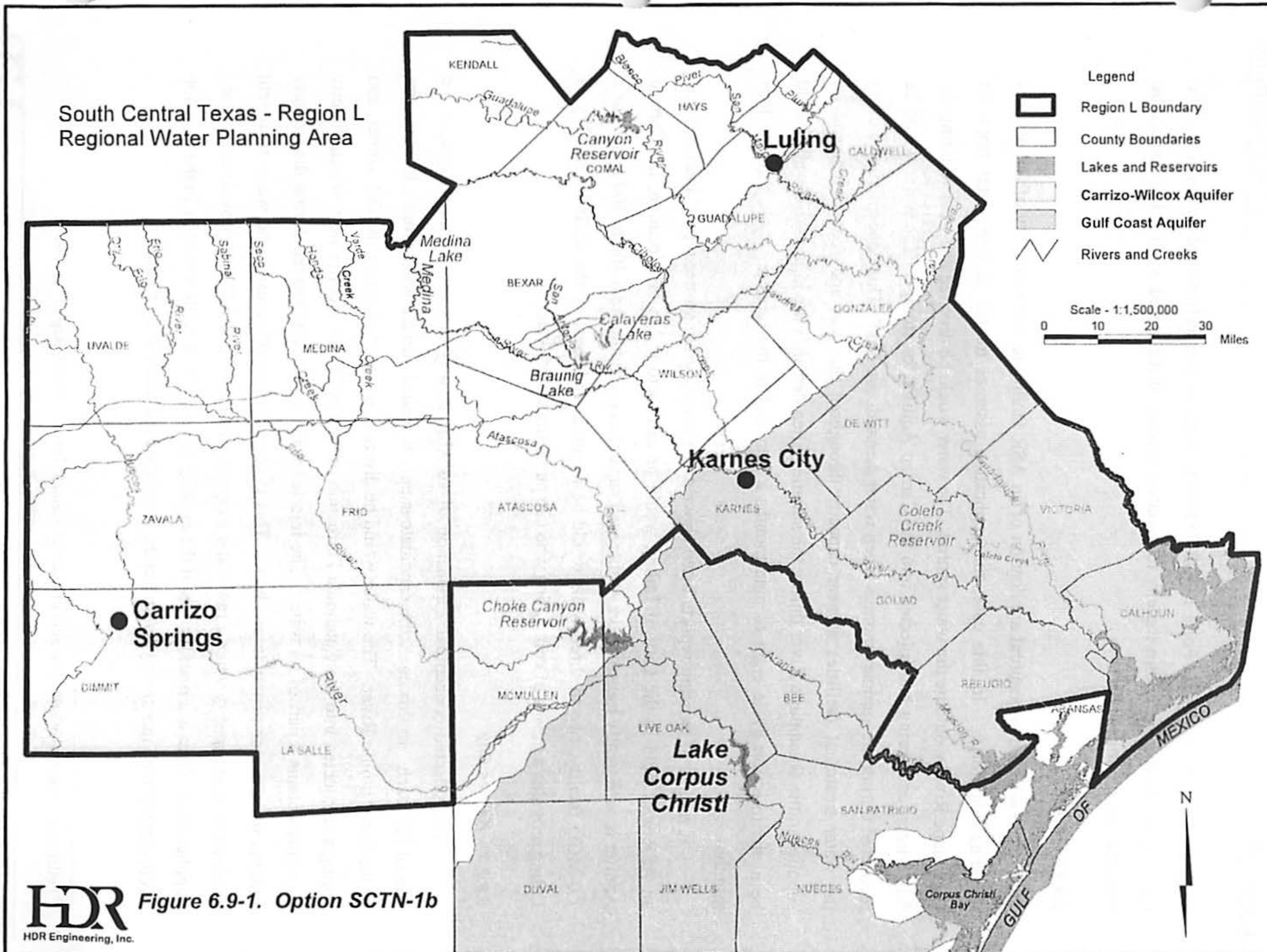


Figure 6.9-1. Option SCTN-1b

range from 200 to 300 gpm. For a 1.0-MGD facility, three to five wells would be required. The wells would be located within the city to maintain control of the stored water. They would be spaced about 0.5 miles apart.

6.9.2.2 City of Luling

The selected conceptual application of an ASR facility to serve the City of Luling uses the annual approach. In this case, the application assumes treated surface water from the Guadalupe River would be the water source. The water would be diverted and treated during the fall, winter, and spring and injected into the Carrizo Aquifer for storage. The water would be recovered during the summer months when water demands are high. This concept allows using the water treatment facilities at near capacity throughout the year and reduces demand on supplies in the Guadalupe River during the summer when demands are high. ASR wells would be in the injection cycle eight to nine months a year and in the recovery cycle three to four months.

A review of existing reports listed above and a county groundwater report[5] indicates that an ASR well field in the City of Luling would be satisfactory. In this location, the Carrizo Aquifer is sufficiently transmissive so that well capacities can range from 400 to 500 gpm. For a 1.0-MGD facility, two to three wells would be required, and locating the wells in the City of Luling provides a means of controlling who can pump the stored water.

6.9.2.3 Karnes City

The selected conceptual application of an ASR facility to serve Karnes City uses the annual approach. In this case, the candidate supply is treated surface water from a local stream or the San Antonio River. The water would be diverted and treated during the fall, winter, and spring and injected into the Catahoula Formation of the Gulf Coast Aquifer from which the city presently obtains a part of its water. The injected water could be recovered during the summer months when water demands are high. This concept would allow using the water treatment facilities at near capacity when a raw water supply is available. It would also provide emergency supplies when there is a malfunction of the existing system. ASR wells would be in the injection cycle eight to nine months a year and in the recovery cycle three to four months.

[5] Follett, C.R., "Ground-Water Resources of Caldwell County, Texas," TWDB, Report 12, 1966

In Karnes City, depth to the Catahoula Formation is about 100 feet; however, native water in the Catahoula Formation has total dissolved solids concentrations between 1,000 and 2,000 milligrams per liter. Water from the Carrizo Aquifer comes from a water-bearing zone over 3,000 feet deep and has total dissolved solids concentrations less than 1,000 milligrams per liter. However, the water temperature is over 150 degrees Fahrenheit. Thus, an ASR operation using the Catahoula Formation would be expected to improve the quality and increase the quantity of supply for Karnes City.

A review of existing reports listed above and other reports[6,7] indicates that an ASR well field in Karnes City would be satisfactory. In this location, the Catahoula Formation is sufficiently transmissive so that well capacities can range from 200 to 250 gpm. For a 1.0-MGD facility, three to four wells would be required, and locating the wells in Karnes City provides a means of controlling who can pump the stored water.

6.9.2.4 Coastal Area Water Suppliers of Calhoun County

The selected conceptual application of an ASR facility to serve the municipal and industrial suppliers of Calhoun County use the annual approach. In this case, groundwater from the Gulf Coast Aquifer in the northwestern part of Calhoun County about 12 miles from the Gulf Coast would be the water supply and would be pumped at a rather uniform rate throughout the year. During the fall, winter, and spring when water demands are low, the water in excess of demands would be injected into the Gulf Coast Aquifer for storage, which is slightly saline at about 10 miles inland. The water would be recovered during the summer months to meet water demands that exceed system capacity of the remote wells and pipeline. This concept allows using the remote wells and pipeline to operate at near capacity throughout the year and provides emergency supplies close to the demands. ASR wells would be in the injection cycle eight to nine months a year and in the recovery cycle 3 to 4 months.

[6] Wood, L. A., et al., "Reconnaissance Investigation of Ground-Water Resources of the Gulf Coast Region, Texas," Texas Water Commission Bulletin 6305, 1963.
[7] Anders, R.B., "Ground Water Geology of Karnes County, Texas," TWDB Bulletin 6007, 1960.

A review of existing reports listed above and other reports[8,9] indicates that an ASR well field in the vicinity of the City of Seadrift would be satisfactory.[10] In this location, the Gulf Coast Aquifer is sufficiently transmissive so that well capacities can range up to 500 gpm. For a 1.0-MGD facility, two to three wells would be required.

6.9.3 Environmental Issues

Option SCTN-1b involves the construction of well fields in the Carrizo-Wilcox and Gulf Coast Aquifers regions that would support local municipalities. These local scale facilities would store surplus groundwater or surface water in the aquifers and recover the water when demand exceeds ordinary supply. The facilities would have a capacity of 0.5 to 1 MGD.

In this option, the sources of water would probably be local stream or river systems and groundwater from aquifers. In the case of surface water sources, reduced streamflows would be a potential environmental concern. Reduced streamflow could affect species endemic to the water systems, terrestrial species that rely on the river or stream as a water supply, and the riparian zone along the river's course.

Data from well fields in the Carrizo Aquifer area show a variety of trends in groundwater levels over the past 30 years. The effects of ASR wells on groundwater levels would need to be considered when evaluating this option.

The injection of water into aquifers and the pumping of groundwater from aquifers where ASR is practiced would be expected to contribute to variations in aquifer levels, springflow, and temporary pools in these areas. Some species inhabit or use temporary pools as well as aquifers and springs. Possible negative effects on these species need to be considered when evaluating this option.

Habitat studies and surveys for protected species would need to be conducted at the proposed well field sites and along any pipeline routes. When potential protected species habitat or other significant resources cannot be avoided, additional studies would have to be conducted to evaluate habitat use or eligibility for inclusion in the National Register for Historic Places,

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8 Marvin, R.F., et al., "Ground-Water Resources of Victoria and Calhoun Counties, Texas," Texas Board of Water Engineers Bulletin 6202, 1962.

9 Carr, J.E., et al., "Digital Models for Simulation of Ground-Water Hydrology of the Chicot and Evangeline Aquifers Along the Gulf Coast of Texas," Texas Department of Water Resources Report 289, 1985.

10 It is important to note that the City of Seadrift has recently installed a reverse-osmosis desalination plant to meet its needs. Thus, it may become advantageous to use desalted water as a source of water for ASR.

respectively. Wetland impacts, primarily pipeline stream crossings, can be minimized by right-of-way selection and appropriate construction methods, including erosion controls and revegetation procedures. Compensation for net losses of wetlands would be required where impacts are unavoidable.

6.9.4 Engineering and Costing

Securing a water supply for the aquifer storage and recovery option and transporting the water to the ASR facility is beyond the scope of this evaluation, which is to locate potential sites for ASR facilities and to calculate the costs of constructing and operating such facilities in case they are needed. The major facilities required for the ASR options described above are:

- Water Treatment Plant (if needed):
  - Conventional treatment of surface water (projected to be necessary).
  - Necessary treatment (if any for groundwater).
- Freshwater Supply Wells (Calhoun County).
- Transmission System to the ASR wells and to a central storage facility for blending:
  - Pipeline(s).
  - Pump Station(s).
- ASR Well Field(s):
  - ASR wells.
  - Injection controls.
  - Monitoring wells.
  - Pumps and motors.

The approximate locations of the ASR facilities for the four sites are shown in Figure 6.9-1.

Estimates were prepared for capital costs, annual debt service, operation and maintenance, water purchases, power, and land. These costs are summarized in Tables 6.9-1, 6.9-2, 6.9-3, and 6.9-4 for the cities of Carrizo Springs, Luling, Karnes City, and Calhoun County, respectively. As shown, the annual costs for a 1.0 MGD size facility, including debt service for a 30-year loan at 6 percent interest and operation and maintenance costs, including power, are estimated to be $763,000, $703,000, $756,000 and $111,000, respectively. The annual costs for the respective ASR facilities are estimated at $2,734/acft, $2,519/acft, $2,708/acft, and $396/acft, respectively. The costs are based on operating the facilities in the

Table 6.9-1.
Cost Estimate Summary
SCTN-1b: City of Carrizo Springs
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
ASR Wells (4 wells, 1 MGD total)	$1,044,000
Transmission Pipeline (12-inch dia., 4 miles)	950,000
Water Treatment Plant (1 MGD)	2,654,000
Total Capital Cost	**$4,648,000**
Engineering, Legal Costs and Contingencies	$1,453,000
Environmental & Archaeology Studies and Mitigation	31,000
Land Acquisition and Surveying (3 acres)	43,000
Interest During Construction (2 years)	466,000
Total Project Cost	**$6,806,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$495,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	10,000
Water Treatment Plant	249,000
Pumping Energy Costs (152,613 kWh @ $0.06 per kWh)	9,000
Total Annual Cost	**$763,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$2,734**
Annual Cost of ASR ($ per 1,000 gallons)	**$8.39**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.9-2.
Cost Estimate Summary
SCTN-1b: City of Luling
(Second Quarter 1999 Prices)

Item	*Estimated Costs for Facilities*
Capital Costs	
ASR Wells (3 wells, 1 MGD total)	$783,000
Transmission Pipeline (12-inch dia., 3 miles)	713,000
Water Treatment Plant (1 MGD)	2,654,000
Total Capital Cost	**$4,150,000**
Engineering, Legal Costs and Contingencies	$1,417,000
Environmental & Archaeology Studies and Mitigation	17,000
Land Acquisition and Surveying (3 acres)	23,000
Interest During Construction (2 years)	449,000
Total Project Cost	**$6,056,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$440,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	7,000
Water Treatment Plant	249,000
Pumping Energy Costs (111,768 kWh @ $0.06 per kWh)	7,000
Total Annual Cost	**$703,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$2,519**
Annual Cost of ASR ($ per 1,000 gallons)	**$7.73**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.9-3.
Cost Estimate Summary
SCTN-1b: Karnes City
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
ASR Wells (4 wells, 1 MGD total)	$1,044,000
Transmission Pipeline (12-inch dia., 4 miles)	950,000
Water Treatment Plant (1 MGD)	2,654,000
Total Capital Cost	**$4,648,000**
Engineering, Legal Costs and Contingencies	$1,579,000
Environmental & Archaeology Studies and Mitigation	3,000
Land Acquisition and Surveying (3 acres)	4,000
Interest During Construction (2 years)	499,000
Total Project Cost	**$6,733,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$489,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	10,000
Water Treatment Plant	249,000
Pumping Energy Costs (132,333 kWh @ $0.06 per kWh)	8,000
Total Annual Cost	**$756,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$2,708**
Annual Cost of ASR ($ per 1,000 gallons)	**$8.31**

* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

Table 6.9-4.
Cost Estimate Summary
SCTN-1b: Calhoun County near City of Seadrift
(Second Quarter 1999 Prices)

Item	Estimated Costs for Facilities
Capital Costs	
ASR Wells (2 wells, 1 MGD total)	$470,000
Transmission Pipeline (12-inch dia., 2 miles)	475,000
Total Capital Cost	**$945,000**
Engineering, Legal Costs and Contingencies	$307,000
Environmental & Archaeology Studies and Mitigation	1,000
Land Acquisition and Surveying (1 acre)	2,000
Interest During Construction (2 years)	101,000
Total Project Cost	**$1,356,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$99,000
Operation and Maintenance:	
Intake, Pipeline, Pump Station	5,000
Pumping Energy Costs (111,768 kWh @ $0.06 per kWh)	7,000
Total Annual Cost	**$111,000**
Project Capacity (acft/yr)*	**279**
Annual Cost of ASR ($ per acft)	**$396**
Annual Cost of ASR ($ per 1,000 gallons)	**$1.21**

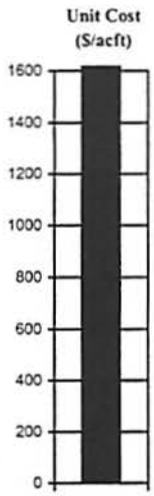
* Project capacity if operated on a pumping cycle of 3 months per year, however, does not include costs of a source(s) of ASR water. This is not necessarily an optimum size nor injection/recovery cycle. Detailed optimization analyses will be required in order to size and schedule ASR facilities for an individual water supply system.

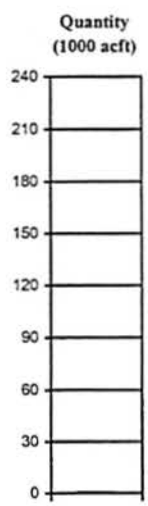
pumping cycle 3 months each year. It is reiterated that these cost estimates do not include the cost of securing a water supply nor the transportation of water to the ASR facility. The estimated cost of the ASR facility at the Calhoun County site is considerably less because no water treatment would be required.

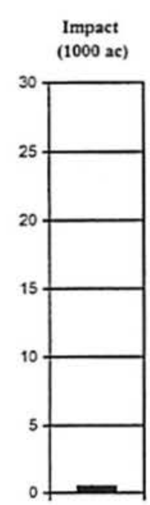
6.9.5 *Implementation Issues*

Implementation of the ASR concepts includes the following issues:

- Suitable supplies of water for injection;
- Rules and regulations of groundwater conservation districts where ASR facilities would be located;
- Water treatment prior to injection;
- Lack of experience to develop confidence in the ability to inject and recover water from an aquifer. This includes the uncertainty about the compatibility of the injected water with native groundwater and aquifer materials;
- Availability of access to local aquifers for an efficient application of ASR;
- Regulations by the TNRCC;
- Controlling the loss of injected water to neighboring groundwater users;
- Initial cost;
- Experience in operating the facilities; and/or
- Developing a management plan to efficiently use the ASR wells with balanced injection and recovery cycles.







OPTION NUMBER: SCTN-8
OPTION NAME: Trinity Aquifer Optimization

OPTION DESCRIPTION: *Recharge to the Trinity Aquifer in Kendall County would be enhanced through the operation of a system of one or more recharge reservoirs on tributaries of the Guadalupe River. Enhanced recharge could be available for local domestic needs or for transmission to a municipality. Representative costs include enhanced recharge to the Trinity Aquifer from a single recharge structure. Multiple structures could be constructed to maximize recharge at approximately the same unit cost.*

TIME NEEDED TO IMPLEMENT: ☐ 1-5 yr. ☒ 5-15 yr. ☐ > 15 yr.

COST, QUANTITY OF WATER, AND LAND IMPACTED			
UNIT COST OF WATER:	$1,886	per acft[1]	Raw Water in Aquifer
QUANTITY OF WATER:	390	acft/yr[2]	(Program of Five Structures)
LAND IMPACTED:	460	acres[3]	(Program of Five Structures)

POSITION RELATIVE TO ALL OPTIONS		
UNIT COST OF WATER:	of	(1=lowest unit)
QUANTITY OF WATER:	of	(1=highest volume)
LAND IMPACTED:	of	(1=least acreage)

<u>FACTORS AFFECTING COST, QUANTITY, AND LAND IMPACTED</u>

[1]**COST:** Representative cost for recharge dam and reservoir, including mitigation.

[2]**QUANTITY OF WATER:** Upstream and downstream water rights, size and number of recharge reservoirs.

[3]**LAND IMPACTED:** Reservoir sites.

ENVIRONMENTAL ISSUES: Inundation of about 92 acres (per site) of Guadalupe River tributary channel. Archaeological and cultural resource surveys should be conducted. The Guadalupe River in Kendall County is recommended for designation as an Ecologically Unique River Segment by TPWD.

SIGNIFICANT ISSUES AFFECTING FEASIBILITY: Cost of water high, primarily due to expected low infiltration rates and associated evaporation. Recharge rates could be much greater in areas where the aquifer formation is highly fractured. However, the likelihood of rapid losses to proximate springs is also greater in these areas.

ADDITIONAL FACTORS: Ability to obtain permits to use surface water from the Guadalupe River Basin.

OTHER WATER SUPPLY OPTIONS DIRECTLY AFFECTED: G-19, G-30, SCTN-2c, and/or SCTN-10.

6.10 Trinity Aquifer Optimization (SCTN-8)

6.10.1 Description of Option

Recharge to the Trinity Aquifer within the South Central Texas Region occurs primarily where the Lower Member of the Glen Rose Limestone outcrops in portions of Hays, Comal, Bexar, Kendall, Medina, and Uvalde Counties. The majority of Kendall County lies within this outcrop area, as indicated in Figure 6.10-1. Water recharged to the aquifer generally travels to the south and southeast.[1] The aquifer can be described as a generally "tight" formation, referring to a relatively low permeability. This low permeability limits the quantity of water that may be pumped by individual wells, and conversely, the quantity of water that can be recharged to the aquifer. Reported permeabilities range from 0.0012 to 0.108 feet per day for cores taken at depth, to 0.1 to 0.4 feet per day at the surface. This is extremely low in contrast to reported permeabilities of other aquifer formations investigated for water supply potential within the South Central Texas Region. For example, the Carrizo Aquifer has reported permeabilties ranging from 1.2 to 4 feet per day.

This option evaluates the potential for enhancing recharge of the Trinity Aquifer in Kendall County with available (unappropriated) water from tributaries of the Guadalupe River. With this option, available flows from these tributaries would be impounded in small- to medium-sized recharge reservoirs, and allowed to percolate into the underlying aquifer formation. Water recharged in this fashion would then be available for pumpage by wells in the surrounding area. However, due to the low permeability and other characteristics of the formation, water recharged in this fashion would likely be available for pumpage only in the immediate geographic vicinity of the recharge project.

Water recharged by implementation of this option would be available for local domestic needs, or for transmission to a nearby municipality. Only costs for enhanced recharge of the Trinity Aquifer are considered in this analysis.

[1] Texas Department of Water Resources, "Report 273: Ground-Water Availability of the Lower Cretaceous Formations in the Hill Country of South-Central Texas," January 1983.

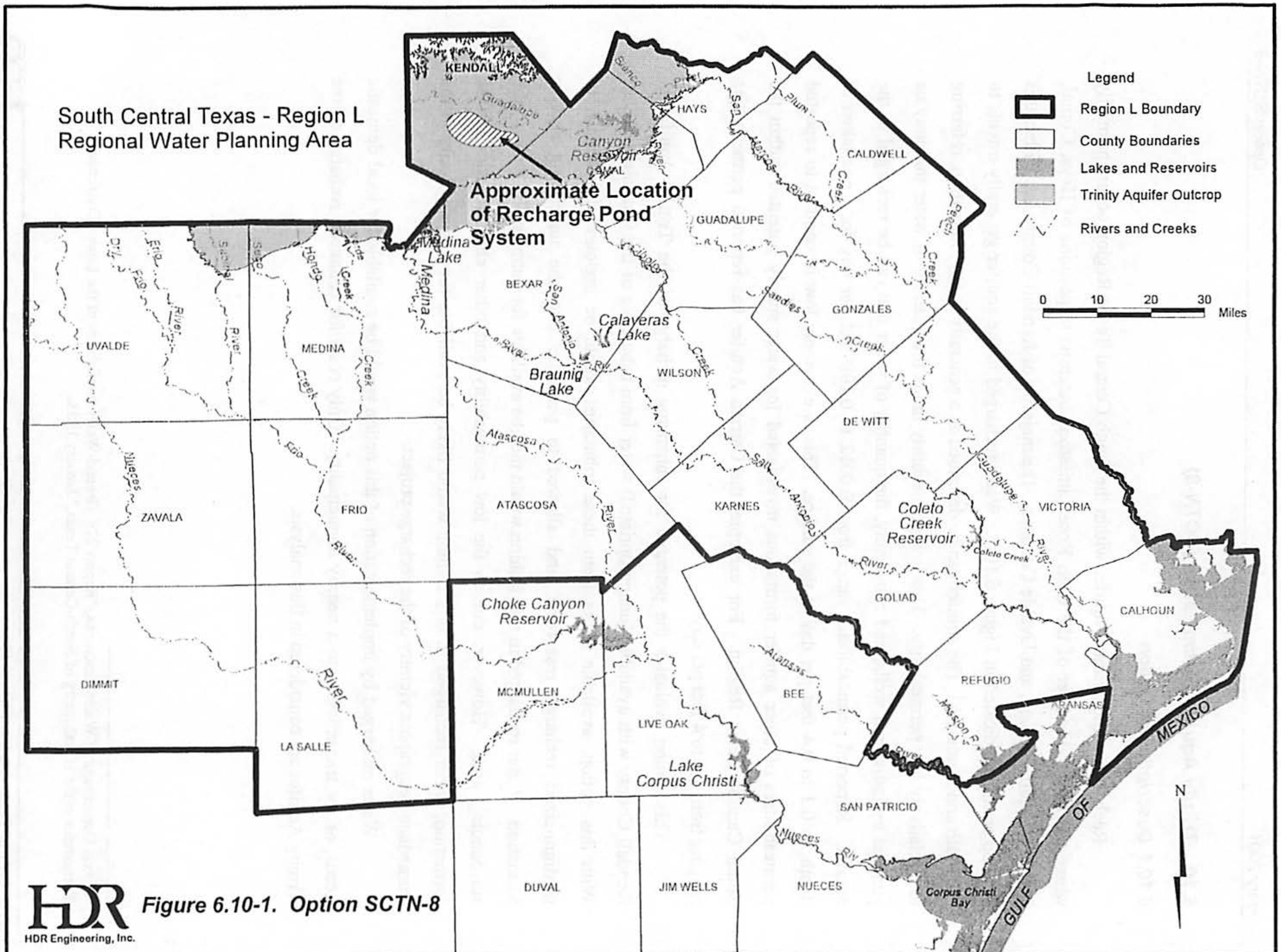


Figure 6.10-1. Option SCTN-8

6.10.2 Water Availability

Water available for recharge enhancement from tributaries of the Guadalupe River in Kendall County is limited by upstream and downstream water rights. Water would be available sporadically, during periods of high flow when existing water rights (including priority hydropower) are fully satisfied, and Canyon Reservoir is full. The availability of water for recharge enhancement was computed utilizing the Environmental Water Needs Criteria of the Consensus Planning Process (Consensus Criteria, Appendix B). Monthly regulated streamflow and unappropriated streamflow available from the Guadalupe River Basin were estimated using the Guadalupe-San Antonio River Basin Water Availability Model (GSA WAM),[2] developed for TNRCC under the SB1 Water Availability Modeling Project. The current version of the GSA WAM includes the 1934 to 1989 historical period. Input data files for the GSA WAM were modified so as to match the general assumptions adopted by the South Central Texas Regional Water Planning Group and summarized in the Introduction.

Water availability was estimated for one representative site in central Kendall County. The drainage area of this site (15 square miles) is representative of other sites in this area at which small-to-medium-sized recharge reservoirs could be constructed. Figure 6.10-1 shows a general outline of the vicinity within which one or more of these structures might be constructed. Daily streamflow available for diversion at a representative site was estimated by distributing the monthly regulated and unappropriated streamflows computed by the GSA WAM to daily values using nearby gaged streamflow records.

A computer program was developed to simulate daily impoundment of available streamflow and subsequent recharge of the water to the Trinity Aquifer. Data inputs to the program include the monthly regulated and available streamflows estimated using the GSA WAM, monthly evaporation rates, daily gaged flows used to distribute the monthly flows to daily values, the Consensus Criteria pass-through requirements, the storage capacity of the reservoir, and the infiltration (recharge) rate estimated for the site. As gaged flows for this small watershed are not available, the streamflow statistics used to determine the monthly Consensus Criteria pass-through requirements were prorated by drainage area from those for the Guadalupe River near Comfort (USGS #08167000). Monthly unappropriated flows for the representative

[2] HDR, "Water Availability in the Guadalupe-San Antonio River Basin-Draft Report," Texas Natural Resource Conservation Commission, September 1999.

Criteria pass-through requirements were prorated by drainage area from those for the Guadalupe River near Comfort (USGS #08167000). Monthly unappropriated flows for the representative site are shown in Figure 6.10-2. As is apparent in the figure, available flows occur relatively infrequently. Note that additional water could be made available for impoundment (at additional cost) through negotiation of an hydropower subordination agreement with downstream water rights owners.

An infiltration rate of 0.01 feet per day was assumed. This rate is within the range reported by the Texas Department of Water Resources[4] for cores obtained from test wells, but is lower than permeability test data presented in a soil survey of Kendall County.[5] The lower rate would control recharge into the formation, and was adopted for this analysis. Recharge rates could be much greater in areas where the aquifer formation is highly fractured. However, the likelihood of rapid losses to proximate springs is also greater in these areas. A recharge reservoir capacity of 500 acft was assumed, based upon the area of land that might be controlled by the facility (15 square miles). Based upon a generalized area-capacity relationship for small reservoirs developed by Texas A&M University,[6] the land area within the recharge pool for this size reservoir would be approximately 92 acres. Estimated annual recharge over the 1934 through 1989 simulation period is shown in Figure 6.10-3. For the representative site, the long-term average (mean) annual recharge enhancement to the Trinity Aquifer is about 78 acft. Due to the relatively low rate of infiltration, such a reservoir would evaporate an average of 55 acft per year, a volume equal to 71 percent of the recharge enhancement.

Figure 6.10-4 illustrates simulated storage fluctuations in the representative recharge reservoir. The reservoir would be more than 50 percent full approximately 16 percent of the time, as most inflows must be passed to satisfy downstream senior water rights and instream flow requirements of the Consensus Criteria, only high flows would be affected by the reservoir, and no significant change in median and low streamflows would occur.

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3 Ibid.

4 Texas Department of Water Resources, Op. Cit., January 1983.

5 U.S. Department of Agriculture, "Soil Survey of Kendall County, Texas," March 1981.

6 Texas Water Resources Institute, "Hydrologic and Institutional Water Availability in the Brazos River Basin, TR-144," Texas A&M University, August 1988.

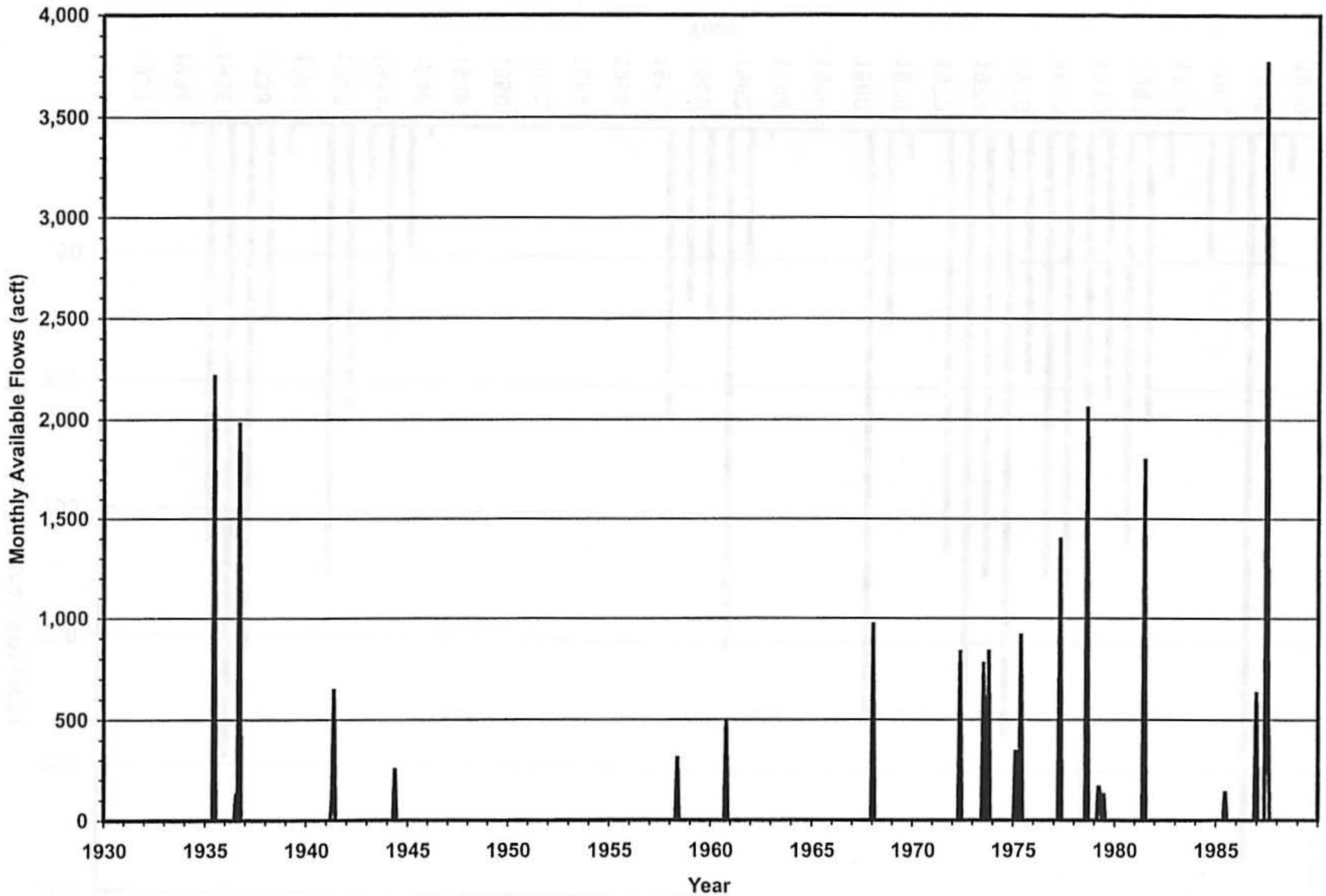


Figure 6.10-2. Monthly Available Flows for a Representative 15 Square Mile Watershed in Kendall County

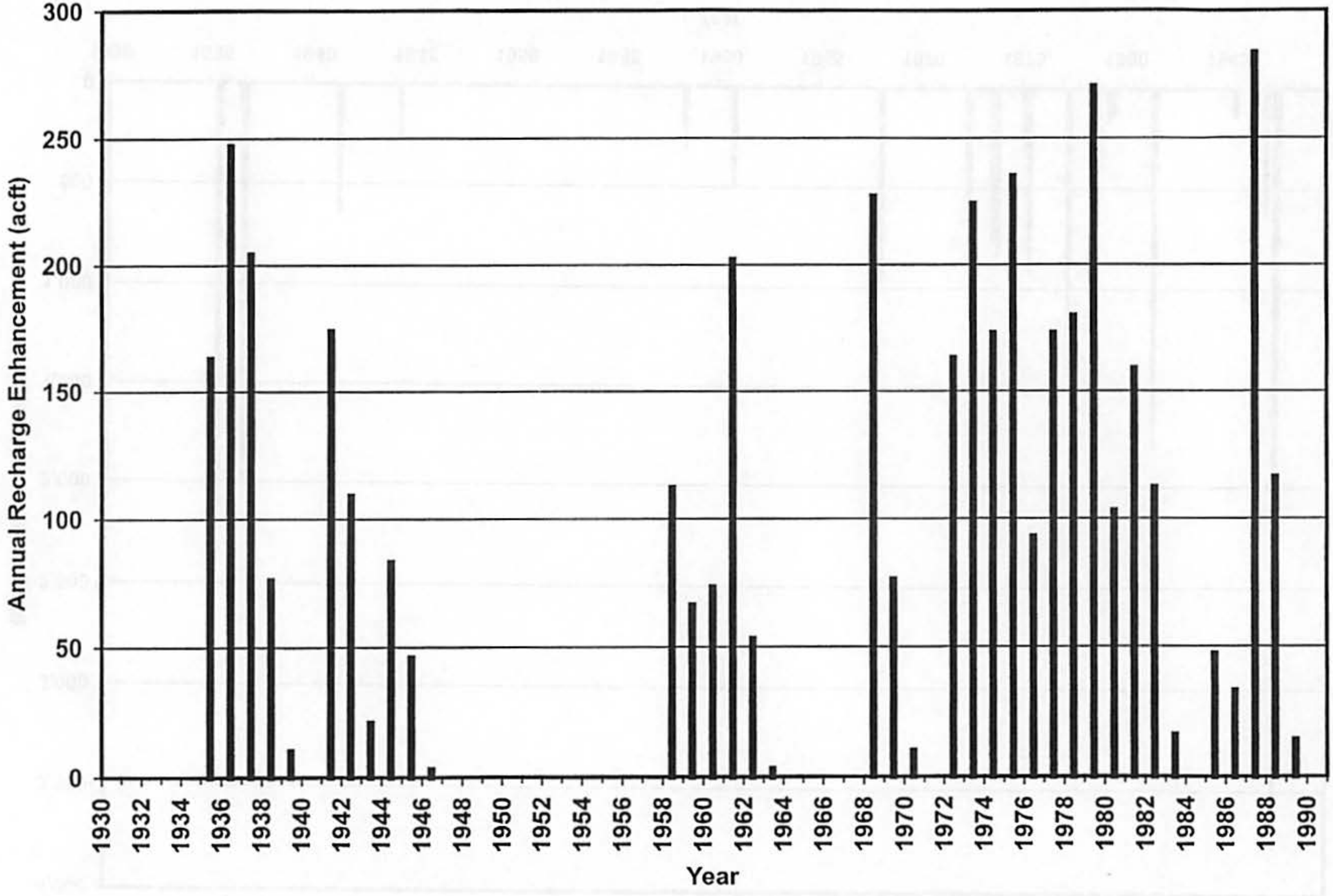
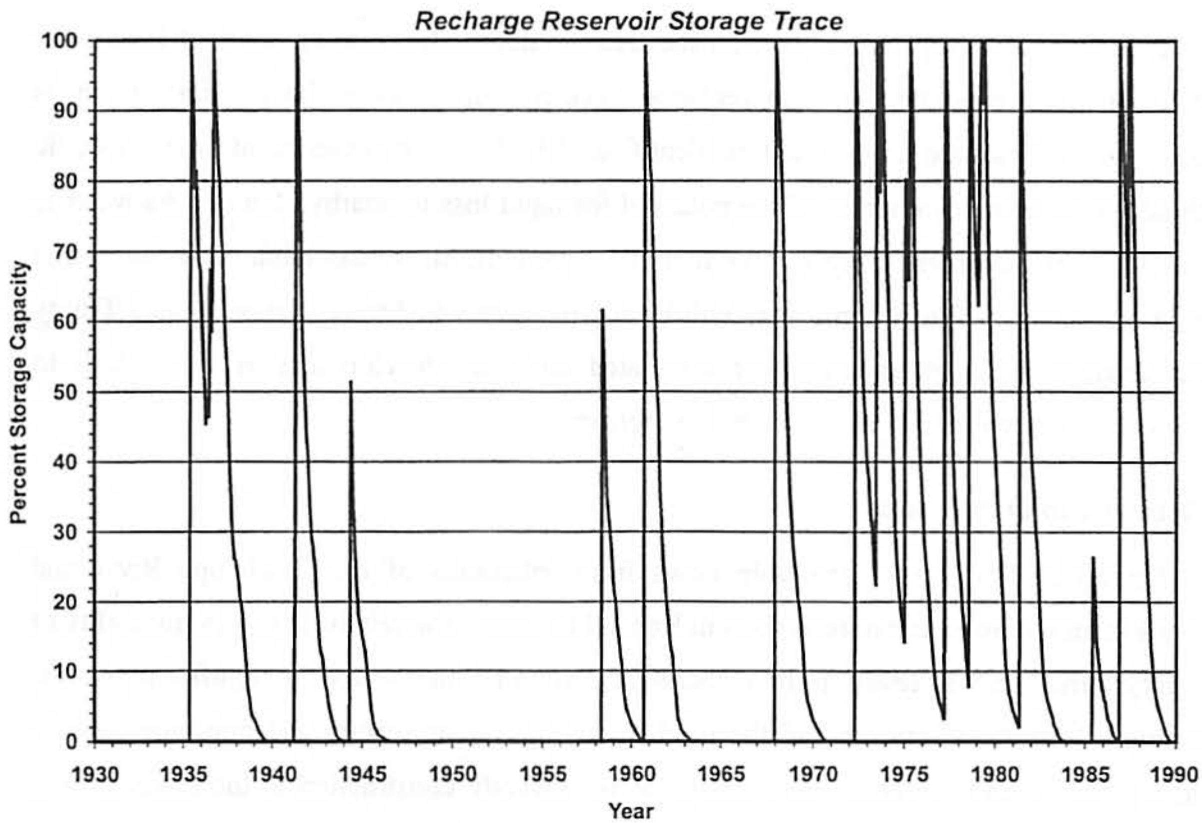


Figure 6.10-3. Trinity Aquifer Recharge Enhancement by a Representative Recharge Reservoir



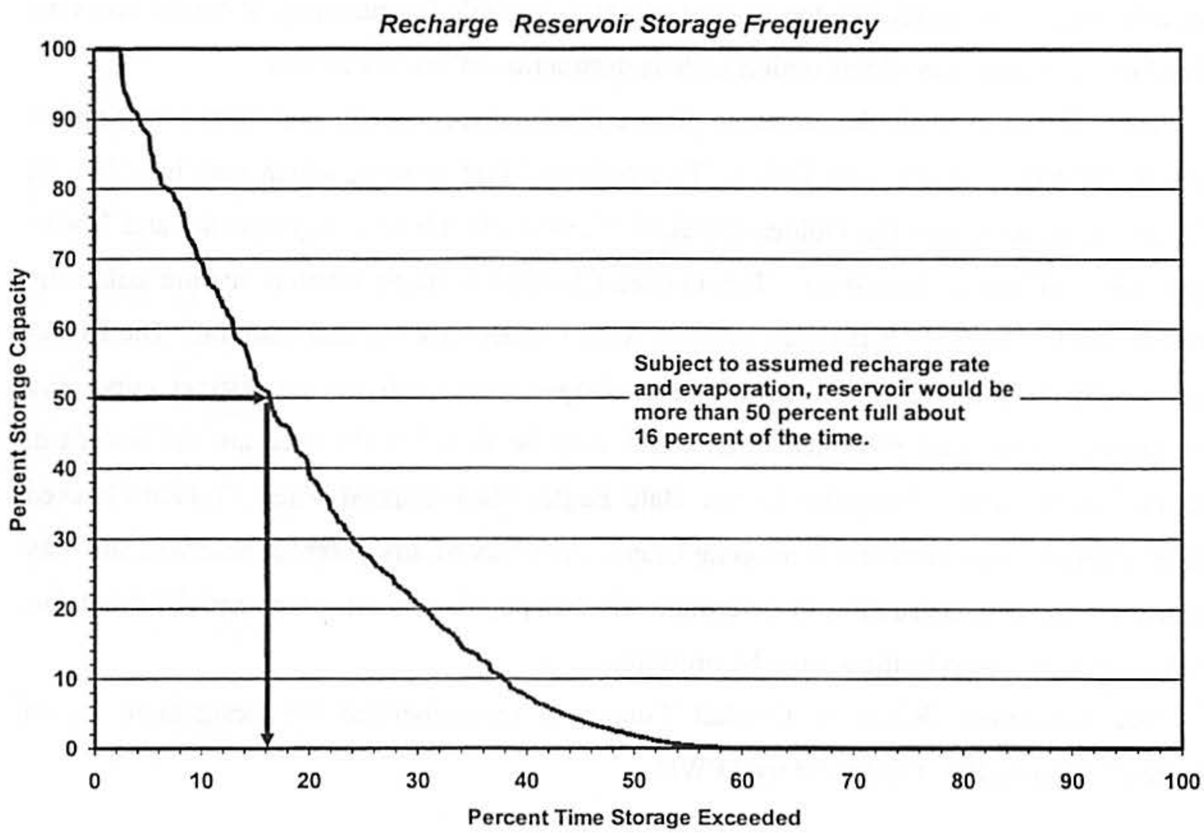


Figure 6.10-4. Recharge Reservoir Storage Considerations

Review of topographic mapping for the area of interest shown in Figure 6.10-1 indicates that five (or more) candidate sites for recharge enhancement reservoirs having drainage areas averaging about 15 square miles could be identified. The feasibility assessment of any specific site should include the evaluation of the potential for rapid loss to nearby springs. As water is available for impoundment only during high flow periods, it is reasonable to assume that recharge enhancement for multiple sites will be approximately additive. Hence, annual Trinity Aquifer average recharge enhancement associated with the development of five small- to medium-sized reservoirs is estimated to be 390 acft/yr.

6.10.3 Environmental Issues.

Option SCTN-8 takes available flows from tributaries of the Guadalupe River and impounds them within recharge reservoirs in Kendall County. The relatively low permeability of the Trinity formation will result in the recharge reservoirs holding water for significant periods. Evaporation from the reservoirs and the need to control vector species and nuisance growths should be considered in overall management plans. Overall, construction of the reservoir will enhance the aquifer by increasing the amount of water available for pumping. Potential concerns involved with construction of this option include destruction of species habitat.

Table 6.10-1 presents the protected plant and animal species which are listed for Kendall County by TPWD, USFWS, and TOES. Two protected bird species, which may have habitat within the study area, are the Golden-Cheeked Warbler (*Dendroica chrysoparia*) and Black-Capped Vireo (*Vireo atricapillus*). The Golden-Cheeked Warbler inhabits mature oak-Ashe juniper woods for nesting. It requires strips of Ashe juniper bark for nest material. The Black-Capped Vireo nests in dense underbrush in semi-open woodlands having distinct upper and lower stories. Additional protected birds which may be found in the area are the American Peregrine Falcon, Arctic Peregrine Falcon, Bald Eagle, Black-Capped Vireo, Golden-Cheeked Warbler, Interior Least Tern and Whooping Crane. A survey of any potential reservoir site may be required prior to construction to determine whether populations of, or potential habitat for, species of concern occur in the area to be impacted.

The Guadalupe River in Kendall County is recommended for designation as an Ecologically Unique River Segment by TPWD.

Table 6.10-1.
Important Species* Having Habitat or Known to Occur in Counties Potentially Affected by Option Trinity Aquifer Optimization (SCTN-8)

Common Name	Scientific Name	Summary of Habitat Preference	Listing Entity			Potential Occurrence in County
			USFWS[1]	TPWD[1]	TOES[2,3]	
American Peregrine Falcon	*Falco peregrinus anatum*	Open country; cliffs		E	E	Nesting/Migrant
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Open country; cliffs		T	T	Nesting/Migrant
Bald Eagle	*Haliaeetus leucocephalus*	Large bodies of water with nearby resting sites	T	T	E	Nesting/Migrant
Basin Bellflower	*Campanula reverchonii*	Dry gravels and shallow sandy soils; open slopes			WL	Resident
Big Red Sage	*Salvia penstemonoides*	Endemic; Creekbeds and seepage slopes of limestone canyons			WL	Resident
Black Bear	*Ursus americanus*	Mountains, broken country, woods, brushlands, forests		T	T	Resident
Black-Capped Vireo	*Vireo atricapillus*	Semi-open broad-leaved shrublands	E	E	T	Nesting/Migrant
Blanco River Springs Salamander	*Eurycea pterophila*	Subaquatic; Springs and caves of the Blanco River				Resident
Cagle's Map Turtle	*Graptemys caglei*	Waters of the Guadalupe River Basin	C			Resident
Canyon Mock-Orange	*Philadelphus ernestii*	Edwards Plateau			WL	Resident
Cascade Caverns Salamander	*Eurycea latitans*	Endemic; Subaquatic; Springs and caves		T	T	Resident
Cave Myotis Bat	*Myotis velifer*	Colonial & cave dwelling; hibernates in limestone caves of Edwards Plateau				Resident
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; Semi-troglobitic; Springs and waters of caves		T	T	Resident
Edge Falls Anemone	*Anemone edwardsiana var petraea*	Woodlands in mesic canyons			WL	Resident
Edwards Plateau Spring Salamander	*Eurycea sp. 7*	Troglobitic; Edwards Plateau				Resident
Golden-Cheeked Warbler	*Dendroica chrysoparia*	Woodlands with oaks and old juniper	E	E	E	Nesting/Migrant
Guadalupe Bass	*Micropterus treculi*	Streams of eastern Edwards Plateau			WL	Resident
Hill Country Wild-Mercury	*Argythamnia aphoroides*	Shallow to moderately deep clays; live oak woodlands			WL	Resident
Headwater Catfish	*Ictalurus lupus*	Clear streams			WL	Resident
Interior Least Tern	*Sterna antillarum athalassos*	Bays, large rivers	E	E	E	Nesting/Migrant
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Oak-juniper woodlands and mesquite-prickly pear				Resident
Texas Horned Lizard	*Phrynosoma cornutum*	Varied, sparsely vegetated uplands		T	T	Resident
Texas Mock-Orange	*Philadelphus texensis*	Endemic; Limestone cliffs and boulders in mesic stream bottoms and canyons			WL	Resident
Whooping Crane	*Grus americana*	Potential migrant	E	E	E	Migrant

[1] Texas Parks and Wildlife Department. Unpublished 1999. September 1999, Data and map files of the Texas Biological and Conservation Data System maintained by TPWD Wildlife Diversity Branch, Resource Protection Division, Austin, Texas.
[2] Texas Organization for Endangered Species (TOES). 1995. Endangered, threatened, and watch list of Texas vertebrates. TOES Publication 10. Austin, Texas. 22 pp.
[3] Texas Organization for Endangered Species (TOES). 1993. Endangered, threatened, and watch list of Texas plants. TOES Publication 9. Austin, Texas. 32 pp.
[4] Texas Organization for Endangered Species (TOES). 1988. Invertebrates of Special Concern. TOES Publication 7. Austin, Texas. 17 pp.
[5] Correll, Donovan S. and Marshall Johnston. 1979. Manual of the Vascular Plants of Texas. University of Texas at Dallas. Austin, Texas. pp 1201.

* E = Endangered T = Threatened C = Candidate Category, Substantial Information E/PT = Proposed Endangered or Threatened
Blank = Rare, but no regulatory listing status WL = Conservation Watch List

6.10.4 Engineering and Costing

Construction costs for a representative 500-acft capacity recharge dam were estimated from detailed cost estimates for similarly sized recharge enhancement projects.[7, 8] Operation and maintenance costs were developed in accordance with the cost estimation procedure presented in Appendix A. Land was assumed to be purchased for the recharge reservoir pool. The cost estimate shown in Table 6.10-3 is for a single 500 acft capacity recharge enhancement reservoir.

Financing a single recharge enhancement reservoir under the Senate Bill 1 assumptions (40 years at 6 percent annual interest) results in an annual expense of $131,000. Annual operation and maintenance costs total $16,000. The annual cost, including debt service and operation and maintenance, totals $147,000. For an average annual recharge enhancement of 78 acft per site, the resulting annual cost of water recharged to the Trinity Aquifer from tributaries of the Guadalupe River in Kendall County is $1,886 per acft per reservoir site (Table 6.10-2).

With the development of a program of five reservoirs, average annual recharge of the Trinity Aquifer in Kendall County could be enhanced by about 390 acft at an estimated annual cost of $1,886/acft.

6.10.5 Implementation Issues

Implementation of this option for one or more sites could directly affect the feasibiltiy of other water supply options under consideration, including G-19, G-30, SCTN-ZC, and/or SCTN-10.

1. It will be necessary to obtain these permits:
   a. TNRCC Water Right and Storage permits.
   b. USCE Sections 10 and 404 dredge and fill permits for the reservoir and pipelines.
   c. GLO Sand and Gravel Removal permits.
   d. TPWD Sand, Gravel, and Marl permit.

[7] HDR, et al., "Nueces River Basin Edwards Aquifer Recharge Enhancement project, Phase IV A," Edwards Underground Water District, June 1994.
[8] HDR, et al., "Trans-Texas Water Program, West Central Study area, Edwards Aquifer Recharge Analyses," San Antonio River Authority, et al., march 1998.

Table 6.10-2.
Cost Estimate Summary for a Representative Recharge Enhancement Reservoir
Trinity Aquifer Optimization (SCTN-8)
Second Quarter 1999 Prices

Item	*Estimated Costs for Facilities*
Capital Costs	
Dam and Reservoir (500 acft, 92 acres)	$1,054,000
Total Capital Cost	**$1,054,000**
Engineering, Legal Costs and Contingencies	$369,000
Land Acquisition and Surveying (92 acres)	147,000
Interest During Construction (4 years)	272,000
Environmental & Archaeology Studies, Mitigation and Permitting	133,000
Total Project Cost	**$1,975,000**
Annual Costs	
Reservoir Debt Service (6 percent, 40 years)	$131,000
Operation and Maintenance	16,000
Total Annual Cost	**$147,000**
Available Annual Recharge Enhancement (acft)	**78**
Annual Cost of Water ($ per acft) Raw Water in Aquifer[1]	**$1,886**
Annual Cost of Water ($ per 1,000 gallons) Raw Water in Aquifer[1]	**$5.79**

[1] Reported Annual Cost of Water is for additional water supply in the Trinity Aquifer.

2. Permitting, at a minimum, will require these studies:
   a. Assessment of effects on instream flows.
   b. Habitat mitigation plan.
   c. Environmental studies.
   d. Cultural resources.
3. Land or easements will need to be acquired through either negotiations or condemnation.
4. Recovery of the enhanced recharge would need to be coordinated and permitted through local groundwater conservation districts.

Appendix A

Cost Estimating Procedures South Central Texas Region

Appendix A
Cost Estimating Procedures
South Central Texas Region

The cost estimates of this study are expressed in three major categories: (1) construction costs or capital (structural) costs, (2) other (non-structural) project costs, and (3) annual costs. Construction costs are the direct costs incurred in constructing facilities, such as those for materials, labor, and equipment. "Other" project costs include expenses not directly associated with construction activities of the project, such as costs for engineering, legal counsel, land acquisition, contingencies, environmental studies and mitigation, and interest during construction. Capital costs and other project costs comprise the total project cost. Operation and maintenance (O&M), energy costs, and debt service payments are examples of annual costs. Major components that may be part of a preliminary cost estimate are listed in Table A-1. Cost estimating procedures employed in the technical evaluation of water supply options for the South Central Texas Region are summarized in the following sections.

Table A-1.
Major Project Cost Categories

Capital Costs (Structural Costs)	*Other Project Costs (Non-Structural Costs)*
1. Pump Stations	1. Engineering (Design, Bidding and Construction Phase Services, Geotechnical, Legal, Financing, and Contingencies)
2. Pipelines	2. Land and Easements
3. Water Treatment Plants	3. Environmental - Studies and Mitigation
4. Water Storage Tanks	4. Interest During Construction
5. Off-Channel Reservoirs	
6. Well Fields	
a. Injection	
b. Recovery	*Annual Project Costs*
c. ASR Wells	
7. Dams and Reservoirs	1. Debt Service
8. Relocations	2. Operation and Maintenance (excluding pumping energy)
9. Water Distribution	3. Pumping Energy Costs
10. Other Items	4. Purchase Water Cost (if applicable)

A.1 Capital Costs

Capital costs for elements of each water supply option are estimated from reliable cost information. Cost tables are the most useful reference for estimating the costs for a project element quickly and efficiently. The cost tables report all-inclusive costs to construct. For example, the pump station cost table values include the building, pumps, control equipment, all other materials, labor, and installation costs. Cost tables that have been created for planning cost estimates are discussed and presented throughout this section. The costs for a project element are typically computed by applying a unit cost from the cost tables to a specific unit quantity. Estimates are reported to the nearest thousand dollars. If previous cost estimates are used, a ratio of the Engineering News Record's Construction Cost Index (ENR CCI)1 values is applied to update the cost to Second Quarter 1999. For example, based on an average of the monthly index values for the second quarter of 1999 (6008, 6006, 6039) the representative Second Quarter 1999 index value would be 6018. The ENR CCI values are based upon construction costs, including labor and materials, averaged over 20 cities. The index measures how much it would cost to purchase a hypothetical package of goods and services compared to what it was in a base year. The index values are reported monthly from 1977 to present. Average annual index values are reported from 1908 to 1976.

A.1.1 Pump Stations

Anticipated intake and transmission pump station costs vary according to the discharge and pumping head requirements, and structural requirements for housing the equipment and providing proper flow conditions at the pump suction intake. The cost tables provided herein are based on the station size, or horsepower, necessary to deliver the peak flow rate. Pump station costs are listed as millions of dollars in Table A-2 for a range of horsepower requirements. The costs include those for pumps, housing, motors, electric control, site work, and all materials needed. The costs in Table A-2 were estimated using generalized cost data related to station horsepower from actual construction costs of equipment installed. The cost for an intake structure is included when pumping from a raw water source, such as a river or reservoir. Based on costs of actual projects, the intake structure cost is estimated as 45 percent of the intake pump

[1] ENR: Engineering News Record, Vol. 242, No. 25, June 1999, McGraw-Hill, http:\\www.enr.com\cost\costcci.asp.

Table A-2.
Pump Station Costs[1]
(With and Without Intake Structures)[2]

Pump Station (HP)	Pump Station Cost (dollars)	Pump Station (HP)	Pump Station Cost (dollars)
—	—	7,000	5,470,000
< 400	550,000	8,000	5,760,000
400	650,000	9,000	6,040,000
1,000	1,350,000	10,000	6,300,000
2,000	2,450,000	15,000	7,280,000
3,000	3,380,000	30,000	9,230,000
4,000	4,080,000	60,000	12,010,000
5,000	4,610,000	80,000	13,050,000
6,000	5,040,000	100,000	13,980,000

[1] Values are current as of Second Quarter 1999.
[2] Intake structure costs are estimated as an additional 45 percent to be added to the pump station cost shown.

station cost. The cost of bringing power to each pump station is estimated as $125/hp, with a minimum cost of $50,000. Power connection costs are calculated for each pump station and for well pumps. Costs for pump stations located at water treatment plants are accounted for in the capital cost table for water treatment plants (Table A-5).

A.1.2 Pipeline

Pipeline construction costs are influenced by pipe materials, bedding requirements, geologic conditions, urbanization, terrain, and special crossings. For technical evaluation of water supply options, pipeline costs are obtained from Table A-3, which shows unit costs based on the pipe diameters from 12-inches to 120-inches, soil type, and level of urban development. In the case of a high-pressure pipeline (>150 psi), the unit cost is increased by 13 percent for the length of pipe designated as high-pressure class pipe. The unit costs listed in Table A-3 represent the installed cost of the pipeline and appurtenances, such as markers, valves, thrust restraint systems, corrosion monitoring and control equipment, air and vacuum valves, blow-off valves, erosion control, revegetation of right-of-way, fencing, and gates.

Table A-3.
Pipeline Unit Cost for Various Soil Environments[1]

	Soil		Combination Rock and Soil		Rock	
Pipe Diameter (inches)	Rural ($/foot)	Urban ($/foot)	Rural ($/foot)	Urban ($/foot)	Rural ($/foot)	Urban ($/foot)
12	28	45	35	54	42	63
14	31	51	40	61	48	71
16	35	57	45	69	53	79
18	39	63	50	75	59	86
20	41	67	53	81	62	92
24	46	76	59	91	70	104
27	53	87	67	103	80	118
30	60	97	75	114	90	133
33	70	113	87	134	104	155
36	80	128	100	153	118	177
42	96	155	119	185	144	214
48	111	180	138	216	167	250
54	128	210	160	250	193	290
60	147	240	184	286	221	331
64	165	269	206	320	248	371
66	182	297	229	355	275	411
72	218	354	272	422	326	490
78	239	387	293	462	358	536
84	257	415	320	495	384	574
90	270	438	337	522	405	606
96	317	516	398	616	478	704
102	365	594	457	708	547	821
108	412	670	516	799	619	928
114	462	751	577	896	693	1,039
120	520	846	651	1,008	781	1,170

[1] Values as of Second Quarter 1999. Add 13 percent to unit price for length of pipe with pressure class >150 psi.

Table A-4.
Crossing Costs for
Tunneling and Pipe Jacking[1]

Pipe Diameter (inches)	*Tunneling Cost ($/inch diameter/ft)*
48	23
54	22
60	21
66	20
72	19
78	18
84	17

[1] Values current as of 2nd Quarter 1999.

Additional costs are included for pipeline installation when crossing roads, streams, or rivers. Some form of trenchless technology will likely be used to install the pipeline when obstructions (e.g., larger streams, major roads, railways, rivers, and structures) are encountered. The two trenchless technologies included herein are: (1) pipe jacking utilizing boring and/or tunnel techniques to excavate the soil, and (2) horizontal directional drilling. Table A-4 shows costs that are used to estimate pipeline borings.

A.1.3 Water Treatment Plants

Water treatment plant costs shown in Table A-5 are based on plant capacity for four different types or levels of treatment. It is not the intent of these cost estimating procedures to establish an exact treatment process, but rather to estimate the cost of a general process appropriate for bringing the source water quality to the required standard of the receiving system (i.e., potable water distribution system, a stream in an aquifer recharge zone, or an aquifer injection well). The process options presented include treatment of groundwater, simple filtration, conventional surface water treatment, and reclaimed wastewater treatment. Table A-6 gives a description of the processes involved in each treatment level. The costs in Table A-5 include costs for all processes required, site work, buildings, storage tanks, sludge handling and disposal, clearwell, pumps, and equipment. The costs assume pumping through and out of the

Table A-5.
Water Treatment Plant Costs[1]

Capacity (MGD)	Level 1[2]	Level 2[3]	Level 3[4]	Level 4[5]
	Capital Cost (dollars)	Capital Cost (dollars)	Capital Cost (dollars)	Capital Cost (dollars)
1	558,000	3,399,000	2,654,000	5,970,000
10	2,322,000	7,600,000	10,303,000	23,218,000
50	6,744,000	19,209,000	34,849,000	71,867,000
75	9,730,000	24,738,000	50,000,000	99,508,000
100	11,921,000	29,381,000	60,607,000	132,677,000
150	18,243,000	38,005,000	90,909,000	199,015,000
200	21,007,000	42,428,000	112,121,000	265,354,000

1 Values current as of 2nd Quarter 1999.
2 Level 1: Aquifer Treatment.
3 Level 2: Direct Filtration.
4 Level 3: Conventional.
5 Level 4: Reclaimed Wastewater.

plant as follows: Levels 2, 3, & 4 treatment plants include raw water pumping into the plant for a total pumping head of 100 feet, and finished water pumping for 300 feet of total head. Level 1 treatment includes only finished water pumping at 300 feet of head. O&M costs are included in the non-structural costs discussed in Section 3.

A.1.4 Storage Tanks

Ground storage tanks may be used for stand-alone storage, as part of a distribution system, or as part of a pumping station. The costs for storage tanks are listed in Table A-7 as cost per million gallons of capacity. A storage tank should be included at each transmission pump station along a pipeline. It is assumed that storage tanks at these stations will provide storage for 5 percent of the daily flow.

A.1.5 Off-Channel Reservoirs

An off-channel reservoir is a reservoir located away from a main river channel that receives little or no natural inflow. Off-channel reservoirs are built by placing a dam across a minor tributary or by constructing a ring dike that has no associated tributary. The capacity of

Table A-6.
Water Treatment Level Descriptions

Level 1:	Groundwater Treatment – This treatment process is used to disinfect and, if necessary, to lower the iron and manganese content of groundwater. The process includes application of chlorine dioxide for taste and odor control and addition of phosphate to sequester iron and manganese. Disinfection by chlorine is applied as the final treatment. With this treatment, the water is suitable for public water system distribution, aquifer injection, and/or delivery to an aquifer recharge zone.
Level 2:	Direct Filtration Treatment – This process is used for treating waters from sources with anticipated low turbidity and low color where turbidity and taste and odors levels are low. In the direct filtration process, low doses of alum and polymer are used and settling basins are not required, as filters remove all suspended solids. The process includes alum and polymer addition, rapid mix, flocculation, gravity filtration, and disinfection. Level 2 treatment costs were also used to estimate costs for iron and manganese removal from groundwater at levels in excess of 0.3 mg/L for iron and 0.05 mg/L for manganese. Water treated with either of these processes is suitable for aquifer injection or for delivery to an aquifer recharge zone, and for groundwater sources, is suitable for public water system distribution.
Level 3:	Conventional Treatment – This process is used for treating all surface water sources to be delivered to a potable water distribution system. The process includes alum and polymer addition, rapid mix, flocculation, settling, filtration, and disinfection with chlorine. In options where the source contains a large proportion of reclaimed water, this level may be modified to include GAC and pre-ozone treatment. This treatment produces water that is suitable for public water system distribution.
Level 4:	Reclaimed Water Treatment – This process is used for treatment where wastewater effluent is to be reclaimed and delivered to a supply system or injected to an aquifer. The concept includes renovation of wastewater plant effluent by phosphorous removal, storage in a reservoir, blending with surface runoff from the reservoir catchment, followed by conventional water treatment. Phosphorous is removed from the effluent by lime softening including lime feed, rapid mix, flocculation, settling, recarbonation, and gravity filtration. The final conventional treatment will include ozonation, activated carbon, addition of alum and polymer, rapid mix, flocculation, sedimentation, second application of ozone, filtration, and disinfection with chlorine. This treatment results in water that can be delivered to a public water system for distribution or injection to an aquifer.

these reservoirs is typically used for storing water that is pumped from another location, such as a nearby river. Because natural inflow is an insignificant factor, spillway requirements are minimal. The values in Table A-8 are referenced for a cost estimate for an off-channel reservoir. In this study, the cost of ring dikes is used for all off-channel reservoirs.

Table A-7. Ground Storage Tank Costs[1]

Tank Volume (MG)	Cost (dollars)
0.01	86,400
0.05	146,400
0.10	209,300
0.50	393,600
1.00	·679,100
2.00	1,129,300
4.00	1,768,600
6.00	2,408,000
7.50	2,926,600
9.00	3,299,200

[1] Values current to Second Quarter 1999.

Table A-8. Off Channel Storage Costs[1]

Storage Volume (acft)	Ring Dike Capital Cost (dollars)[1]	Storage Volume (acft)	Ring Dike Capital Cost (dollars)[1]
500	1,390,000	15,000	12,111,000
1,000	2,781,000	17,500	12,869,000
2,500	5,203,000	19,000	13,323,000
4,000	6,782,000	20,000	13,626,000
5,000	7,709,000	22,000	14,233,000
10,000	10,440,000	25,000	15,142,000
12,500	11,353,000	—	—

[1] Values from Dr. N. Johns, Pierce Ranch ring dike storage reservoir study, current to June 1999 prices (ENR CCI June 1999 = 6039), also used as costs for dams on tributaries.

A.1.6 Well Fields

The costs for public water supply wells are summarized in Table A-9. These reconnaissance level values were estimated by the Wellspec Company and LBG-Guyton Associates, Inc. The costs include well completion, pumps, and other necessary facilities, such as access roads, fending, and site improvements. The cost for irrigation wells is assumed to be 55 percent of the well cost for public water supply wells. Aquifer storage and recover (ASR) well costs are estimated using the values represented in Table A-10.

A.1.7 Dams and Reservoirs

Construction costs for these projects were handled individually. Since each reservoir site is unique, costs were based on the specific project requirements. Items included in the estimate consist of the capital (structural) and "other" (non-structural) costs listed in Table A-1. Most dams and reservoirs under consideration in the South Central Texas Region have been studied in the past and previous cost estimates were updated to Second Quarter 1999 prices, using the ENR CCI.

A.1.8 Relocations

Large-scale projects, such as reservoirs, may require the use of lands that contain existing improvements or facilities such as utilities, roads, homes, businesses, and cemeteries. The cost estimating procedures include an accounting for either the cost of relocation or outright purchase of these types of improvements and facilities. Because the type of improvements and facilities that would need to be relocated vary significantly from project to project, estimating the costs for relocation items is addressed on an individual project basis.

A.1.9 Water Distribution System Improvements

The introduction of treated water to a city or other entity may require improvements to the entity's water distribution system, which is comprised of piping, valves, storage tanks, pump stations, and other equipment used to distribute water throughout the entity's service area.

Table A-9.
Public Supply Well Costs

Well Depth (feet)	Well Capacity (gpm)				
	200	400	700	1,000	1,500
Static Water Levels Less Than 200 Feet Below Land Surface					
150	$156,000	$157,000	—	—	—
300	$190,000	$191,000	$209,000	—	—
500	$214,000	$217,000	$238,000	$337,000	—
700	$233,000	$235,000	$257,000	$359,000	$383,000
1,000	$270,000	$274,000	$296,000	$391,000	$415,000
1,500	$328,000	$331,000	$348,000	$446,000	$470,000
Static Water Levels Between 200 and 400 Feet Below Land Surface					
300	$194,000	—	—	—	—
500	$215,000	$ 221,000	$ 250,000	—	—
700	$233,000	$ 237,000	$ 269,000	$ 376,000	$ 398,000
1,000	$277,000	$ 278,000	$ 312,000	$ 395,000	$ 417,000
1,500	$320,000	$ 323,000	$ 352,000	$ 453,000	$ 475,000
Static Water Levels Between 400 and 600 Feet Below Land Surface					
500	$221,000	—	—	—	—
700	$238,000	$238,000	$272,000	$384,000	$400,000
1,000	$277,000	$296,000	$306,000	$394,000	—
1,500	$324,000	$342,000	$376,000	$455,000	$475,000
Static Water Levels Between 600 and 800 Feet Below Land Surface					
1,000	$283,000	$334,000	$347,000	$426,000	—
1,500	$328,000	$362,000	$382,000	$468,000	—

Table A-10.
ASR Well Costs
(Static Water Levels = 200 Feet Below Land Surface)

Well Depth (Feet)	ASR Well Capacity (gpm)			
	400	700	1,000	1,500
300	$235,000	$268,000	—	—
500	$261,000	$292,000	$389,000	—
700	$288,000	$323,000	$420,000	$508,000
1,000	$323,000	$349,000	$446,000	$531,000
1,500	$380,000	$434,000	$526,000	$554,000

Previous cost estimate guidelines were developed specifically for distribution system improvements for the City of San Antonio during the Trans-Texas Water Program. These costs were obtained from a 1991 report to the City Water Board by Black and Veatch entitled "Report on Master Plan for Water Works Improvements" and include estimated costs for improvements to San Antonio's distribution system to convey treated water from the proposed Applewhite project. Using Applewhite Phase 1 capacity of 50 MGD and water distribution cost of $51,750,000 (1991 costs) results in a mid-1991 cost of $1,035,000 per MGD for the first 50-MGD increment. For alternatives producing up to 50-MGD the annual costs were estimated at $1,288,000 per MGD of capacity (Second Quarter 1999). Above 50-MGD capacity, the unit cost is $758,000 per MGD (Second Quarter 1999). (Note: The cost of distribution system improvements is assumed applicable to taking the same quantity of water from the demand center to the nearby aquifer recharge locations.)

A.1.10 Stilling Basins

If an option involves discharging into a water body or perhaps into a recharge structure, it may require the use of a stilling basin. Stilling basin costs, when applicable, were estimated as $2,764 per cfs discharge.

A.2 Other Project Costs

As previously mentioned, "other" (non-structural) project costs are costs incurred in a project that are not directly associated with construction activities. These include costs for engineering, legal counsel, financing, contingencies, land, easements, surveying and legal fees for land acquisition, environmental and archaeology studies, permitting, mitigation, and interest during construction. These costs are added to the capital costs to obtain the total project cost. The major components of these costs are described below.

A.2.1 Engineering, Legal, Financing, and Contingencies

A percentage applied to the capital costs is used to calculate a combined cost that includes engineering, financial, legal services, and contingencies. The contingency allowance accounts for unforeseen costs and for variances in design elements. In accordance with TWDB guidelines, the percentages used are 30 percent of the total construction costs for pipelines and 35 percent for all other facilities.

A.2.2 Land Acquisition and Easements

Land related costs for a project can typically be divided into two categories: (1) land purchase costs and (2) easement costs. Land areas acquired for various facility types are considered based upon previous project experience. Two types of easements are usually acquired for pipeline construction – temporary and permanent. Permanent easements are those in which the pipeline will reside once constructed. These permanent easements provide access for maintenance and protection from other parallel underground utilities. Temporary easements provide extra working space during construction for equipment movement, material storage, and related construction activities. Pipeline easement costs are estimated using a value of $8,712 per acre ($0.20 per ft^2), based in large part on recent experience with the Mary Rhodes Pipeline extending from Lake Texana to Corpus Christi. The pipeline area considered in the acquisition cost includes a permanent easement width of 30 to 50 feet, depending upon the pipe size. This value includes costs for the temporary easement.

Land costs vary significantly with location and economic factors. Land costs in Texas are estimated using Rural Land Values in the Southwest, by Charles E. Gilliland, published biannually by the Real Estate Center at Texas A&M University, College Station, Texas. Other sources of land values, such as county appraisal district records, are also utilized. The land acquisition area estimated for reservoirs includes the acreage inundated by the 100-year or standard project flood.

A.2.3 Surveying and Legal Fees

Ten percent (10 percent) is added to the total land and easement costs to account for surveying and legal fees associated with land acquisition, except for reservoirs and large well fields. The surveying cost for reservoirs is estimated at $50 per acre of inundation, and for large well fields is computed at $50 per acre purchased.

A.2.4 Environmental and Archaeology Studies, Permitting, and Mitigation

Costs for environmental studies, permitting, and mitigation, as well as archaeological recovery, are project-dependent and were estimated on an individual basis using information available and the judgement of qualified professionals. In the case of reservoir options, environmental studies and mitigation costs were generally based on 100 percent of the land value for the acreage purchased. The environmental studies and mitigation costs for pipelines were estimated at $25,000 per mile of pipeline.

A.2.5 Interest During Construction

Interest during construction (IDC) is calculated as the cost of interest on the borrowed amount less the return on the proportion of borrowed money invested during construction. In accordance with TWDB guidelines, IDC is calculated as the total of interest accrued at the end of the construction period using a 6 percent annual interest rate on total borrowed funds, less a 4 percent rate of return on investment of unspent funds.

A.3 Annual Costs

Annual costs are those that the project owner can expect to incur if the project is implemented. These costs include repayment of borrowed funds (debt service), operation and maintenance costs of the project facilities, pumping power costs, and water purchase costs, when applicable.

A.3.1 Debt Service

Debt service is the estimated annual payment that can be expected for repayment of borrowed funds based on the total project cost (present worth), an assumed finance rate, and the finance period in years. As specified in TWDB Exhibit B, Section 1.71, debt service for all projects was calculated assuming an annual interest rate of 6 percent and a repayment period of 40 years for reservoir projects and 30 years for all other projects. The debt service factor of

0.06646 or 0.07265 for 40- or 30-year repayment periods is applied, respectively, to the total estimated project costs.

A.3.2 Operation and Maintenance

Operation and maintenance (O&M) costs for dams, pump stations, pipelines, and well fields (excluding pumping power costs) include labor and materials required to operate the facilities and provide for regular repair and/or replacement of equipment. In accordance with TWDB guidelines, O&M costs are calculated at 1 percent of the total estimated construction costs for pipelines, distribution, facilities, tanks and wells, at 1.5 percent of the total estimated construction costs for dams and reservoirs, and at 2.5 percent for intake and pump stations.

Water treatment plant O&M is estimated using Table A-11. The O&M costs listed in Table A-11 include labor, materials, replacement of equipment, process energy, building energy, chemicals, and pumping energy.

Table A-11.
Operation and Maintenance Costs for Water Treatment Plants[1]

Capacity (MG)	Level 1[2] O&M Cost (dollars)	Level 2[3] O&M Cost (dollars)	Level 3[4] O&M Cost (dollars)	Level 4[5] O&M Cost (dollars)
1	111,000	199,000	249,000	387,000
10	619,000	829,000	973,000	2,875,000
50	2,322,000	3,538,000	3,980,000	12,715,000
75	3,538,000	5,307,000	6,192,000	19,902,000
100	4,367,000	6,744,000	7,739,000	26,535,000
150	7,076,000	9,951,000	11,056,000	39,803,000
200	8,292,000	13,268,000	14,373,000	53,071,000

[1] Values current as of 2nd Quarter 1999.
[2] Level 1: Aquifer Treatment.
[3] Level 2: Direct Filtration.
[4] Level 3: Conventional.
[5] Level 4: Reclaimed Wastewater.

A.3.3 Pumping Energy Costs

In accordance with TWDB guidelines, power costs are calculated on an annual basis using the appropriate calculated power load and a power rate of $0.06 per kWh. The amount of energy consumed is based upon the pumping horsepower required.

A.3.4 Purchase of Water

The purchase cost, if applicable, is included if the water supply option involves purchase of raw or treated water from an entity. This cost varies by source.

A.4 Cost Estimate Presentation

Each individual option is presented with total capital costs, total project costs, and total annual costs. The level of detail is dependent upon the characteristics of each option. Additionally, a summary is calculated, showing the cost per unit of water involved in the option, reported as costs per acft and cost per 1,000 gallons of water developed. The individual option cost tables specify the point within the region at which the cost applies (e.g., raw water at the lake, treated water at the municipal and industrial demand center, or elsewhere as appropriate).

Appendix B

Environmental Water Needs Criteria of the Consensus Planning Process

Environmental Water Needs

PLANNING CRITERIA OF THE CONSENSUS STATE WATER PLAN

CONSENSUS PROCESS

The consensus-based state water planning process joins the three primary State water or natural resource agencies, the Texas Water Development Board (TWDB), the Texas Natural Resource Conservation Commission (TNRCC), and Texas Parks and Wildlife Department (TPWD) with other stakeholders in a major effort to update the State Water Plan. This effort is addressing the long-range, multi-purpose water needs of Texas through broad-based involvement, negotiation, and consensus-building among key parties.

The overall goals of these consensus efforts are summarized in Exhibit 1. This effort involves planning for the water needs of Texas' citizens for the next fifty years, while trying to ensure adequate flows to maintain ecosystems and protect water quality.

Exhibit 1
Consensus Goals

The consensus-based water planning process was initiated by the State water agencies to address the following management goals:

★ To promote consistent planning, policy, regulation, management, and wise use of the State's water resources.

★ To minimize or avoid any needless and unproductive conflict in the planning and management of these resources.

★ To provide an on-going, cooperative planning and policy process for orderly and responsible water conservation, development, and management.

PLANNING GOALS

To accomplish this balancing between competing purposes, environmental water needs criteria have been developed consisting of:

(1) *philosophical planning goals* for environmental water needs that the consensus process is trying to achieve, and

(2) *specific numerical planning criteria* that can serve as desk-top, reconnaissance-level planning guidance, or possibly as regulatory default values where detailed field studies are not required. The numerical criteria outlined below can provide early planning

guidance for developing applications for new or amended water rights permits. They not intended to be used as an exact formula for determining specific environmental requirements that may be conditioned to new or amended water right permits.

Since water development projects, such as river impoundments and diversions, can alter the natural flow regime of streams and rivers, assessment of fish and wildlife maintenance needs in the affected downstream segments is an important project activity. The primary objective is to minimize development impacts on living resources by managing for environmental flow needs through watershed management. This can best be done on a regional basis. Also, decreasing the flow in streams below a certain threshold can affect the assimilative capacity or dilution ability of streams, thereby leading to increased costs associated with higher levels of wastewater treatment and nonpoint source pollution prevention activities. Therefore, multi-stage rules for environmentally safe operation of these necessary water projects over the normal range of weather conditions experienced in Texas, which is extreme, are needed.

The environmental criteria have generally been accepted by State water agencies for use in planning and for use as "default" values in the permitting of certain small projects in the absence of site-specific information. However, they are not intended to replace site-specific information in the permit process, and the TNRCC is charged by law with the final decision in all permit matters.

As part of the State Water Plan process, a team of instream flow and aquatic biology specialists was asked to develop guidelines to be used in planning for water resource projects. The general consensus planning methods developed by the State water agencies attempt to balance human and environmental water needs. These criteria provide instream flow recommendations that serve as initial "placeholders" for instream flow needs until more site-specific assessments can be performed.

ECOLOGICAL FLOW AND WATER SUPPLY GOALS

In developing the criteria, general *ecological goals* were specified to provide adequate water to maintain instream flows and freshwater inflows to bays and estuaries. Identified environmental flows should represent an estimate of full ecological water needs and how those ecological targets might be met or altered in balancing them with human needs. The methods developed should help ensure the *long-term health* of the aquatic environment, realizing that periodic dry conditions are a natural part of the climate, hydrology, and ecosystem development in Texas. Also, ecological water need targets would be based on "naturalized" stream flow conditions to address slowing the degradation of the natural, pre-development environment, and to provide a more stable streamflow record that would not change with each new water development project, which would be the case if gaged flow records were used in the analyses.

Conditioning these environmental goals, *water supply goals* were identified. To acknowledge the priority of human needs during dry periods and drought, the relative share of water provided for the environment will be successively reduced to protect water supplies. Also, ecological flow needs will be based on inflows to water project sites and will not be provided from the project's water supply storage. Further, all downstream water right needs will be honored at all times.

To address these goals, a three-zone approach, summarized in Exhibit 2 and described in detail below, was formulated to ensure instream environmental maintenance during normal flow periods, while protecting human water supply needs during times of low flows and drought. Regional or watershed-specific differences are inherent in these criteria, since pass-through flows are based on the specific, "on-site" hydrology of each river system.

Exhibit 2
Three-Zone Concept
for the Provision of Instream Flow
Environmental Water Needs

Zone 1. During normal or higher flow periods, promote the *long-term health* of the natural environment with the pass-through provision of the most-common flow regime, identified by an appropriate central tendency value such as median, mode, or geometric mean of naturalized flows.

Zone 2. During drier periods, provide pass-through flows for *minimum ecological maintenance* where the aquatic species are impacted by lower flows, but can survive for a short period.

Zone 3. During severe drought conditions, provide pass-through flows sufficient to maintain *water quality*.

As a planning place-holder value, the Zone 1 reservoir pass-throughs or direct diversion by-passes will also provide freshwater inflow to the bays and estuaries (B&E). However, where inflow values adequate to meet the beneficial inflow needs as described in Texas Water Code §11.147 have been established, those inflow volumes will be used for projects within 200 river miles of the coast, commencing from the mouth of the river, as the basis for calculating the relative contributions of fresh water from the associated rivers and coastal basins during Zone 1 conditions. No other special provisions would be made for B&E purposes in Zone 2 or 3 conditions for either new reservoirs or large direct diversions. These inflow values may be determined by TPWD until a regulatory determination is made in accordance with Texas Water Code Section 11.1491.

It is the intent of the consensus-based water planning process that the goals of these environmental flow criteria be met with the *best information possible*. The numerical values given below are for default purposes only, given the lack of more detailed, site-specific investigations at many locations around the State. Where more site-specific or better data can be obtained, this information should replace the default values, but still remain consistent with the overall policy goals and general structure of the criteria.

REGULATORY GOALS AND PROVISIONS

A primary regulatory goal of the environmental water needs planning criteria is to reasonably predict the ultimate regulatory outcome so that future applicants will have increased certainty concerning the way environmental issues will generally be addressed in their applications. An overall structure for regulatory consideration should be established that defines general performance standards that an applicant would be expected to meet, but also allows the applicant considerable flexibility to conduct field work and technical analyses to devise an application that best meets their needs and those of the State. Finally, regulatory flexibility in the joint consideration for providing downstream water rights and environmental flows should be allowed. There may be some instances where "stacking" of environmental flows on top of downstream rights may not be a necessary provision of the water right, especially where a release or pass-though for one purpose can fully satisfy both.

When the results of intensive fresh water inflow or instream flow studies are available and criteria have been established regulatorily, those criteria will be used in the Water Plan in lieu of any generic rule. For example, the instream flow requirements for the Colorado River have been approved by TNRCC in the LCRA Management Plan. When established criteria are available and agreed to by TPWD and TNRCC, bay and estuary inflow requirements would be apportioned to each new project identified in the plan according to its proportional share, based on its contribution to the total hydrology of the estuary. Where possible, this process will seek to restore seasonal flow patterns and minimize cumulative impacts from water development projects.

AMENDMENTS TO EXISTING PERMITS

The scope of environmental review and permit consideration of an amendment to an existing water right is limited by law. Because of the many varied conditions around the State, and the fact that an applicant may propose a project different than that identified in the Plan, the TNRCC can only provide general guidance as to how the Commission would evaluate applications for water rights and amendments to existing permits.

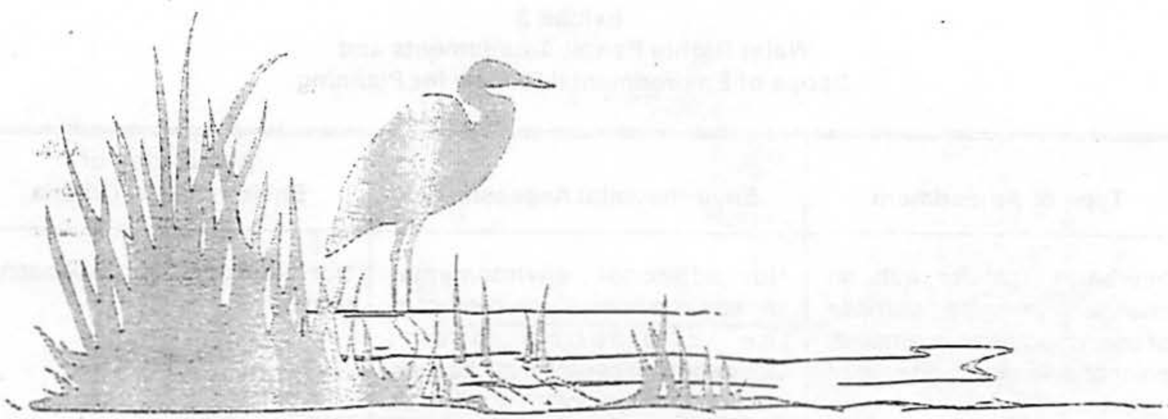
In general, evaluation of impacts to instream or estuarine ecosystems will occur when there is a *significant* change in the point of diversion from downstream to upstream, to an adjoining tributary, to an area with endangered species habitat, increase in the amount and/or rate of diversion, or if there is a change of purpose of use from non-consumptive to consumptive. Other changes in place or type of use and changes made by SB 1 to sections 11.122 and 11.085, Texas Water Code, may have limited or no further environmental review. This limited scope of review for proposed amendments to existing water rights was codified by SB 1. Section 11.122 of the Water Code now expressly provides that, except for an amendment that increases the amount of water authorized to be diverted or the authorized rate of diversion, an amendment shall be authorized if the requested change will not cause any greater adverse impact on other water right holders or the environment than the full legal exercise of the water right prior to its amendment. An exception to this is provided by changes made by SB 1 to Section 11.085 of the Water Code relating to interbasin transfers. If the water right sought to be transferred is currently authorized to be used under an existing water right, potential environmental impacts shall only be considered in relation to that portion of the right proposed for transfer and shall be based on the historical use of the water.

For planning purposes, proposed amendments, such as conversion from non-consumptive to consumptive use (having the effect of a new appropriation) would have the appropriate environmental considerations described for new projects. For other types of amendments where only the intervening river or stream would be affected, the appropriate reservoir or direct diversion instream flow criteria would be applied. Where applicable, environmental flow criteria would only affect that portion of the existing water right subject to change. A summarization and categorization of the TNRCC's general guidance for determining potential adverse impact to the environment for types of possible water right amendments likely to be considered in the consensus planning process is shown in Exhibit 3.

Exhibit 3
Water Rights Permit Amendments and Scope of Environmental Review for Planning

Type of Amendment	Environmental Assessment	Application of Environmental Criteria
Interbasin Transfer with no change in *permitted* purpose of use, appropriative amount, point of diversion, and rate of diversion.	No additional environmental impacts considered with respect to the originating basin. ~~Consideration of potential changes in water quality and/or migration of~~ nuisance species, and excessive freshwater inflows to maintain proper salinity levels for B&E's may be made for receiving basin. An impact statement may be required to be submitted.	Not applicable for originating basin.
Significant change in point of diversion from downstream to upstream, to adjoining tributary, or to endangered species habitat	Evaluation of impacts to intervening instream or site-affected environmental resources.	Case-by-case basis where level of significance is evaluated as per TNRCC's guidance.
Change of purpose of use from non-consumptive to consumptive use	Evaluation of impacts to instream and B&E environmental resources.	Three-zone planning criteria described previously.
Change in purpose of use where there is no increase in the consumption of water from that legally authorized in the existing water right	No environmental review.	Not applicable.

Where applicable, the "environmental planning criteria" would only affect that portion of the existing water right subject to change. Also, where regional or local planning efforts may specify higher environmental goals than those provided by the existing minimum legal or regulatory requirements, such alternate goals may be requested by the applicant and may ultimately be provided in the water right permit.



DEFAULT NUMERICAL VALUES AND OPERATIONAL GUIDELINES OF THE ENVIRONMENTAL WATER NEEDS PLANNING CRITERIA

OVERVIEW

The following discussion is intended as planning guidance to help water planners and engineers meet the goals of the environmental flow criteria, while protecting water supply yield during low flow conditions. The concepts described are intended as guidelines for planning, or in some cases, to be used as "default" values for permitting in situations where site-specific information from detailed field studies is not required. For larger projects, the intent of these guidelines is that they be used as a basic structure for providing environmental flows, with the actual numerical values determined by site-specific studies. A daily reservoir operations model (e.g., SIMDLY-B&E) should be used to simulate performance of potential future water impoundment projects over a multi-year period that includes the drought-of-record. Similarly, a daily diversion operations model (e.g., DIVERT) should be used to simulate performance of potential future direct diversion projects over a multi-year period that includes the drought-of-record. Results will provide estimates of the amount of water produced by the project and the amount that must be passed downstream to protect environmental resources.

NEW PROJECT ON-CHANNEL RESERVOIRS

As illustrated in Figure 1, the conservation storage of new-project, on-channel water supply reservoirs would be divided into three zones for the provision of environmental flows as follows:

Zone 1

In Zone 1 of a reservoir, when reservoir water levels are greater than 80% of storage capacity, inflows to the reservoir will be passed downstream in amounts up to the monthly median value, as calculated from naturalized daily streamflow estimates.[1] Depending on the hydrology of the basin, it may be appropriate to pass the "most common" or central tendency flow frequency which historically occurred, whether it be the median or some other more appropriate expression of central tendency value, such as modal or geometric mean.

Periodic flushing flows for channel and habitat maintenance are beneficial both for the hydraulic properties of the water course itself, and for maintaining the habitat of the aquatic ecosystem.

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[1] Naturalized streamflow is the estimated amount of water that would have been present in a watercourse with no direct man-made impacts in the watershed. It is calculated by taking values of historically measured streamflow, adding amounts of estimated man-made losses from the upstream watershed caused by water diversion and lake evaporation, then subtracting amounts of estimated man-made gains to the upstream watershed caused by return flows.

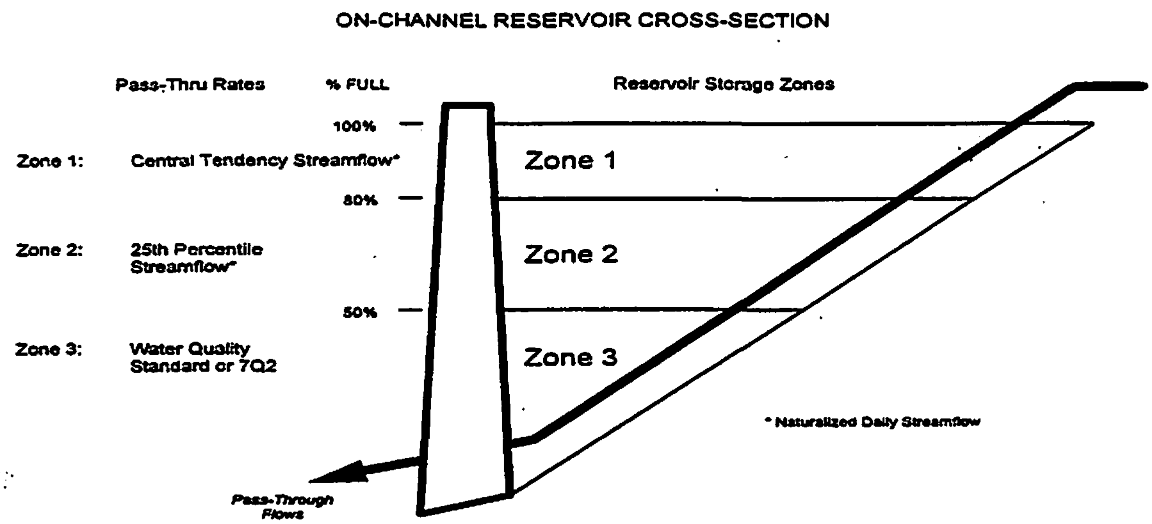

Figure 1
New Project, On-Channel Reservoir Criteria for Passing Environmental Flows

Flushing events appear to occur naturally with enough frequency that planning criteria requiring them may be unnecessary. However, the feasibility of providing flushing flows should be explored during site-specific investigations, and may be required as a condition of obtaining State or Federal permits.

Zone 2

When dry conditions develop and reservoir water levels decline into Zone 2, between 50 and 80% storage capacity, the amount of inflows passed would be reduced to rates up to the monthly 25th percentile flows, as calculated from the naturalized daily streamflow estimates.

Zone 3

As more severe drought conditions develop and reservoir water levels decline into Zone 3, below 50% storage capacity, environmental pass-throughs would be reduced further, and inflows would be passed up to a level determined adequate for the protection of water quality in the downstream segment. In lieu of any site-specific data, the 7Q2 low-flow value, as published in the TNRCC's State Water Quality Standards, would be used as the default criterion for Zone 3 pass-throughs. If in Zones 1 and 2, the value necessary to maintain downstream water quality is higher than the monthly medians or 25th percentiles, respectively, then the value necessary to maintain downstream water quality will be used instead of the other target flow values.

The goal of Zone 3 is to protect water quality. Water quality standards consisting of specific numerical and general narrative criteria are established to protect designated uses based on *current* law and policy. In effluent dominated stream segments, it may difficult to justify any water quality flow value other than the seven-day, two-year, low-flow value (7Q2). In non-effluent dominated or high base flow segments, other analytical methods that address dissolved oxygen (DO) and toxicity may be more appropriate for defining water quality flows than the 7Q2 value used here for planning purposes. More detailed analyses, such as QUALTEX modeling, may be required in a permit application for a large project.

All Reservoir Zones

In all zones, it is the intent of the planning criteria that flows passed for instream purposes also contribute to meeting the ecological needs of the associated bay and estuary system. In addition to passage of environmental flows, adequate flows will be passed through for protection of downstream water rights.

Also in all zones, water that can be captured by reservoirs in excess of the environmental provisions is available for water supply storage, and no water will be released from storage to meet environmental targets when inflows are below these limits. However, since most future reservoir projects and direct diversions are anticipated to be designed solely for water supply rather than flood control, then most floods can't be captured by the reservoirs, but will pass (spill) downstream anyway. These high flow events increase the amount of water available for instream flow maintenance and estuarine needs beyond the levels that would be provided by the environmental criteria alone.

NEW PROJECT DIRECT DIVERSIONS

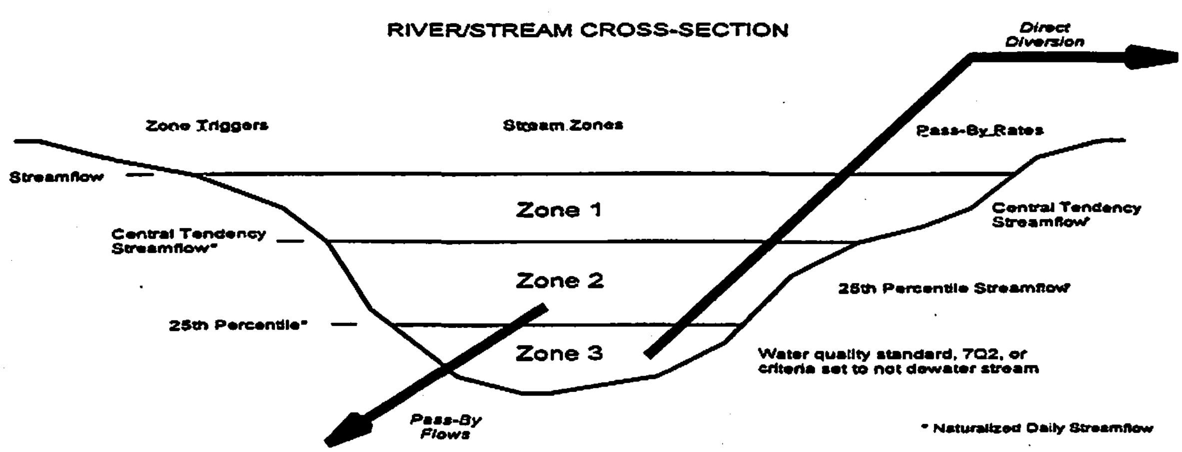

Figure 2
New Project, Direct Diversion Criteria
for Passing Environmental Flows

As illustrated in Figure 2, the criteria for direct diversions from a river or stream that are recommended in the Water Plan, would be based on streamflow conditions just upstream of the diversion point, and would also be divided into three zones as follows:

Zone 1

Zone 1 occurs when actual streamflow is greater than the monthly central tendency values calculated from naturalized daily streamflow estimates. When streamflow is within Zone 1, minimum flows passed will be up to the monthly median or other appropriate central tendency value calculated from naturalized daily streamflow estimates.

Zone 2

Zone 2 occurs when actual streamflow is less than or equal to the central tendency value, but greater than the monthly 25th percentile value. When streamflow is within Zone 2, minimum flows passed will be the monthly 25th percentile values calculated from naturalized daily streamflow estimates.

Zone 3

Zone 3 occurs when actual streamflow is less than or equal to monthly 25th percentile values. During Zone 3, minimum flows passed will be the greater of: (1) the value necessary to maintain downstream water quality or (2) a continuous-flow threshold (e.g., 15th percentile) to be determined by consensus planning staff that will not allow the diversion by itself, to dry up the stream.

For all river and stream segments, the amount of flow necessary to protect water quality downstream will be used as the by-pass target. Where such a rate has not been determined from site-specific or other data, the default planning criterion is the 7Q2 value as published in the TNRCC's State Water Quality Standards. For Zones 1 and 2, if the value necessary to maintain downstream water quality is higher than the medians or 25th percentiles, respectively, then the value necessary to maintain downstream water quality will be used instead of the other target flow values.

All Zones

The streamflow values which trigger different zonal operations will be calculated from naturalized daily streamflow estimates. The above procedure, because it provides a specific quantity of flow for environmental uses in each zone, does not have smooth transitions between zones for diversion projects, and the State water agencies agree that the procedure should be improved to make smoother transitions.

NEW DIRECT DIVERSIONS INTO LARGE OFF-CHANNEL STORAGE

As illustrated in Figure 3, in those cases where a large water supply project would divert its water from a river or stream into off-channel storage, a combination of the direct diversion and reservoir criteria would apply. The direct diversion criteria will govern the ability to divert water into the off-channel project. The reservoir criteria will address the ability of the reservoir to capture water from its own watershed, define the reservoir's multi-stage operations to pass environmental flows, and to ensure flows for protection of downstream water rights.

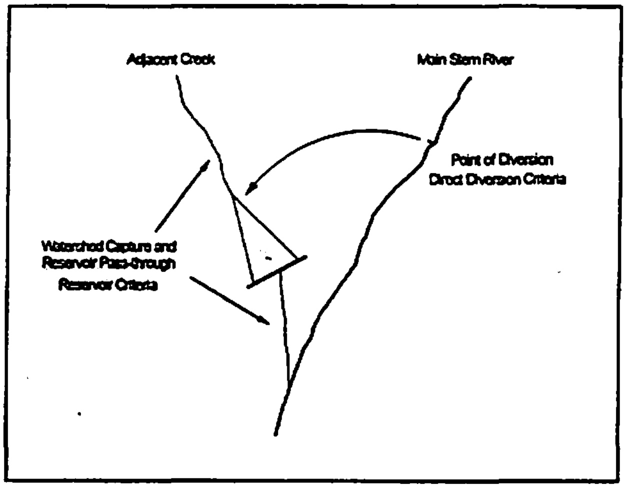

Figure 3
Combined Criteria for Diversion into Off-channel Reservoir

BAY AND ESTUARY CONSIDERATIONS

As a planning place-holder value, the Zone 1 reservoir pass-throughs or direct diversion by-passes described previously will also provide freshwater inflows to the bays and estuaries. However, where inflow values adequate to meet the beneficial inflow needs as described in Texas Water Code §11. 147 have been established, those inflow volumes will be used for projects within 200 river miles of the coast, commencing from the mouth of the river, as the basis for calculating the relative contributions of fresh water from the associated rivers and coastal basins during times of Zone 1 conditions. No other special provisions would be made for B&E purposes in Zone 2 or 3 conditions for either new reservoirs or large direct diversions. These inflow values may be determined by TPWD until a regulatory determination is made in accordance with Texas Water Code Section 11.1491.

The target flows in Zone 1 of the reservoir operating procedure should be established to provide the "beneficial flows" defined in Section 11.147(a) of the Texas Water Code as providing a "salinity, nutrient, and sediment loading regime adequate to maintain an ecologically sound environment in the receiving bay and estuary system that is necessary for the maintenance of productivity of economically important and ecologically characteristic sport or commercial fish and shellfish species and estuarine life upon which such fish and shellfish are dependent."

In practical terms, that means it is not necessarily the MinQ or MaxQ value produced by TxEMP, the fresh water inflow optimization model, but a point along that curve between these values that allows some margin of safety in providing sufficient flows in Zone 1 to maintain the ecological health and historic productivity of the fisheries. The fresh water inflow target is validated in part by comparing the seasonal distribution of salinity regimes in the estuary with the density distribution of selected estuarine flora and fauna.

B&E pass-through requirements for a new water development project will be based on a pro-rata share of that location's contribution of flow to the estuary in question. Once the target amount of water reaches an estuary during a month, no additional flows need to be provided for bay and estuary purposes during that month. For the remainder of the month, environmental flows revert to the instream criteria.

When the results of intensive fresh water inflow or instream flow studies are available and criteria have been established in the regulatory process, those criteria will be used in the Water Plan rather than any generic rule. The instream flow requirements for the Colorado River have been approved by TNRCC in the LCRA Management Plan. When established criteria are available and agreed to by TPWD and TNRCC, bay and estuary inflow requirements would be apportioned to each new project identified in the plan according to its proportional share, based on its contribution to the total hydrology of the estuary. Where possible, this process seeks to restore seasonal flow patterns and minimize cumulative impacts from water development projects.

In order to facilitate the timely completion of the determination of the inflow conditions necessary for the (remaining) bays and estuaries, TPWD and TNRCC will each designate an employee under Section 11.1491of the Texas Water Code to share equally in the oversight of the effort to review the studies jointly prepared by TWDB and TPWD under Section 16.058 (bay and estuary inflow studies) to determine inflow conditions necessary for the bays and estuaries. The three agencies will continue to work together as they have in the past to develop target flows to meet the needs of each principal bay and estuary system for a salinity, nutrient, and sediment loading regime at or above the identified needs.

Fresh water optimization curves are available for (1) San Antonio Bay and the Guadalupe Estuary; (2) Matagorda Bay and the Lavaca-Colorado Estuary; (3) Corpus Christi Bay and the Nueces Estuary; and (4) Galveston Bay and the Trinity-San Jacinto Estuary. The remaining Texas bays and estuaries are currently under study. A summary of the study protocol, the completion schedule, and results to date are attached to this briefing document.

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Appendix C

Technical Evaluation Procedures for Edwards Aquifer Recharge Enhancement Options

Appendix C
Technical Evaluation Procedures for Edwards Aquifer Recharge Enhancement Options

C.1 Introduction

Several of the water supply options under consideration in the South Central Texas Region involve the enhancement of recharge to the Edwards Aquifer. Such recharge enhancement is intended not only to increase springflows protecting endangered species and downstream water uses, but also to enhance the reliability of the Edwards Aquifer as a regional water supply. With regard to enhanced water supply, the Edwards Aquifer Authority (EAA) is in the process of formulating rules regarding recharge recovery permits,[1] which could define the amount of additional authorized pumpage to which the developer of a recharge enhancement project might be entitled. It is not yet known whether such recharge recovery would be authorized on an annual ("put and take") basis[2] or on a long-term ("sustained yield") basis similar to that for surface water reservoirs. More specifically, annual "put and take" refers to a management policy suggested by a provision in SB1477 that may be interpreted as requiring that waters artificially recharged to the aquifer (less an adjustment for springflow) must be recovered during the following 12-month period. "Sustained yield," on the other hand, refers to an alternative management policy under which a fixed or firm annual amount of recharge recovery could be authorized based on the long-term operations of a recharge enhancement project. Hence, recharge recovery would not be limited by actual recharge enhancement in the preceding year, but would be limited to the increase in reliable supply from the Edwards Aquifer during the drought of record. Adoption of a "sustained yield" basis for the issuance of recharge recovery permits could require modification of the referenced provision in SB1477.

For the purposes of regional water supply planning under rules set forth by the Texas Water Development Board (TWDB), recharge enhancement options are evaluated herein based on the reliable supply available during the drought of record. In this way, recharge enhancement options may be considered by the South Central Texas Regional Water Planning Group on the same basis as surface water supply options, such as reservoirs and run-of-river diversions. While

[1] HDR Engineering, Inc. (HDR), "Introduction to Technical Application Requirements for Artificial Recharge Contracts and Recharge Recovery Permits," Edwards Aquifer Authority, December 1998.
[2] Senate Bill 1477, Section 1.44(c).

numerous studies quantifying recharge enhancement on both long-term and drought average bases have been completed in recent years, the quantification of additional reliable supply based on maintenance of springflows during the drought of record was not a part of these studies. Hence, the TWDB's model of the Edwards Aquifer is used in this regional water supply planning effort to simulate aquifer performance subject to recharge enhancement, quantify the associated increase in reliable supply, and allow for more direct comparisons between recharge enhancement and other water supply options. The following paragraphs provide a brief summary of the technical procedures used for evaluation of Edwards Aquifer recharge enhancement options.

C.2 Edwards Aquifer Model

In order to simulate aquifer response to a recharge enhancement option, the TWDB GWSIM4 Edwards Aquifer groundwater flow model (Figure C-1) is used to make the necessary calculations. It is designed to simulate aquifer response in terms of water levels and springflows for specified recharge and pumping rates. The model was developed by the TWDB in the 1970s[3] as a tool for use in developing a water resources management program for the Nueces, San Antonio, and Guadalupe River Basins. Originally, the model operated on an annual timestep and was calibrated to data collected from 1947 to 1971. Major assumptions in the model include: (1) no lateral movement of water from the Glen Rose formation in the Hill Country (Trinity Aquifer-Edwards Plateau); (2) no water movement across the so-called 'bad-water line'; and (3) no leakage from underlying or overlying formations except in an area southeast of Uvalde near Leona Springs.

The TWDB recalibrated the model in the early 1990s[4] with information compiled between 1971 and 1989 and refined the timestep to monthly intervals. The recalibration was based on comparisons of water levels and springflows for 1947 to 1959 and "verified" with 1978 to 1989 data. During the process of adjusting the aquifer parameters for recalibration, the model developers gave special emphasis to minimum flow periods at Comal and San Marcos Springs

[3] Klemt, W.B., Knowles, T.R., Elder, G.R., and Sieh, T.W., "Ground-water Resources and Model Applications for the Edwards (Balcones Faulty Zone) Aquifer in the San Antonio Region, Texas," Texas Water Development Board Report 239, 88p., 1979.
[4] Thorkildsen, D. and McElhaney, P.D.., "Model Refinement and Applications for the Edwards (Balcones Fault Zone) Aquifer in the San Antonio Region, Texas," Texas Water Development Board Report 340, 33p., 1992.

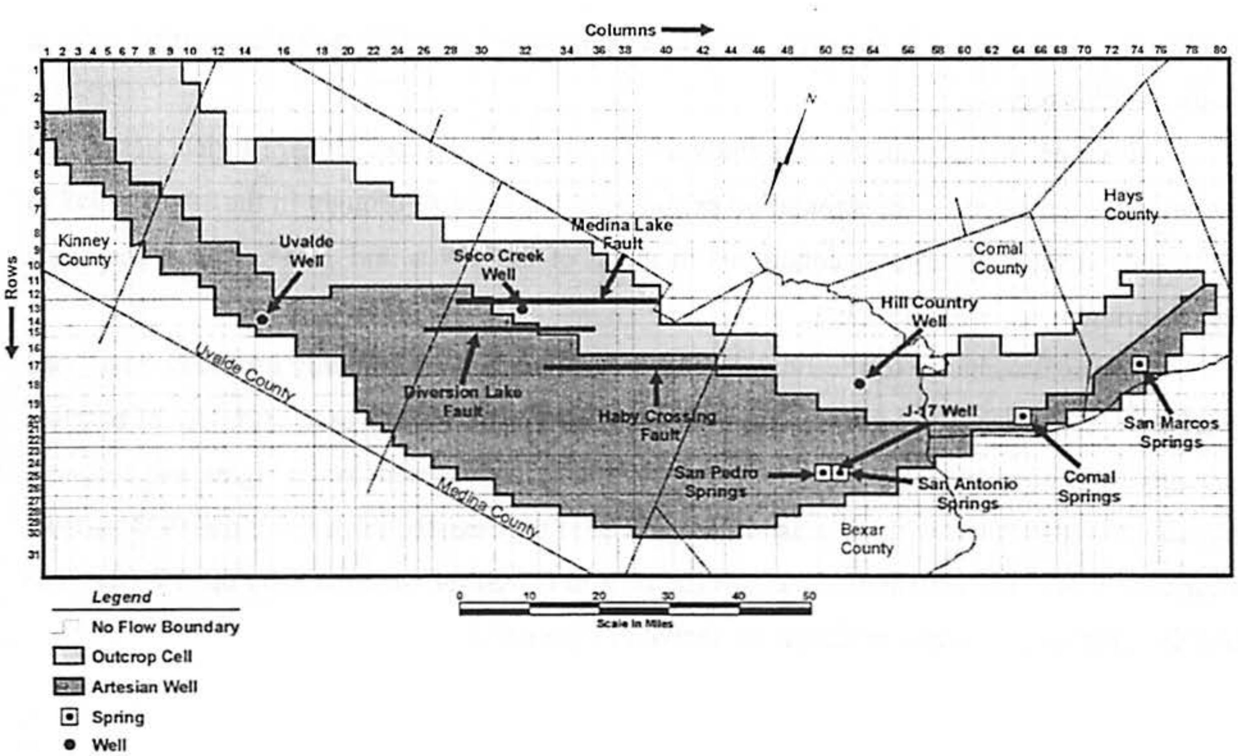

Figure C-1. GWSIM 4 Model for Edwards Aquifer

and water levels at observation well J-17 in San Antonio. The recalibration did not revise any of the major assumptions used in the original model.

At the request of the Texas Natural Resource Conservation Commission (TNRCC) and the South Central Texas Regional Water Planning Group, the TWDB made additional modifications to GWSIM4 and performed a simulation for use in surface water availability and water supply options in the Nueces, San Antonio, and Guadalupe River Basins.[5] As part of this effort, the TWDB modified GWSIM4 to simulate implementation of the EAA's original Critical Period Management rules by separating pumpage by category and location. These categories and locations include: domestic and livestock use, municipal and industrial use in Kinney County, irrigation use by county, industrial use by county and by San Antonio Water System (SAWS), and municipal by county and SAWS. Application of the EAA's original Critical Period Management rules does not, however, force a reduction in overall pumpage during critical aquifer conditions. Hence, the original Critical Period Management rules were turned OFF in all

[5] Kabir, N., Bradley R.G., and Chowdury, A., "Summary of a GWSIM4 Model Run Simulating the Effects of the Edwards Aquifer Authority's Critical Period Management Plan for the Regional Water Planning Process," Texas Water Development Board, July 1999.

simulations. The EAA is in the process of developing new Critical Period Management rules at the time of this report.

All model simulations for this study are for the 1934 through 1989 historical period and have monthly timesteps. The simulation period includes a severe drought in the 1950s (1947 to 1956) and wetter than normal conditions in much of the 1970s and 1980s, except for short, intense droughts in 1984 and 1989.

Historical recharge to the Edwards Aquifer is based upon monthly estimates developed by HDR.[6,7] For the most recent application of GWSIM4, the TWDB used estimates of baseline recharge, developed by HDR, that reflect full utilization of current water rights and recharge enhancement associated with all existing projects as if they existed throughout the 1934 to 1989 historical period. The distributions to specific cells in GWSIM4 were made by the TWDB. The annual estimates of baseline recharge are shown in Figure C-2.

[6] HDR, "Guadalupe-San Antonio River Basin Recharge Enhancement Study," Edwards Underground Water District, September 1993.
[7] HDR, "Nueces River Basin Regional Water Supply Planning Study," Nueces River Authority, et al., May 1991.

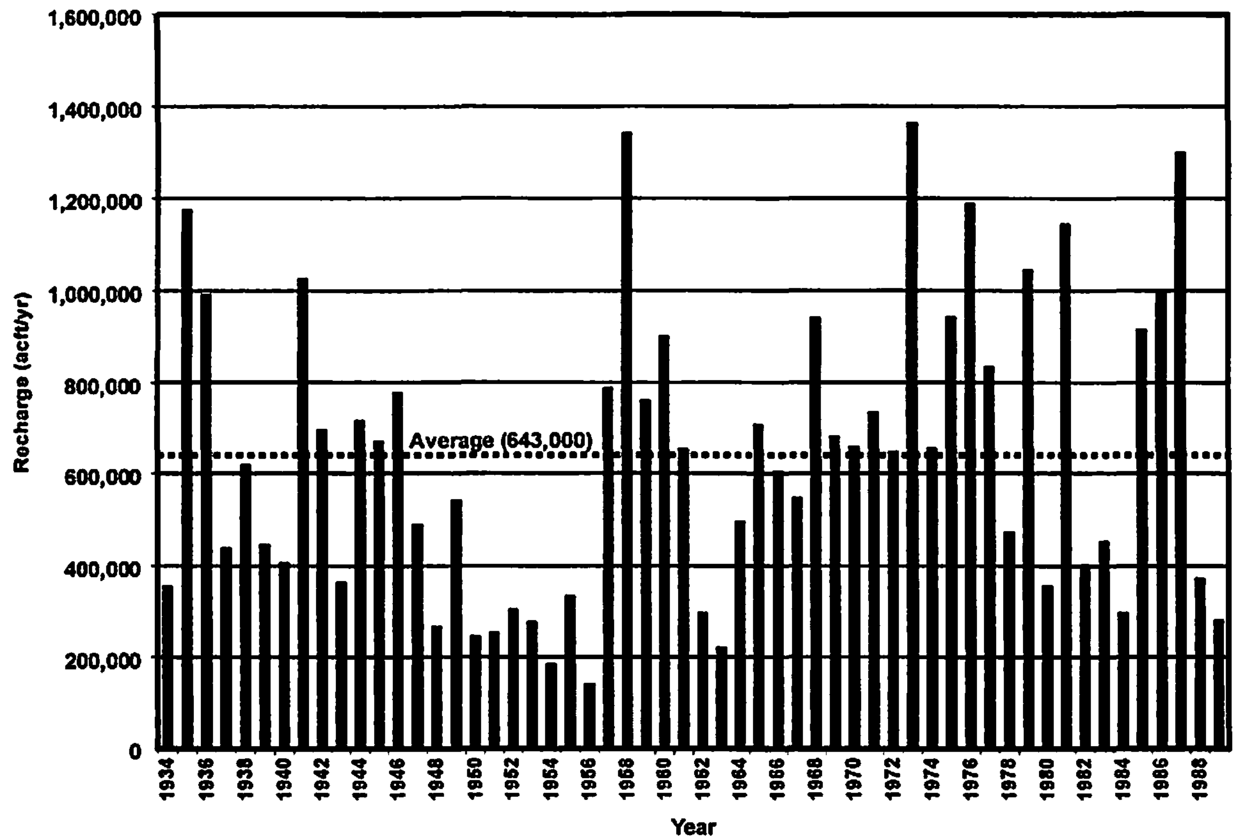

Figure C-2. Edwards Aquifer Recharge

Natural water losses from the Edwards Aquifer model are springflow at Leona, San Pedro, San Antonio, Comal, and San Marcos Springs. Springflow is calculated from aquifer heads at the spring and an aquifer head-springflow rating curve for each spring. Another natural loss is cross-formational leakage in an area southeast of Uvalde. This loss is calculated similarly to springflow. The current version of GWSIM4 includes an estimate of discharge to the Guadalupe River (largely associated with Hueco Springs) and is considered a negative (rejected) recharge by the model. The discharge is estimated from a regression equation of streamflow gains and water levels in observation well J-17.

Pumpage is assigned by category to specific cells in the model by the TWDB, based on the locations of permitted wells. For the baseline permitted pumpage, the total pumpage for irrigation, industrial, and municipal purposes in Kinney, Uvalde, Medina, Bexar, Atascosa, Comal, and Hays Counties, is adjusted to 400,425 acft/yr. Domestic and livestock pumpage does not require permits and totals 12,312 acft/yr. Thus, the total annual pumpage used in the model is 412,737 acft/yr. Annual pumpage is distributed to monthly pumpage values by multiplying the annual pumpage for each category by a monthly distribution factor. The distribution of pumpage, by category and month, is shown in Figure C-3.

C.3 Technical Evaluation Procedure

The technical evaluation procedure used in determining the increase in water supply attributable to a recharge enhancement option is based on the definitions, assumptions, and steps summarized in the following paragraphs.

Definitions:

- *Baseline Pumpage:* The sum of the regular permitted industrial, municipal, and irrigation pumpage categories adjusted to 400,425 acft/yr plus the unpermitted domestic and livestock pumpage. The total is 412,737 acft/yr.
- *Baseline Sustained Yield:* The portion of baseline pumpage that will maintain a minimum monthly flow at Comal Springs of 60 (cfs) in one and only one month of the simulation period. This simulation is performed merely to obtain a baseline estimate of aquifer yield for the "no enhanced recharge" case.
- *Sustained Yield with Recharge Enhancement Project(s)*: The sum of the pumpages for the baseline sustained yield scenario plus an across the board increase in municipal pumpage such that the minimum monthly flow at Comal Springs is 60 cubic feet per second (cfs) in one and only one month of the simulation period.
- *Recharge Recovery Permit Pumpage:* The increase in sustained yield that is attributable to the recharge enhancement project(s).

Assumptions:

- The GWSIM4 Model provides a reasonable simulation of Edwards Aquifer response (in terms of springflow and water levels) to enhanced recharge and various pumpage rates. Note that the EAA, in cooperation with regional, state, and federal interests, has undertaken the development of a new model of the Edwards Aquifer.
- Minimum Comal Springs discharge of 60 cfs (in one and only one month of the 56-year simulation period) provides a reasonable point of reference for assessment of potential changes in sustained yield of the Edwards Aquifer associated with recharge enhancement. Note that the selection of 60 cfs as a minimum discharge simply provides a point of reference for consistent computations and does not necessarily imply acceptability under the law.
- The increase in sustained yield of the Edwards Aquifer during the drought of record provides a reasonable basis for consideration of recharge enhancement options in a manner consistent with other water supply options in the regional water planning process. Note that the EAA is in the process of formulating rules governing recharge enhancement and recovery.

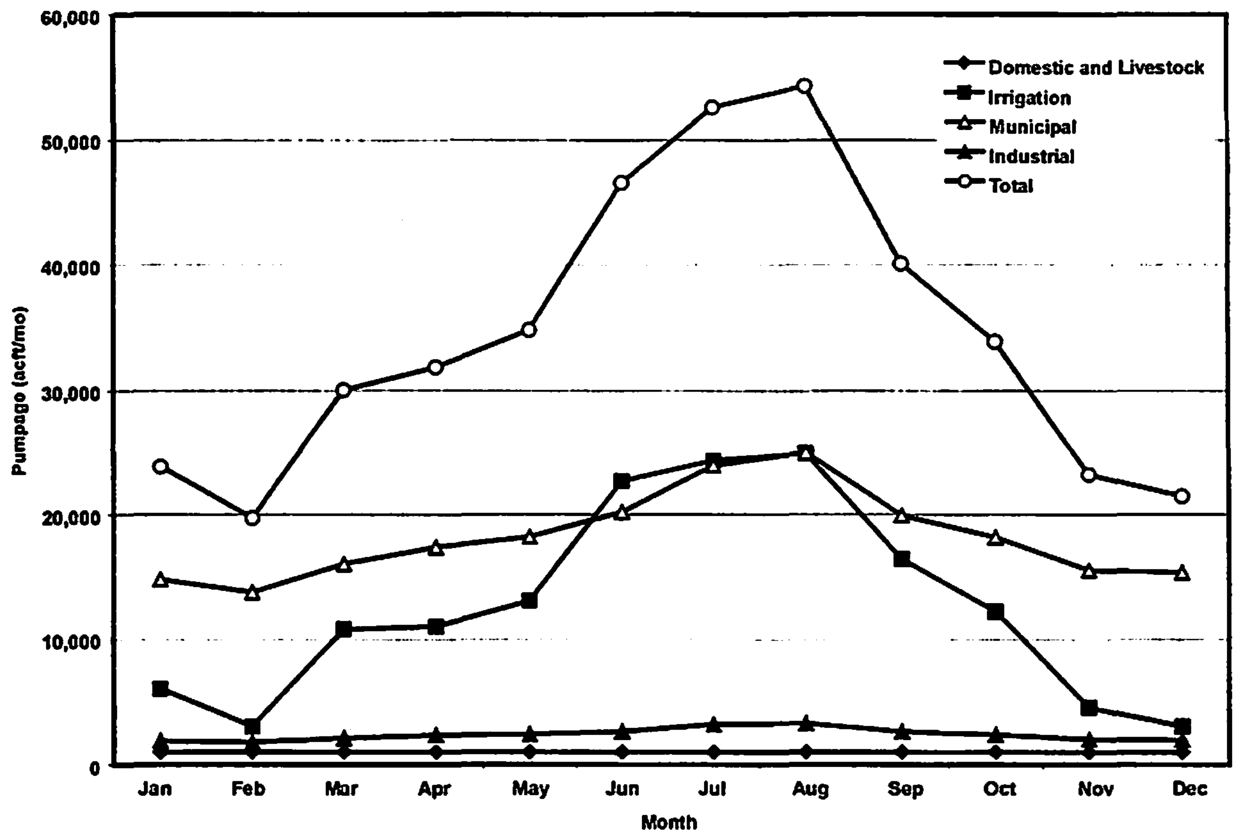

Figure C-3. Summary of Baseline Pumpage — Edwards Aquifer

Steps:

1. Make a baseline GWSIM4 simulation with baseline pumpage and baseline recharge. Count the number of months when flow at Comal Springs (Figure C-4) is less than specified values of interest (200 cfs, 150 cfs, and 60 cfs) and when J-17 levels fall below specified values of interest (650, 642, 636, 632, and 628 ft-msl).
2. Make a series of trial and error GWSIM4 simulations with reductions in baseline pumpage until the flow at Comal Springs is 60 cfs in one and only one month of the simulation period. The final run provides the baseline sustained yield of the Edwards Aquifer (Figure C-4).
3. Calculate the enhanced recharge provided by the water supply option using a surface water model.
4. Add the baseline recharge and the enhanced recharge.
5. Make a series of trial and error GWSIM4 simulations (including enhanced recharge) with the baseline sustained yield pumpage plus across the board increases in municipal pumpage until the flow at Comal Springs is 60 cfs in one and only one month of the simulation period. The final run provides the sustained yield with the recharge enhancement option.

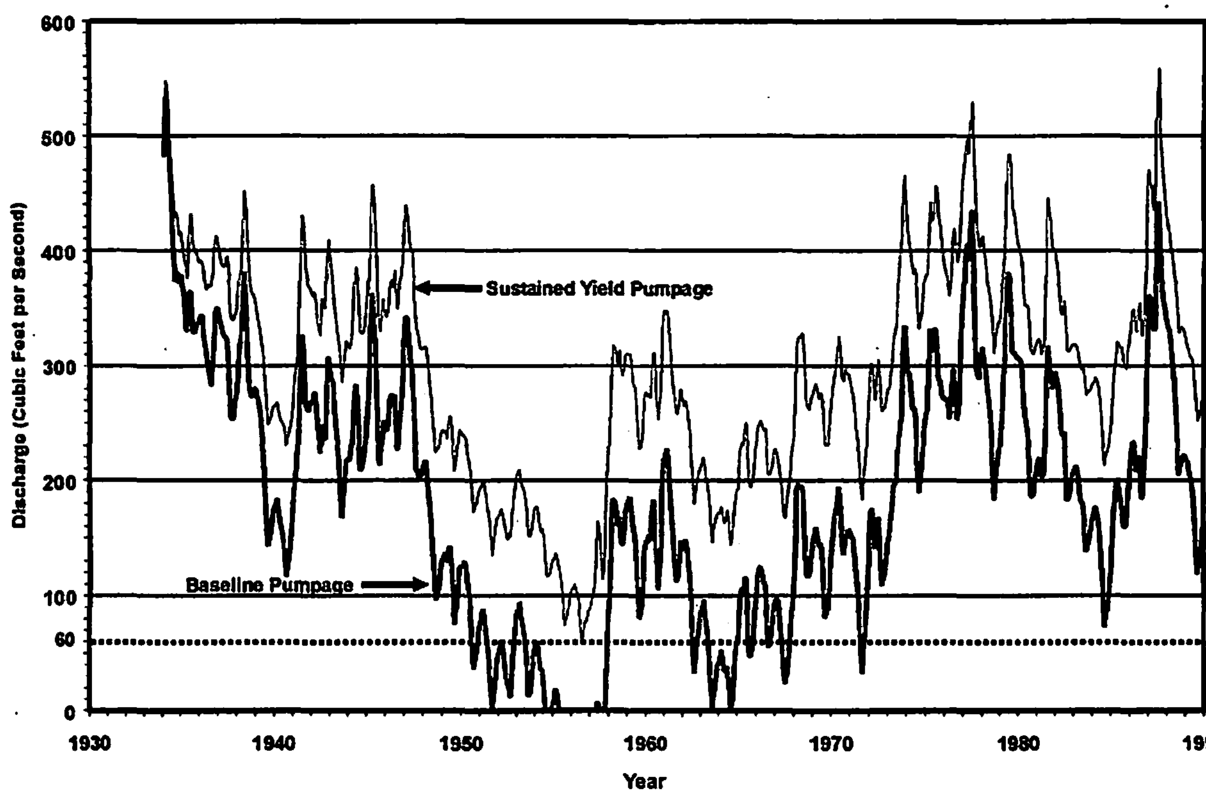

Figure C-4. Comal Springs Discharge Subject to Pumpage Scenarios

6. Calculate the amount of annual pumpage for a recharge recovery permit by subtracting the baseline sustained yield from the sustained yield with recharge enhancement.
7. Add the recharge recovery permit pumpage to the baseline pumpage.
8. Run GWSIM4 with the pumpage calculated in Step 7 and the combined baseline and enhanced recharge. Count the number of months when flow at Comal Springs is specified values of interest (200 cfs, 150 cfs, and 60 cfs) and when J-17 levels fall below specified values of interest (650, 642, 636, 632, and 628 ft-msl).
9. Compare the number of months below specified values of interest for the baseline pumpage simulation (Step 1) with the combined baseline and recharge recovery permit pumpage (Step 8).
10. Prepare a summary of the water balance in the Edwards Aquifer, with and without recharge enhancement, as shown in Figure C-5.

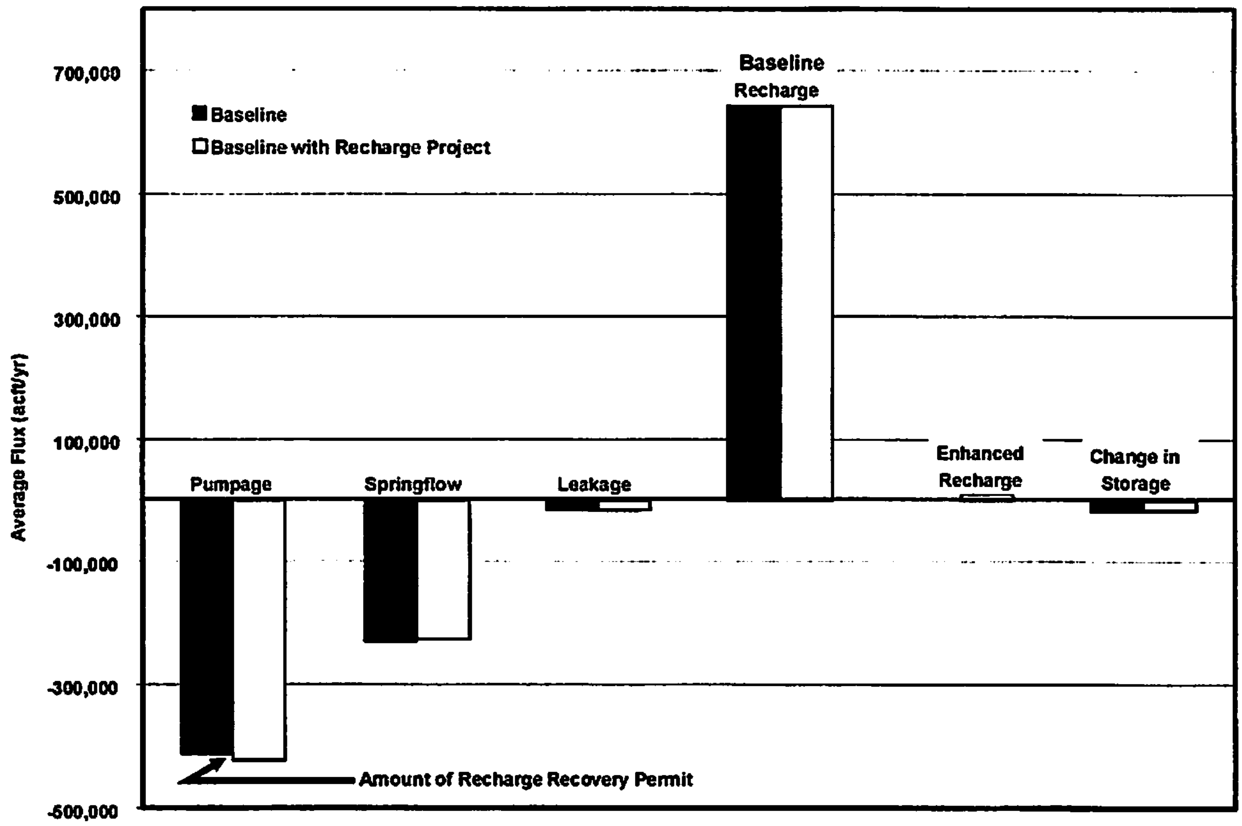

Figure C-5. Water Balance of the Edwards Aquifer (1934 - 1989)

Appendix D

Endangered, Threatened, and Rare Species by County

TABLE 1
THREATENED, ENDANGERED, AND RARE SPECIES OF ATASCOSA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/walking; likely to occur, but few records within this county		
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats		T
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	E	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	E	E
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie		
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T

TABLE 1 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF ATASCOSA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Mountain Plover	*Charadrius montanus*	Nonbreeding-shortgrass plains and fields, plowed fields (bare, dirt fields), and sandy deserts; primarily insectivorous	PT	
Whooping Crane	*Grus americana*	Potential migrant	E	E
Audubon's oriole	*Icterus graduacauda audubonii*	Wet woodland thickets, open oak woodland, scrub and riparian thickets		
Loggerhead shrike	*Lanius ludovicianus*	Mid-story/canopy nesting, semi-open country with lookout posts		
Texas olive sparrow	*Arremonops rufivirgatus rufivirgatus*	Ground-low nesting, prefered breeding habitat; successional-scrub		
Elmendorf's onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations; flowering April-May		
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations, including disturbed areas; flowering spring-summer		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		

PE, PT - Federally Proposed Endangered/Threatened
C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Atascosa County, 8/26/99.

TABLE 2
THREATENED, ENDANGERED, AND RARE SPECIES OF BEXAR COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Black Spotted Newt	*Notophthalmus meridionalis*	Can be found in wet or sometimes wet areas, such as arroyos, canals, ditches, or even shallow depressions; aestivates in the ground during dry periods; Gulf Coastal Plain south of the San Antonio River		T
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; semi-troglobitic; found in springs and waters of caves in Bexar and Comal counties		T
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
Government Canyon Cave Spider	*Neoleptoneta microps*	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County	E	
Madla's Cave Spider	*Cicurina madla*	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County	E	
Robber Baron Cave Spider	*Cicurina baronia*	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County	E	
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Small, eyeless harvestman; karst features in north and northwest Bexar County	E	
Veni's Cave Spider	*Cicurina venii*	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County	E	
Vesper Cave Spider	*Cicurina vespera*	Small, eyeless, or essentially eyeless spider; karst features in north and northwest Bexar County	E	
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous & broad-leaved shrubs & trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level & required structure; nests mid April-late summer	E	E
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests placed in various trees other than the Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees & shrubs; nests late March-early summer	E	E
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/walking; likely to occur, but few records within this county		
Mountain Plover	*Charadrius montanus*	Nonbreeding-shortgrass plains and fields, plowed fields (bare, dirt fields), and sandy deserts; primarily insectivorous	PT	
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats		T
Whooping Crane	*Grus americana*	Potential migrant	E	E

TABLE 2 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF BEXAR COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain country, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Toothless Blindcat	*Trogloglanis pattersoni*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T
Widemouth Blindcat	*Satan eurystomus*	Troglobitic, blind catfish endemic to the San Antonio Pool of the Edwards Aquifer		T
A Ground Beetle	*Rhadine exilis*	Small, essentially eyeless ground beetle; karst features in north and northeast Bexar County	E	
A Ground Beetle	*Rhadine infernalis*	Small, essentially eyeless ground beetle; karst features in north and northeast Bexar County	E	
Helotes Mold Beetle	*Batrisodes venyivi*	Small, eyeless mold beetle; karst features in north and northwest Bexar County	E	
Maculated Manfreda Skipper	*Stallingsia maculosus*	Most skippers are small and stout-bodied; name derives from fast, erratic flight; at rest most skippers hold front and hind wings at different angles; skipper larvae are smooth, with the head and neck constricted; skipper larvae usually feed inside a leaf shelter and pupate in a cocoon made of leaves fastened together with silk		
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie		
Mimic Cavesnail	*Phreatodrobia imitata*	Subaquatic; only known from two wells penetrating the Edwards Aquifer		
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially within ca. 30 feet of water's edge	C	
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		

TABLE 2 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF BEXAR COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover		T
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creekbeds and seepage slopes of limestone canyons; flowering June-October		
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone, mostly on rocky slopes, in openings in juniper-oak woodlands; flowering April-May		
Correll's false dragon-head	*Physostegia correllii*	Wet soils including roadside ditches and irrigation channels; flowering June-July		
Elmendorf's onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations; flowering April-May		
Glass Mountain coral root	*Hexalectris nitida*	Mostly in mesic woodlands in canyons, but also in various lower elevations farther east; usually under oaks; flowering July-August		
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations, including disturbed areas; flowering spring-summer		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		
South Texas rushpea	*Caesalpinia phyllanthoides*	Tamaulipan thorn shrublands or grasslands on very shallow sandy to clayey soil over calcareous rock outcrops and caliche hills; flowering in spring		

PE, PT - Federally Proposed Endangered/Threatened
C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Bexar County, 8/26/99.

TABLE 3
THREATENED, ENDANGERED, AND RARE SPECIES OF CALDWELL COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	T	T
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/ walking; likely to occur, but few records within this county		
Mountain Plover	*Charadrius montanus*	Nonbreeding-shortgrass plains and fields, plowed fields (bare, dirt fields), and sandy deserts; primarily insectivorous	PT	
Whooping Crane	*Grus americana*	Potential migrant	E	E
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Blue Sucker	*Cycleptus elongatus*	Usually inhabits channels and flowing pools with a moderate current; bottom type usually consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles		T
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover		T

TABLE 3 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF CALDWELL COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone, mostly on rocky slopes, in openings in juniper-oak woodlands; flowering April-May		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		

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E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Caldwell County, 8/26/99.

TABLE 4
THREATENED, ENDANGERED, AND RARE SPECIES OF CALHOUN COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies		T
Snowy Plover	*Charadrius alexandrinus*	Gulf coastal beaches in Texas, avoids thick vegetation and narrow beaches; found worldwide		
Piping Plover	*Charadrius melodus*	Beaches and Mudflats	T	T
Reddish Egret	*Egretta rufescens*	Coastal wetland islands		T
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Whooping Crane	*Grus americana*	Potential migrant	E	E
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	T	T
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Eskimo Curlew	*Numenius borealis*	Coastal fields	E	E
Cerulean warbler	*Dendroica cerulea*	canopy-foraging insectivore breeds locally in mature deciduous forests with broken canopy		
Ferruginous hawk	*Buteo regalis*	open grassy prairies, pastures, hayland, cropland and dry mesas		
Loggerhead Shrike	*Lanius ludovicianus*	Mid-story/canopy nesting, semi-open country with lookout posts		
Brown Pelican	*Pelecanus occidentalis*	Gulf, salt bays and coastal areas	E	E
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats		T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Sooty Tern	*Sterna fuscata*	Coastal wetland islands		T
Red Wolf	*Canis rufus*	Oak-hickory-pine forest, southern riparian forest	E	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	E	E
Loggerhead Sea Turtle	*Caretta caretta*	Gulf coast, bay waters and beaches; scattered beach nesting	T	E
Scarlet Snake	*Cemophora coccinea*	Mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-September		T
Leatherback Sea Turtle	*Dermochelys coriacea*	Gulf coast, bay waters and beaches		
Green Sea Turtle	*Chelonia mydas*	Gulf coast, bay waters and beaches	T	T
Atlantic Hawksbill Sea Turtle	*Eretmochelys imbricata*	Gulf coast, bay waters and beaches	E	E

TABLE 4 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF CALHOUN COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Kemp's Ridley Sea Turtle	*Lepidochelys kempi*	Gulf coast, bay waters and beaches; scattered beach nesting	E	E
Texas diamondback terrapin	*Malaclemys terrapin littoralis*	Bays and Coastal marshes		
Gulf Saltmarsh Snake	*Nerodia clarkii*	Estuaries, beaches, crayfish and fiddler crab burrows		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

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E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Calhoun County, 4/24/98.

TABLE 5
THREATENED, ENDANGERED, AND RARE SPECIES OF COMAL COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Cascade Cavern Salamander	*Eurycea latitans*	Endemic; subaquatic; springs and caves in Comal, Kendall, and Kerr Counties		T
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; semi-troglobitic; found in springs and waters of caves in Bexar and Comal counties		T
Comal Springs Salamander	Eurycea sp. 8	Endemic; Comal Springs		
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous & broad-leaved shrubs & trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level & required structure; nests mid April-late summer	E	E
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests placed in various trees other than the Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees & shrubs; nests late March-early summer	E	E
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/walking; likely to occur, but few records within this county		
Whooping Crane	*Grus americana*	Potential migrant	E	E
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain country, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
Peck's Cave Amphipod	*Stygobromus pecki*	Small, aquatic crustacean; lives underground in the Edwards Aquifer; collected at Comal Springs and Hueco Springs	E	
Fountain Darter	*Etheostoma fonticola*	Known only from the San Marcos and Comal Rivers; springs and spring-fed streams in dense beds of aquatic plants growing close to bottom, which is normally mucky; feeding mostly diurnal; spawns year-round with August and late winter to early spring peaks		T
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Dryopids usually cling to objects in a stream; dryopids are sometimes found crawling on stream bottoms or along shores; adults may leave the stream and fly about, especially at night; most dryopid larvae are vermiform and live soil or decaying wood	E	
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Comal and San Marcos Springs	E	
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Habitat poorly known; known from an artesian well in Hays County		

TABLE 5 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF COMAL COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie		
Horseshoe Liptooth	*Polygyra hippocrepis*	Terrestrial snail known only from the steep, wooded hillsides of Landa Park in New Braunfels		
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially within ca. 30 feet of water's edge	C	
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone, mostly on rocky slopes, in openings in juniper-oak woodlands; flowering April-May		
Canyon mock-orange	*Philadelphus ernestii*	Solution-pitted outcrops of Cretaceous limestone on caprock along mesic canyons, usually in shade of mixed evergreen-deciduous canyon woodlands; flowering April-May, fruit maturing in September		
Hill country wild-mercury	*Argythamni aphoroides*	Shallow to moderately deep clays and clay loams over limestone, in grasslands associated with plateau live oak woodlands, mostly on rolling uplands; flowering April-May, fruit persisting until midsummer		
Lindheimer's tickseed	*Desmodium lindheimeri*	Known in Texas only from a specimen collected in 1850 by Ferdinand Lindheimer from an undetermined location presumed to by in Comal County; presumably flowering in mid-summer		
Texas Mock-orange	*Philadelphus texensis*	Endemic; limestone cliffs and boulders in mesic stream bottoms and canyons, usually in shade of mostly deciduous sloped forest; flowering April-May		

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E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Comal County, 10/5/99.

TABLE 6
THREATENED, ENDANGERED, AND RARE SPECIES OF DE WITT COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Whooping Crane	*Grus americana*	Potential migrant	E	E
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Loggerhead Shrike	*Lanius ludovicianus*	Mid-story/canopy nesting, semi-open country with lookout posts		
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially within ca. 30 feet of water's edge	C	
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

PE, PT - Federally Proposed Endangered/Threatened
C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. DeWitt County, 3/23/98.

TABLE 7
THREATENED, ENDANGERED, AND RARE SPECIES OF DIMMIT COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
South Texas Siren	*Siren sp 1*	Wet or temporally wet areas, arroyos, canals, ditches and shallow depressions; requires moisture		T
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	E	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	E	E
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Requires open brush-grasslands; thorn-scrub vegetation, usually on well-drained rolling terrain of shallow gravel, caliche, or sandy soils; often on scattered flat rocks below escarpments or isolated rock outcrops among scattered clumps of prickly pear and mesquite		T
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Dimmit Sunflower	*Helianthess praecos spp. Hirtus*	Known only to sands in Dimmit County, Rio Grande Plains		

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E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Dimmit County, 4/22/98.

TABLE 8
THREATENED, ENDANGERED, AND RARE SPECIES OF FRIO COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/ walking; likely to occur, but few records within this county		
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain country, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Frio Pocket Gopher	*Geomys texenis bakeri*	Associated with nearly level Atco soil, which is well-drained and consists of sandy surface layers with loam extending to as deep as two meters		
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	E	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	E	E
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie		
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Requires open brush-grasslands; thorn-scrub vegetation, usually on well-drained rolling terrain of shallow gravel, caliche, or sandy soils; often on scattered flat rocks below escarpments or isolated rock outcrops among scattered clumps of prickly pear and mesquite		T
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		

TABLE 8 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF FRIO COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Ferruginous hawk	*Buteo regalis*	open grassy prairies, pastures, hayland, cropland and dry mesas		
Loggerhead shrike	*Lanius ludovicianus*	Mid-story/canopy nesting, semi-open country with lookout posts		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		

PE, PT - Federally Proposed Endangered/Threatened
C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Frio County, 8/26/99.

TABLE 9
THREATENED, ENDANGERED, AND RARE SPECIES OF GOLIAD COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower South Texas Plains, Southern Coastal Prairie and marshes		T
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies		T
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Whooping Crane	*Grus americana*	Potential migrant	E	E
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	T	T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Native gulf coastal prairies of the coastal plains; 50% climax grass species composition	E	E
Red Wolf	*Canis rufus*	Oak-hickory-pine forest, southern riparian forest	E	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	E	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	E	E
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Runyon's Water-willow	*Justicia runyonii*	moist, wooded habitats		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

PE, PT - Federally Proposed Endangered/Threatened
C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Goliad County, 4/27/98.

TABLE 10
THREATENED, ENDANGERED, AND RARE SPECIES OF GONZALES COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Whooping Crane	*Grus americana*	Potential migrant	E	E
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover		T
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially within ca. 30 feet of water's edge	C	
Loggerhead Shrike	*Lanius ludovicianus*	Mid-story/canopy nesting, semi-open country with lookout posts		
Ferruginous hawk	*Buteo regalis*	open grassy prairies, pastures, hayland, cropland and dry mesas		
Palmetto pillsnail	*Euchemotrema cheatumi*	moist soil		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

PE, PT - Federally Proposed Endangered/Threatened
C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Gonzales County, 3/24/98

TABLE 11
THREATENED, ENDANGERED, AND RARE SPECIES OF GUADALUPE COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Whooping Crane	*Grus americana*	Potential migrant	E	E
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations, including disturbed areas; flowering spring-summer		
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creekbeds and seepage slopes of limestone canyons; flowering June-October		

PE, PT - Federally Proposed Endangered/Threatened
C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Guadalupe County, 3/24/9

TABLE 12
THREATENED, ENDANGERED, AND RARE SPECIES OF HAYS COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Blanco Blind Salamander	*Eurycea robusta*	Troglobitic; water-filled subterranean caverns; may inhabit deep levels of the Balcones aquifer to the north and east of the Blanco River		T
Blanco River Springs Salamander	*Eurycea pterophila*	Springs and caves in the Blanco River drainage in Blanco, Hays, and Kendall counties		
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
San Marcos Salamander	*Eurycea nana*	Headwaters of the San Marcos River downstream to ca. 1/2 mile past IH-35; water over gravelly substrate characterized by dense mats of algae (*Lyng bya*) and aquatic moss (*Lyeptodictym riparium*), and water temperatures of 21-22C; diet includes amphipods, midge larvae, and aquatic snails	T	T
Texas Blind Salamander	*Eurycea rathbuni*	Troglobitic; water-filled subterranean caverns along a six mile stretch of the San Marcos Spring Fault, in the vicinity of San Marcos; eats small invertebrates, including snails, copepods, amphipods, and shrimp	E	E
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous & broad-leaved shrubs & trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level & required structure; nests mid April-late summer	E	E
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests placed in various trees other than the Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees & shrubs; nests late March-early summer	E	E
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/walking; likely to occur, but few records within this county		
Whooping Crane	*Grus americana*	Potential migrant	E	E
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain country, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
Texas Cave Shrimp	*Palaemonetes antrorum*	Subterranean sluggish streams and ponds		
Ezell's Cave Amphipod	*Stygobromus flagellatus*	Known only from artesian wells		
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		

TABLE 12 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF HAYS COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Blue Sucker	*Cycleptus elongatus*	Usually inhabits channels and flowing pools with a moderate current; bottom type usually consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles		T
Fountain Darter	*Etheostoma fonticola*	Known only from the San Marcos and Comal Rivers; springs and spring-fed streams in dense beds of aquatic plants growing close to bottom, which is normally mucky; feeding mostly diurnal; spawns year-round with August and late winter to early spring peaks	E	E
San Marcos Gambusia	*Gambusia georgei*	Endemic; formerly known from upper San Marcos River; restricted to shallow quiet, mud-bottomed shoreline areas without dense vegetation in thermally constant main channel	E	E
Flint's Net-spinning Caddisfly	*Cheumatopsyche flinti*	Very poorly known species with habitat description limited to "a spring"		
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Habitat poorly known; known from an artesian well in Hays County		
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Comal and San Marcos Springs	E	
San Marcos Saddle-case Caddisfly	*Protoptila arca*	Known from the upper San Marcos River; locally very abundant; swift, well-oxygenated warm water about 1-2 m deep; larvae and pupal cases abundant on rocks		
Comal Springs Dryopid Beetle	*Stygopamus comalensis*	Dryopids usually cling to objects in a stream; dryopids are sometimes found crawling on stream bottoms or along shores; adults may leave the stream and fly about, especially at night; most dryopid larvae are vermiform and line soil or decaying wood	E	
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie		
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially within ca. 30 feet of water's edge	C	
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertabrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

TABLE 12 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF HAYS COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Hill country wild-mercury	*Argythamni aphoroides*	Shallow to moderately deep clays and clay loams over limestone, in grasslands associated with plateau live oak woodlands, mostly on rolling uplands; flowering April-May, fruit persisting until midsummer		
Warnock's coral root	*Hexalectris warnockii*	Leaf litter and humus in oak-juniper woodlands in mountain canyons in the Trans Pecos but at lower elevations to the east, often on narrow terraces along creekbeds		
Canyon mock-orange	*Philadelphus ernestii*	Solution-pitted outcrops of Cretaceous limestone on caprock along mesic canyons, usually in shade of mixed evergreen-deciduous canyon woodlands; flowering April-May, fruit maturing in September		
Texas wild-rice	*Zizania texana*	Perennial, emergent aquatic grass known only from the upper 4 km of the San Marcos River in Hays County	E	E

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E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Hays County, 10/5/99.

TABLE 13
THREATENED, ENDANGERED, AND RARE SPECIES OF KARNES COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Whooping Crane	*Grus americana*	Potential migrant	E	E
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Maculated Manfredo Skipper	*Stallingsia maculosus*	Most skippers are small and stout-bodied; name derives from fast, erratic flight; at rest most skippers hold front and hind wings at different angles; skipper larvae are smooth, with the head and neck constricted; skipper larvae usually feed inside a leaf shelter and pupate in a cocoon made of leaves fastened together with silk		
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	E	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	E	E
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

PE, PT - Federally Proposed Endangered/Threatened
C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Karnes County, 3/27/98.

TABLE 14
THREATENED, ENDANGERED, AND RARE SPECIES OF KENDALL COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Cascade Cavern Salamander	*Eurycea latitans*	Endemic; subaquatic; springs and caves in Comal, Kendall, and Kerr Counties		T
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
Blanco River Springs Salamander	*Eurycea pterophila*	Subaquatic; springs and caves in the Blanco River drainage in Blanco, Hays, and Kendall Counties		
Comal Blind Salamander	*Eurycea tridentifera*	Endemic; semi-troglobitic; found in springs and waters of caves in Bexar and Comal counties		T
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests placed in various trees other than the Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees & shrubs; nests late March-early summer	E	E
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Whooping Crane	*Grus americana*	Potential migrant	E	E
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	T	T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous & broad-leaved shrubs & trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level & required structure; nests mid April-late summer	E	E
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially within ca. 30 feet of water's edge	C	
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		

TABLE 14 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF KENDALL COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Edge Falls Anemone	*Anemone edwardsiana var. petraea*	Shallow to moderately deep clays and clay loams over limestone in grasslands associated with plateau live oak, on rolling uplands		
Hill country wild-mercury	*Argythamni aphoroides*	Shallow to moderately deep clays and clay loams over limestone, in grasslands associated with plateau live oak woodlands, mostly on rolling uplands; flowering April-May, fruit persisting until midsummer		
Canyon mock-orange	*Philadelphus ernestii*	Solution-pitted outcrops of Cretaceous limestone on caprock along mesic canyons, usually in shade of mixed evergreen-deciduous canyon woodlands; flowering April-May, fruit maturing in September		
Texas Mock-orange	*Philadelphus texensis*	Endemic; limestone cliffs and boulders in mesic stream bottoms and canyons, usually in shade of mostly deciduous sloped forest; flowering April-May		
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creekbeds and seepage slopes of limestone canyons; flowering June-October		

PE, PT - Federally Proposed Endangered/Threatened
C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Kendall County, 4/21/98.

TABLE 15
THREATENED, ENDANGERED, AND RARE SPECIES OF LA SALLE COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	E	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	E	E
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Prairie dawn-flower	*Hymenoxys texana*	prefers patches of dull gray barren sand, in sparsely vegetated slightly saline soils of the gulf coastal prairie grasslands	E	E
Audubon's oriole	*Icterus graduacauda audubonii*	Wet woodland thickets, open oak woodland, scrub and riparian thickets		
Loggerhead shrike	*Lanius ludovicianus*	Mid-story/canopy nesting, semi-open country with lookout posts		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Silvery Wild Mercury	*Argythamnia argyraea*	South Texas Plains, perennial herb, also in Atascosa, Kinney, and Maverick Counties		

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C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. La Salle County, 4/27/98.

TABLE 16
THREATENED, ENDANGERED, AND RARE SPECIES OF MEDINA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
Valdina Farms Sinkhole Salamander	*Eurycea troglodytes*	Isolated, intermittent pools of a subterranean stream; sinkhole located in Medina County		
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous & broad-leaved shrubs & trees provide insects for feeding; species composition less importatn than presence of adequate broad-leaved shrubs, foliage to ground level & required structure; nests mid April-late summer	E	E
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; depedent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest contruction; nests placed in various trees other than the Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees & shrubs; nests late March-early summer	E	E
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/ walking; likely to occur, but few records within this county		
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open decidious or pine-oak woodland, mesa or mountain country, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
Frio Pocket Gopher	*Geomys texenis bakeri*	Associated with nearly level Atco soil, which is well-drained and consists of sandy surface layers with loam extending to as deep as two meters		
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		

TABLE 16 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF MEDINA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone, mostly on rocky slopes, in openings in juniper-oak woodlands; flowering April-May		
Texas Mock-orange	*Philadelphus texensis*	Endemic; limestone cliffs and boulders in mesic stream bottoms and canyons, usually in shade of mostly deciduous sloped forest; flowering April-May		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		

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E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Medina County, 8/26/99.

TABLE 17
THREATENED, ENDANGERED, AND RARE SPECIES OF REFUGIO COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Sheep Frog	*Hypopachus variolosus*	Wet areas of the Rio Grande Valley, lower south Texas plains, coastal prairie and marshes		T
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Gulf Coast shoreline		
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; aestivates underground during dry periods		T
South Texas Siren	*Siren sp 1*	Wet or temporally wet areas, arroyos, canals, ditches and shallow depressions		T
Gulf Saltmarsh Snake	*Nerodia clarkii*	Estuaries, beaches, crayfish and fiddler crab burrows		
Mexican Treefrog	*Smilisca baudinii*	Rio Grande valley, vegetation in wet areas		T
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies		T
Piping Plover	*Charadrius melodus*	Beaches and Mudflats	T	T
Reddish Egret	*Egretta rufescens*	Coastal wetland islands		T
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Whooping Crane	*Grus americana*	Potential migrant	E	E
Rio Grande lesser siren	*Siren intermedia texana*	Wet or temporarily wet areas, arroyos, canals, ditches, and shallow depressions		
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	T	T
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Brown Pelican	*Pelecanus occidentalis*	Gulf Coast and salt bays	E	E
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats		T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Native gulf coastal prairies of the coastal plains; 50% climax grass species composition	E	E
Red Wolf	*Canis rufus*	Oak-hickory-pine forest, southern riparian forest	E	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	E	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	E	E
Scarlet Snake	*Cemophora coccinea*	Mixed hardwood scrub on sandy soils; feeds on reptile eggs; semi-fossorial; active April-Sep		T
Elmendorf's onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations		

TABLE 17 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF REFUGIO COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover		T
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban irrigated croplands; requires moist microhabitats, such as rodent burrows, for shelter		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-		T
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Loggerhead Sea Turtle	*Caretta caretta*	Gulf coast, bay waters and beaches; scattered beach nesting	T	E
Leatherback Sea Turtle	*Dermochelys coriacea*	Gulf coast, bay waters and beaches		
Green Sea Turtle	*Chelonia mydas*	Gulf coast, bay waters and beaches	T	T
Atlantic Hawksbill Sea Turtle	*Eretmochelys imbricata*	Gulf coast, bay waters and beaches	E	E
Kemp's Ridley Sea Turtle	*Lepidochelys kempi*	Gulf coast, bay waters and beaches; scattered beach nesting	E	E
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Texas Windmill Grass	*Chloris texensis*	Sandy to sandy loam soils in relatively bare areas in coastal prairie grassland remnants; also roadsides, with coastal prairie endemics is slightly saline soils in bare areas		
Black Lace Cactus	*Echinocerus reichenbachii var albertii*	Brushy, grassy areas with huisache, mesquite, blackbrush, retama, shrubs; South Texas Plains	E	E
Mountain Plover	*Charadrius montanus*	Nonbreeding-shortgrass plains and fields, plowed fields (bare, dirt fields), sandy deserts		
Texas olive sparrow	*Arremonops rufivirgatus rufivirgatus*	Ground-low nesting, prefered breeding habitat; successional-scrub		
Loggerhead shrike	*Lanius ludovicianus*	Mid-story/canopy nesting, semi-open country with lookout posts		
Northern gray hawk	*Buteo nitidus maximus*	open coastal grassy prairies		
Ferruginous hawk	*Buteo regalis*	open grassy prairies, pastures, hayland, cropland and dry mesas		
Cerulean warbler	*Dendroica cerulea*	canopy-foraging insectivore breeds locally in mature deciduous forests with broken canopy		
Black rail	*Laterallus jamaicensis*	Coastal wetlands		
Black tern	*Chlidonias niger*	Coastal wetlands		
Welder Machaeranthera	*Machaeranthera heterocarpa*	Shrub grasslands; grows on mostly clayey to silty soils over Beaumont-Lissie Formations		

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E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Refugio County, 3/27/98.

TABLE 18
THREATENED, ENDANGERED, AND RARE SPECIES OF UVALDE COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Edwards Plateau Spring Salamanders	*Eurycea sp. 7*	Endemic; troglobitic; springs, seeps, cave streams, and creek headwaters; often hides under rocks and leaves in water; Edwards Plateau, from near Austin to Val Verde County		
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain country, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
Golden-cheeked Warbler	*Dendroica chrysoparia*	Juniper-oak woodlands; dependent on Ashe juniper (also known as cedar) for long fine bark strips, only available from mature trees, used in nest construction; nests placed in various trees other than the Ashe juniper; only a few mature junipers or nearby cedar brakes can provide the necessary nest material; forage for insects in broad-leaved trees & shrubs; nests late March-early summer	E	E
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Black-capped Vireo	*Vireo atricapillus*	Oak-juniper woodlands with distinctive patchy, two-layered aspect; shrub and tree layer with open, grassy spaces; requires foliage reaching to ground level for nesting cover; return to same territory, or one nearby, year after year; deciduous & broad-leaved shrubs & trees provide insects for feeding; species composition less important than presence of adequate broad-leaved shrubs, foliage to ground level & required structure; nests mid April-late summer	E	E
Blue Sucker	*Cycleptus elongatus*	Usually inhabits channels and flowing pools with a moderate current; bottom type usually consists of exposed bedrock, perhaps in combination with hard clay, sand, and gravel; adults winter in deep pools and move upstream in spring to spawn on riffles		T
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Flint's Net-spinning Caddisfly	*Cheumatopsyche flinti*	Very poorly known species with habitat description limited to "a spring"		
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	E	E
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	E	E
Frio Pocket Gopher	*Geomys texensis bakeri*	Associated with nearly level Atco soil, which is well-drained and consists of sandy surface layers with loam extending to as deep as two meters		

TABLE 18 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF UVALDE COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
White-nosed Coati	*Nasua narica*	Arid open plains; Rio Grande plains in woodlands		T
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Requires open brush-grasslands; thorn-scrub vegetation, usually on well-drained rolling terrain of shallow gravel, caliche, or sandy soils; often on scattered flat rocks below escarpments or isolated rock outcrops among scattered clumps of prickly pear and mesquite		T
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Tobusch Fishhook Cactus	*Ancistrocactus tobuschii*	Gravel terraces along drainages, limestone ledges, ridges, and rocky hills in openings of live oak-juniper woodland	E	E
Hill country wild-mercury	*Argythamni aphoroides*	Shallow to moderately deep clays and clay loams over limestone, in grasslands associated with plateau live oak woodlands, mostly on rolling uplands; flowering April-May, fruit persisting until midsummer		
Sabinal Prairie Clover	*Dalea sabinalis*	Edwards Plateau, isolated local		
Sonora Fleabane	*Erigeron mimegletes*	Grasslands in shallow clay soils over limestone, possibly more frequent in areas poorly drained during spring		
Texas Grease Bush	*Forsellesia texensis*	Dry limestone ledges and chalk bluffs above Nueces River; isolated		
Texas Mock-orange	*Philadelphus texensis*	Endemic; limestone cliffs and boulders in mesic stream bottoms and canyons, usually in shade of mostly deciduous sloped forest; flowering April-May		
Bracted twistflower	*Streptanthus bracteatus*	Endemic; shallow clay soils over limestone, mostly on rocky slopes, in openings in juniper-oak woodlands; flowering April-May		

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E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

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Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Uvalde County, 4/30/98.

TABLE 19
THREATENED, ENDANGERED, AND RARE SPECIES OF VICTORIA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Black-spotted Newt	*Notophthalmus meridionalis*	Wet or temporally wet areas such as arroyos, canals, ditches and shallow depressions; aestivates underground during dry periods		T
White-tailed Hawk	*Buteo albicaudatus*	Grasslands and coastal prairies		T
Reddish Egret	*Egretta rufescens*	Coastal wetland islands		T
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Whooping Crane	*Grus americana*	Potential migrant	E	E
Bald Eagle	*Haliaeetus leucocephalus*	Found primarily near seacoasts, rivers, and large lakes; nests in tall trees or on cliffs near water; communally roosts, especially in winter; hunts live prey, scavenges, and pirates food from other birds	T	T
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Eskimo Curlew	*Numenius borealis*	Coastal fields	E	E
Brown Pelican	*Pelecanus occidentalis*	Gulf Coast and salt bays	E	E
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats		T
Interior Least Tern	*Sterna antillarum athalassos*	Large river sandbars	E	E
Attwater's Prairie-Chicken	*Tympanuchus cupido attwateri*	Native gulf coastal prairies of the coastal plains; 50% climax grass species composition	E	E
Guadalupe Bass	*Micropterus treculi*	Endemic; headwater, perennial streams of the Edwards Plateau region		
Red Wolf	*Canis rufus*	Oak-hickory-pine forest, southern riparian forest	E	E
Timber/Canebrake Rattlesnake	*Crotalus horridus*	Swamps, floodplains, upland pine and deciduous woodlands, riparian zones, abandoned farmland; limestone bluffs, sandy soil or black clay; prefers dense ground cover		T
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Diamondback Terrapin	*Malaclemys terrapin littoralis*	Gulf Coast shoreline		
Gulf Saltmarsh Snake	*Nerodia clarkii*	Estuaries, beaches, crayfish and fiddler crab burrows		

TABLE 19 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF VICTORIA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Cagle's Map Turtle	*Graptemys caglei*	Endemic; Guadalupe River System; short stretches of shallow water with swift to moderate flow and gravel or cobble bottom, connected by deeper pools with a slower flow rate and a silt or mud bottom; gravel bar riffles and transition areas between riffles and pools especially within ca. 30 feet of water's edge	C	
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T
Mountain Plover	*Charadrius montanus*	Nonbreeding-shortgrass plains and fields, plowed fields (bare, dirt fields), and sandy deserts; primarily insectivorous		
Ferruginous hawk	*Buteo regalis*	open grassy prairies, pastures, hayland, cropland and dry mesas		
Loggerhead shrike	*Lanius ludovicianus*	Mid-story/canopy nesting, semi-open country with lookout posts		
Welder Machaeranthera	*Machaeranthera heterocarpa*	Shrub invaded grasslands; grows on mostly clayey to silty soils over Beaumont-Lissie Formations		

PE, PT - Federally Proposed Endangered/Threatened
C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Victoria County, 3/27/98.

TABLE 20
THREATENED, ENDANGERED, AND RARE SPECIES OF WILSON COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Henslow's Sparrow	*Ammodramus henslowii*	Wintering individuals (not flocks) found in weedy fields or cut-over areas where lots of bunch grasses occur along with vines and branches; a key component is bare ground for running/walking; likely to occur, but few records within this county		
Mountain Plover	*Charadrius montanus*	Nonbreeding-shortgrass plains and fields, plowed fields (bare, dirt fields), and sandy deserts; primarily insectivorous	PT	
White-faced Ibis	*Plegadis chihi*	Prefers freshwater marshes, sloughs, and irrigated rice fields, but will attend brackish and saltwater habitats; nests in marshes, in low trees, on the ground in bulrushes or reeds, or on floating mats		T
Whooping Crane	*Grus americana*	Potential migrant	E	E
Wood Stork	*Mycteria americana*	Forages in prairie ponds, flooded pastures or fields, ditches, and other shallow standing water, including salt-water; usually roosts communally in tall snags, sometimes in association with other wading birds; breeds in Mexico and birds move into Gulf States in search of mud flats and other wetlands, even those associated with forested areas; formerly nested in Texas, but no breeding records since 1960		T
Maculated Manfreda Skipper	*Stallingsia maculosus*	Most skippers are small and stout-bodied; name derives from fast, erratic flight; at rest most skippers hold front and hind wings at different angles; skipper larvae are smooth, with the head and neck constricted; skipper larvae usually feed inside a leaf shelter and pupate in a cocoon made of leaves fastened together with silk		
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	E	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	E	E
Plains Spotted Skunk	*Spilogale putorius interrupta*	Open fields, prairies, croplands, fence rows, farmyards, forest edges, and woodlands; prefers wooded, brushy areas and tallgrass prairie		
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

TABLE 20 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF WILSON COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Big red sage	*Salvia penstemonoides*	Endemic; moist to seasonally wet clay or silt soils in creekbeds and seepage slopes of limestone canyons; flowering June-October		
Elmendorf's onion	*Allium elmendorfii*	Endemic; deep sands derived from Queen City and similar Eocene formations; flowering April-May		
Loggerhead shrike	*Lanius ludovicianus*	Mid-story/canopy nesting, semi-open country with lookout posts		
Park's jointweed	*Polygonella parksii*	Endemic; deep loose sands of Carrizo and similar Eocene formations, including disturbed areas; flowering spring-summer		

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E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Wilson County, 8/26/99.

TABLE 21
THREATENED, ENDANGERED, AND RARE SPECIES OF ZAVALA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
American Peregrine Falcon	*Falco peregrinus anatum*	Potential migrant; nests in west Texas		E
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	Due to similar field characteristics, treat all Peregrine Falcons with same listing status; potential migrant		T
Zone-tailed Hawk	*Buteo albonotatus*	Arid open country, including open deciduous or pine-oak woodland, mesa or mountain country, often near watercourses, and wooded canyons and tree-lined rivers along middle-slopes of desert mountains; nests in various habitats and sites, ranging from small trees in lower desert, giant cottonwoods in riparian areas, to mature conifers in high mountain regions		T
Cave Myotis Bat	*Myotis velifer*	Colonial and cave-dwelling; also roosts in rock crevices, old building, carports, under bridges, and even in abandoned Cliff Swallow (*Hirundo pyrrhonota*) nests; roosts in clusters of up to thousands of individuals; hibernates in limestone caves of Edwards Plateau and gypsum cave of Panhandle during winter; opportunistic insectivore		
Frio Pocket Gopher	*Geomys texenis bakeri*	Associated with nearly level Atco soil, which is well-drained and consists of sandy surface layers with loam extending to as deep as two meters		
Jaguarundi	*Felis yaguarondi*	Thick brushlands, near water favored; six month gestation, young born twice per year in March and August	E	E
Ocelot	*Felis pardalis*	Dense chaparral thickets; mesquite-thorn scrub and live oak mottes; avoids open areas; breeds and raises young June-November	E	E
Yuma Myotis Bat	*Myotis yumanensis*	Desert regions; most commonly found in lowland habitats near open water, where forages; roosts in caves, abandoned mine tunnels, and buildings; season of parts is May to early June; usually only one young born to each female		
Indigo Snake	*Drymarchon corais*	Texas south of the Guadalupe River and Balcones Escarpment; thornbush-chaparral woodlands of south Texas, in particular dense riparian corridors; can do well in suburban and irrigated croplands if not molested or indirectly poisoned; requires moist microhabitats, such as rodent burrows, for shelter		T
Keeled Earless Lizard	*Holbrookia propinqua*	Coastal dunes, barrier islands, and other sandy areas; eats insects and likely other small invertebrates; eggs laid underground March-September (most May-August)		
Reticulate Collared Lizard	*Crotaphytus reticulatus*	Requires open brush-grasslands; thorn-scrub vegetation, usually on well-drained rolling terrain of shallow gravel, caliche, or sandy soils; often on scattered flat rocks below escarpments or isolated rock outcrops among scattered clumps of prickly pear and mesquite		T
Spot-tailed Earless Lizard	*Holbrookia lacerata*	Central & southern Texas and Adjacent Mexico; oak-juniper woodlands & mesquite-prickly pear associations; eggs laid underground; eats small invertebrates		
Texas Garter Snake	*Thamnophis sirtalis annectens*	Wet or moist microhabitats are conducive to the species occurrence, but is not necessarily restricted to them; hibernates underground or in or under surface cover; breeds March-August		
Texas Horned Lizard	*Phrynosoma cornutum*	Open, arid and semi-arid regions with sparse vegetation, including grass, cactus, scattered brush or scrubby trees; soil may vary in texture from sandy to rocky; burrows into soil, enters rodent burrows, or hides under rocks when inactive; breeds March-September		T

TABLE 21 (CONTINUED)
THREATENED, ENDANGERED, AND RARE SPECIES OF ZAVALA COUNTY

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Texas Tortoise	*Gopherus berlandieri*	Open brush with a grass understory is preferred; open grass and bare ground are avoided; when inactive occupies shallow depressions at base of bush or cactus, sometimes in underground burrows or under objects; longevity greater than 50 years; active March-November; breeds April-November		T
Loggerhead shrike	*Lanius ludovicianus*	Mid-story/canopy nesting, semi-open country with lookout posts		
Mexican hooded oriole	*Icterus cucullatus cucullatus*	open woods, shade trees, palms		
Rio Grande lesser siren	*Siren intermedia texana*	Wet or temporarily wet areas, arroyos, canals, ditches, and shallow depressions; requires moisture		
Sandhill woolywhite	*Hymenopappus carrizoanus*	Endemic; open areas in deep sands derived from Carrizo and similar Eocene formations, including disturbed areas; flowering late spring-fall		

PE, PT - Federally Proposed Endangered/Threatened
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Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Source: Texas Biological and Conservation Data System. Texas Parks and Wildlife Department, Endangered Resources Branch. County lists of Texas' Special Species. Zavala County, 8/26/99.

Appendix E

Edwards Aquifer Dependent Species and Karst Geology Associated Species

TABLE 1
EDWARDS AQUIFER DEPENDENT SPECIES AND KARST GEOLOGY ASSOCIATED SPECIES

Common Name	Scientific Name	Habitat Preference	Federal Status	State Status
Texas Blind Salamander	*Eurycea rathbuni*	Edwards Aquifer springs and caves, thermally stable; troglobitic	E	E
Blanco Blind Salamander	*Eurycea robusta*	Blanco River; troglobitic; gravel bed of Dry Blanco only occurrence;		T
Comal Blind Salamander	*Eurycea tridentifera*	Honey Creek and limestone caves		T
Cascade Cavern Salamander	*Eurycea latitanus*	Cascade Caverns		T
San Marcos Salamander	*Eurycea nana*	San Marcos River and springs; under rocks and matted stream vegetation	T	T
Fountain Darter	*Etheostoma fonticola*	San Marcos River to confluence with Blanco River	E	E
San Marcos Gambusia	*Gambusia georgei*	San Marcos River to confluence with Blanco River	E	E
Widemouth Blindcat	*Satan eurystomus*	Edwards Aquifer; from artesian wells in Bexar Co.; troglobitic		T
Toothless Blindcat	*Trogloglanis pattersoni*	Edwards Aquifer; from artesian wells in Bexar Co.; troglobitic		T
Texas Cave Shrimp	*Palaemonetes antrorum*	Ezells's Cave and Edwards Aquifer subterranean caverns		
Robber Baron Cave Harvestman	*Texella cokendolpheri*	Karst features in north and northwest Bexar County	E	
Helotes Mold Beetle	*Bartrisodes venyivi*	Karst features in north and northwest Bexar County	E	
A Ground Beetle	*Rhadine exilis*	Karst features in north and northwest Bexar County	E	
A Ground Beetle	*Rhadine infernalis*	Karst features in north and northwest Bexar County	E	
Robber Baron Cave Spider	*Cicurina baronia*	Karst features in north and northwest Bexar County	E	
Madl's Cave Spider	*Cicurina madla*	Karst features in north and northwest Bexar County	E	
(no common name)	*Cicurina venii*	Karst features in north and northwest Bexar County	E	
Vesper Caver Spider	*Cicurina vespera*	Karst features in north and northwest Bexar County	E	
Government Canyon Cave Spider	*Neoleptoneta microps*	Karst features in north and northwest Bexar County	E	
Comal Springs Riffle Beetle	*Heterelmis comalensis*	Comal Springs	E	
Comal Springs Dryopid Beetle	*Stygoparnus comalensis*	Comal Springs	E	
Ezell's Cave Amphipod	*Stygobromus flagellatus*	Ezells's Cave and Edwards Aquifer subterranean caverns		
Flint's Net-spinning Caddisfly	*Cheumatopsyche flinti*	Honey Creek		
Peck's Cave Amphipod	*Stygobromus pecki*	Comal Springs	E	
San Marcos Saddle-case Caddisfly	*Protoptila arca*	San Marcos River		
Edwards Aquifer Diving Beetle	*Haideoporus texanus*	Edwards Aquifer subterranean caverns		
Texas Wildrice	*Zizania texana*	San Marcos River to confluence with Blanco River	E	E

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C - Federal Candidate; information supports proposing to list as endangered/threatened
E, T - State Endangered/Threatened
"blank" - Rare, but with no regulatory listing status

Species appearing on these lists do not all share the same probability of occurrence. Some species are migrants or wintering residents only, or may be historic or considered extirpated.

Appendix F

Application of Consensus Environmental Criteria

Table F-1
Daily Natural Streamflow Statistics for Section 1.5
L-14 Transfer of Water to Corpus Christi (San Antonio River @ Falls City)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	229.4	197.1*
February	231.4	197.1*
March	230.9	197.1*
April	217.3	197.1*
May	258.1	197.1*
June	236.5	197.1*
July	197.1*	197.1*
August	197.1*	197.1*
September	197.1*	197.1*
October	197.1*	197.1*
November	197.1*	197.1*
December	208.7	197.1*
Zone 3 Pass-Through Requirement (cfs)		197.1

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow and Median Flow.

Table F-2
Daily Natural Streamflow Statistics for Section 1.11
SCTN-10b Off-Channel Local Storage (Guadalupe River near Boerne)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	185.5	98.3*
February	200.2	98.3*
March	193.6	98.3*
April	187.5	98.3*
May	212.8	98.3*
June	169.9	98.3*
July	127.6	98.3*
August	127.6	98.3*
September	127.6	98.3*
October	161.8	98.3*
November	177.0	98.3*
December	189.6	98.3*
Zone 3 Pass-Through Requirement (cfs)		98.3

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-3
Daily Natural Streamflow Statistics for Section 2.1
L-17A Edwards Recharge - Type I Projects (Concan)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	68.1	45.4*
February	70.1	50.4
March	67.1	48.9
April	72.1	46.9
May	71.6	47.9
June	69.1	45.4*
July	55.5	45.4*
August	47.9	45.4*
September	51.4	45.4*
October	69.6	45.4*
November	76.1	45.4*
December	73.6	46.9
Zone 3 Pass-Through Requirement (cfs)		45.4

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-4
Daily Natural Streamflow Statistics for Section 2.1
L-17A Edwards Recharge - Type I Projects (Montell)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	80.7	52.9
February	77.1	53.9
March	80.2	53.9
April	80.2	52.4
May	87.2	56.0
June	80.7	48.4
July	69.1	36.8
August	54.4	35.3*
September	55.0	35.3*
October	89.2	36.3
November	93.3	42.9
December	84.2	52.4
Zone 3 Pass-Through Requirement (cfs)		35.3

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-5
Daily Natural Streamflow Statistics for Section 2.1
L-17A Edwards Recharge - Type I Projects (Upper Blanco)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	67.6	31.8*
February	72.1	38.8
March	76.6	31.8*
April	93.3	35.3
May	106.4	49.4
June	104.4	55.5
July	60.5	31.8*
August	39.3	31.8*
September	50.4	31.8*
October	55.0	31.8*
November	55.5	31.8*
December	64.0	31.8*
Zone 3 Pass-Through Requirement (cfs)		31.8

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-6
Daily Natural Streamflow Statistics for Section 2.1
L-17A Edwards Recharge - Type I Projects (Upper Hondo)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	9.6	3.5
February	10.1	4.0
March	10.1	3.5
April	13.1	3.5
May	19.2	5.5
June	18.7	4.0
July	11.6	2.5*
August	7.6	2.5*
September	8.1	2.5*
October	10.1	2.5*
November	9.1	3.0
December	9.6	3.5
Zone 3 Pass-Through Requirement (cfs)		2.5

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-7
Daily Natural Streamflow Statistics for Section 2.1
L-17A Edwards Recharge - Type I Projects (Upper Sabinal)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	25.2	11.1
February	29.2	11.1
March	26.2	10.1
April	25.2	11.1
May	32.3	12.1
June	30.2	8.6*
July	17.6	8.6*
August	13.1	8.6*
September	14.1	8.6*
October	23.2	8.6*
November	25.2	8.6*
December	27.2	9.1
Zone 3 Pass-Through Requirement (cfs)		8.6

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-8
Daily Natural Streamflow Statistics for Section 2.1
L-17A Edwards Recharge - Type I Projects (Upper Verde)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	3.5	0.5
February	4.5	0.5
March	3.5	0.5
April	5.5	1.0
May	10.1	1.5
June	8.1	0.5
July	1.5	0.0
August	1.5	0.0
September	2.5	0.0
October	2.0	0.0
November	0.5	0.0
December	3.5	0.0
Zone 3 Pass-Through Requirement (cfs)		0.0

Table F-9
Daily Natural Streamflow Statistics for Section 2.1
L-17B Edwards Recharge - Type I Projects (Upper Dry Frio)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	13.6	8.1
February	14.1	9.1
March	13.6	8.6
April	14.1	8.1
May	16.6	8.1
June	16.1	5.0
July	11.1	4.0*
August	8.1	4.0*
September	8.6	4.0*
October	15.1	5.0
November	15.1	6.6
December	15.1	7.6
Zone 3 Pass-Through Requirement (cfs)		4.0

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-10
Daily Natural Streamflow Statistics for Section 2.2
L-18A Edwards Recharge - Type II Projects (Indian Creek)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	25.2	22.2*
February	23.7	22.2*
March	22.2*	22.2*
April	23.2	22.2*
May	26.2	22.2*
June	28.2	22.2*
July	29.2	22.2*
August	28.2	22.2*
September	24.7	22.2*
October	30.8	22.2*
November	30.2	22.2*
December	27.2	22.2*
Zone 3 Pass-Through Requirement (cfs)		22.2

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow and Median Flow.

Table F-11
Daily Natural Streamflow Statistics for Section 2.2
L-18A Edwards Recharge - Type II Projects (Lower Blanco)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	40.3	14.6*
February	51.4	14.6*
March	45.4	14.6*
April	67.6	15.1
May	76.1	23.2
June	68.1	27.7
July	37.3	14.6*
August	16.6	14.6*
September	24.2	14.6*
October	29.2	14.6*
November	29.2	14.6*
December	40.3	14.6*
Zone 3 Pass-Through Requirement (cfs)		14.6

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-12
Daily Natural Streamflow Statistics for Section 2.4
G-30 Guadalupe River Diversion to Recharge Zone via Medina (Guadalupe River @ Comfort)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	110.5	98.4*
February	119.2	98.4*
March	115.2	98.4*
April	111.7	98.4*
May	126.7	98.4*
June	101.2	98.4*
July	98.4*	98.4*
August	98.4*	98.4*
September	98.4*	98.4*
October	98.4*	98.4*
November	105.6	98.4*
December	113.0	98.4*
Zone 3 Pass-Through Requirement (cfs)		98.4

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow and Median Flow.

Table F-13
Daily Natural Streamflow Statistics for Section 2.6
SCTN-6 Recirculation (Guadalupe River @ Dunlap)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	567.7	390.2
February	591.9	409.4
March	598.9	396.8
April	606.5	399.8
May	717.9	406.4
June	644.3	370.1
July	507.7	301.0
August	435.6	281.8
September	472.9	335.3
October	517.8	339.3
November	515.3	349.9
December	569.2	369.5
Zone 3 Pass-Through Requirement (cfs)*		221.8

* HDR, "Guadalupe-San Antonio River Basin Environmental Criteria Refinement," Trans-Texas Water Program, West Central Study Area, Plan II, San Antonio River Authority, et.al., March 1998.

Table F-14
Daily Natural Streamflow Statistics for Section 2.6
SCTN-6 Recirculation (Guadalupe River @ Gonzales)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	820.8	580.3
February	887.3	610.0
March	867.2	585.8
April	923.6	581.3
May	1068.8	625.7
June	944.8	576.3
July	755.2	455.8
August	640.8	427.5
September	691.7	500.6
October	733.0	500.1
November	742.6	521.8
December	793.5	547.0
Zone 3 Pass-Through Requirement (cfs)*		317.1

* HDR, "Guadalupe-San Antonio River Basin Environmental Criteria Refinement," Trans-Texas Water Program, West Central Study Area, Plan II, San Antonio River Authority, et.al., March 1998.

Table F-15
Daily Natural Streamflow Statistics for Section 3.1
G-38C Guadalupe River Diverisons (Guadalupe River @ Gonzales)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	820.8	580.3
February	887.3	610.0
March	867.2	585.8
April	923.6	581.3
May	1068.8	625.7
June	944.8	576.3
July	755.2	455.8
August	640.8	427.5
September	691.7	500.6
October	733.0	500.1
November	742.6	521.8
December	793.5	547.0
Zone 3 Pass-Through Requirement (cfs)*		317.1

* HDR, "Guadalupe-San Antonio River Basin Environmental Criteria Refinement," Trans-Texas Water Program, West Central Study Area, Plan II, San Antonio River Authority, et.al., March 1998.

Table F-16
Daily Natural Streamflow Statistics for Section 3.2
SCTN-16 Guadalupe River Diversions (Guadalupe River @ Saltwater Barrier)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	1476.7	899.4
February	1670.3	998.7
March	1483.2	927.1
April	1513.0	913.5
May	1962.7	1038.1
June	1814.5	961.9
July	1278.5	742.1*
August	1002.3	742.1*
September	1223.6	742.1*
October	1360.7	745.7
November	1364.8	861.1
December	1355.7	836.9
Zone 3 Pass-Through Requirement (cfs)		742.1

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-17
Daily Natural Streamflow Statistics for Section 3.6
SCTN-20b & SCTN-20c Colorado River Diversions (Colorado River @ Bay City)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	761.4	362.9
February	1226.6	545.1
March	1052.3	408.0
April	990.6	364.2
May	1745.4	851.6
June	1348.0	514.5
July	599.2	256.5
August	414.1	206.8
September	677.9	405.3
October	821.9	330.7
November	733.9	344.9
December	948.9	392.5
Zone 3 Pass-Through Requirement (cfs)		115.3

Table F-18
Daily Natural Streamflow Statistics for Section 4.3
SCTN-14b Joint Development (San Antonio River @ Falls City)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	229.4	197.1*
February	231.4	197.1*
March	230.9	197.1*
April	217.3	197.1*
May	258.1	197.1*
June	236.5	197.1*
July	197.1*	197.1*
August	197.1*	197.1*
September	197.1*	197.1*
October	197.1*	197.1*
November	197.1*	197.1*
December	208.7	197.1*
Zone 3 Pass-Through Requirement (cfs)		197.1

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow and Median Flow.

Table F-19
Daily Natural Streamflow Statistics for Section 5.1
S-15C, S-15Da, S-15Db, S-15Dc, S-15Ea, & S-15Eb Cibolo Reservoir (Cibolo Creek)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	21.8	15.5
February	21.9	15.7
March	21.8	15.4
April	21.1	13.8
May	24.3	12.9
June	23.6	10.8
July	16.2	10.0*
August	13.0	10.0*
September	15.4	10.0*
October	17.9	10.5
November	21.1	12.4
December	21.2	13.5
Zone 3 Pass-Through Requirement (cfs)		10.0

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-20
Daily Natural Streamflow Statistics for Section 5.2
S-15Da, S-15Db, & S-15Dc Cibolo Reservoir Diversion Point (San Antonio River @ Floresville)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	172.8	148.5*
February	174.3	148.5*
March	174.0	148.5*
April	163.7	148.5*
May	194.5	148.5*
June	178.1	148.5*
July	148.5*	148.5*
August	148.5*	148.5*
September	148.5*	148.5*
October	148.5*	148.5*
November	148.5*	148.5*
December	157.3	148.5*
Zone 3 Pass-Through Requirement (cfs)		148.5

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow and Median Flow.

Table F-21
Daily Natural Streamflow Statistics for Section 5.2
S-15Db & S-15Dc Cibolo Reservoir Diversion Point (Guadalupe River @ Cuero)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	983.6	603.5
February	1050.7	661.5
March	1046.1	637.3
April	1078.9	626.2
May	1295.2	694.7
June	1170.2	624.1
July	865.1	491.1
August	676.6	361.0
September	749.2	432.1
October	837.4	496.1
November	866.6	552.6
December	897.9	581.8
Zone 3 Pass-Through Requirement (cfs)*		317.1

* HDR, "Guadalupe-San Antonio River Basin Environmental Criteria Refinement," Trans-Texas Water Program, West Central Study Area, Plan II, San Antonio River Authority, et.al., March 1998.

Table F-22
Daily Natural Streamflow Statistics for Section 5.3
S-15Ea & S-15Eb Cibolo Reservoir Diversion Point (Guadalupe River @ Saltwater Barrier

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	1476.7	899.4
February	1670.3	998.7
March	1483.2	927.1
April	1513.0	913.5
May	1962.7	1038.1
June	1814.5	961.9
July	1278.5	742.1*
August	1002.3	742.1*
September	1223.6	742.1*
October	1360.7	745.7
November	1364.8	861.1
December	1355.7	836.9
Zone 3 Pass-Through Requirement (cfs)		742.1

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-23
Daily Natural Streamflow Statistics for Section 5.4
S-16C Goliad Reservoir (San Antonio River @ Goliad)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	294.2	211.2*
February	306.6	211.2*
March	306.8	211.2*
April	305.8	211.2*
May	371.0	211.2*
June	346.3	211.2*
July	241.8	211.2*
August	211.2*	211.2*
September	239.9	211.2*
October	258.0	211.2*
November	283.0	211.2*
December	288.9	211.2*
Zone 3 Pass-Through Requirement (cfs)		211.2

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow and Median Flow.

Table F-24
Daily Natural Streamflow Statistics for Section 5.5
S-14D Applewhite Reservoir (Medina River near Somerset)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	99.8	48.0
February	104.6	59.4
March	97.1	55.3
April	103.3	57.3
May	115.5	59.8
June	123.9	42.1
July	71.1	42.0*
August	61.4	42.0*
September	76.1	42.0*
October	96.1	58.2
November	85.7	48.7
December	95.3	51.7
Zone 3 Pass-Through Requirement (cfs)		42.0

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-25
Daily Natural Streamflow Statistics for Section 5.6
G-19 Guadalupe River Dam No 7 (Guadalupe River above Spring Branch)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	145.7	81.7*
February	152.3	81.7*
March	163.9	81.7*
April	155.3	87.7
May	201.7	81.7*
June	164.9	81.7*
July	101.3	81.7*
August	81.7*	81.7*
September	98.3	81.7*
October	126.0	81.7*
November	126.5	81.7*
December	145.2	81.7*
Zone 3 Pass-Through Requirement (cfs)		81.7

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow and Median Flow.

Table F-26
Daily Natural Streamflow Statistics for Section 5.7
G-20 Gonzales Reservoir (San Marcos River upstream of Confluence w/ Guadalupe River)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	225.4	161.3*
February	248.0	161.3*
March	234.4	161.3*
April	267.7	161.3*
May	308.5	161.3*
June	272.2	161.3*
July	201.2	161.3*
August	169.4	161.3*
September	182.5	161.3*
October	186.0	161.3*
November	193.1	161.3*
December	212.8	161.3*
Zone 3 Pass-Through Requirement (cfs)		161.3

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-27
Daily Natural Streamflow Statistics for Section 5.8
G-21 Lockhart Reservoir (Plum Creek near Lockhart)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	14.1	7.1
February	18.1	8.1
March	14.6	6.6
April	12.1	5.5
May	16.1	5.5
June	12.1	4.0
July	5.0	2.0*
August	2.0	2.0*
September	4.0	2.0*
October	5.5	2.0*
November	8.1	4.0
December	10.1	5.0
Zone 3 Pass-Through Requirement (cfs)		2.0

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-28
Daily Natural Streamflow Statistics for Section 5.9
G-22 Dilworth Reservoir (Peach Creek @ Dilworth)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	10.1	0.5*
February	12.1	2.0
March	10.1	0.5*
April	5.0	0.5*
May	13.1	1.0
June	8.1	0.5*
July	1.0	0.5*
August	0.5*	0.5*
September	0.5*	0.5*
October	0.5*	0.5*
November	3.5	0.5*
December	5.0	0.5*
Zone 3 Pass-Through Requirement (cfs)		0.5

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow and Median Flow.

Table F-29
Daily Natural Streamflow Statistics for Section 5.10
G-40 Cloptin Crossing Reservoir (Blanco River near Wimberley)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	52.9	31.8*
February	61.0	31.8*
March	69.1	31.8*
April	81.2	31.8*
May	84.2	37.3
June	81.2	38.8
July	53.9	31.8*
August	32.8	31.8*
September	40.8	31.8*
October	48.4	31.8*
November	46.9	31.8*
December	52.9	31.8*
Zone 3 Pass-Through Requirement (cfs)		31.8

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-30
Daily Natural Streamflow Statistics for Section 5.11
G-17C1 Sandies Creek Reservoir (Sandies Creek near Lindenau)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	16.6	10.6
February	19.7	11.1
March	17.1	10.6
April	16.1	8.1
May	20.2	7.6
June	17.1	7.1
July	9.6	3.5*
August	7.1	3.5*
September	10.6	4.0
October	11.6	5.0
November	14.1	7.1
December	15.1	9.1
Zone 3 Pass-Through Requirement (cfs)		3.5

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-31
Daily Natural Streamflow Statistics for Section 5.11
G-17C1 Sandies Creek Reservoir Diversion Point (Guadalupe River @ Cuero)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	983.6	603.5
February	1050.7	661.5
March	1046.1	637.3
April	1078.9	626.2
May	1295.2	694.7
June	1170.2	624.1
July	865.1	491.1
August	676.6	361.0
September	749.2	432.1
October	837.4	496.1
November	866.6	552.6
December	897.9	581.8
Zone 3 Pass-Through Requirement (cfs)*		317.1

* HDR, "Guadalupe-San Antonio River Basin Environmental Criteria Refinement," Trans-Texas Water Program, West Central Study Area, Plan II, San Antonio River Authority, et.al., March 1998.

Table F-32
Daily Natural Streamflow Statistics for Section 5.12
G-16C1 Cuero Reservoir (Guadalupe River upstream of Cuero)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	943.8	590.4
February	1015.4	641.3
March	1014.9	618.6
April	1042.1	607.5
May	1240.7	671.0
June	1120.2	604.0
July	845.0	476.9
August	660.4	348.9
September	728.5	421.0
October	817.7	485.0
November	851.0	535.9
December	881.3	568.2
Zone 3 Pass-Through Requirement (cfs)*		317.1

* HDR, "Guadalupe-San Antonio River Basin Environmental Criteria Refinement," Trans-Texas Water Program, West Central Study Area, Plan II, San Antonio River Authority, et.al., March 1998.

Table F-33
Daily Natural Streamflow Statistics for Section 5.13
SCTN-13 Palmetto Bend Reservoir (Lavaca River near Edna)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	63.0	26.1
February	92.8	39.0
March	76.9	37.6
April	78.9	36.8
May	92.2	35.4
June	85.6	36.7
July	47.5	22.7
August	37.3	21.6*
September	41.2	21.6*
October	39.2	21.6*
November	48.3	21.6*
December	55.1	24.3
Zone 3 Pass-Through Requirement (cfs)		21.6

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-34
Daily Natural Streamflow Statistics for Section 5.15
SCTN-15 Cummings Creek Reservoir (Cummings Creek near Columbus)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	19.0	9.5
February	25.4	11.6
March	23.9	10.6
April	20.4	8.7
May	20.1	7.6
June	14.7	5.4
July	7.9	2.2
August	3.8	1.8*
September	5.9	2.0
October	6.8	2.7
November	10.6	4.1
December	14.6	7.9
Zone 3 Pass-Through Requirement (cfs)		1.8

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-35
Daily Natural Streamflow Statistics for Section 5.17
SCTN-18 Cotulla Reservoir (Nueces River near Cotulla)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	19.6	7.2
February	23.9	6.8
March	21.3	3.7
April	22.6	3.4
May	26.0	3.0
June	25.5	2.0
July	21.7	0.5
August	11.4	0.1*
September	23.4	1.7
October	38.4	3.8
November	24.4	4.4
December	13.2	4.5
Zone 3 Pass-Through Requirement (cfs)		0.1

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow.

Table F-36
Daily Natural Streamflow Statistics for Section 5.18
SCTN-19 Nueces Reservoir - Smyth Crossing Site (Nueces River below US Highway 90)

Month	*Median Flows - Zone 1 Pass-Through Requirement (cfs)*	*25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)*
January	25.2	12.0
February	23.7	12.0
March	22.1	12.0
April	23.5	11.1
May	27.0	15.0
June	28.8	13.3
July	28.5	13.6
August	27.1	10.9
September	26.2	12.1
October	32.6	13.3
November	31.2	12.1
December	28.0	11.0
Zone 3 Pass-Through Requirement (cfs)		8.6

Table F-37
Daily Natural Streamflow Statistics for Section 6.4
SCTN-7a Wintergarden Carrizo Recharge Enhancement (Nueces River in Zavala Co.)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	23.2	22.2*
February	22.2*	22.2*
March	22.2*	22.2*
April	22.7	22.2*
May	28.7	22.2*
June	26.7	22.2*
July	27.2	22.2*
August	26.7	22.2*
September	26.7	22.2*
October	29.7	22.2*
November	28.2	22.2*
December	25.2	22.2*
Zone 3 Pass-Through Requirement (cfs)		22.2

* Zone 3 Pass-Through Requirement exceeds 25th Percentile Flow and Median Flow.

Table F-38
Daily Natural Streamflow Statistics for Section 6.4
SCTN-7b Wintergarden Carrizo Recharge Enhancement (Atascosa River in Atascosa Co.)

Month	Median Flows - Zone 1 Pass-Through Requirement (cfs)	25th Percentile Flows - Zone 2 Pass-Through Requirement (cfs)
January	3.5	2.0
February	4.0	2.5
March	4.0	2.0
April	3.5	1.5
May	5.0	2.0
June	4.5	1.0
July	2.5	0.5
August	1.5	0.5
September	2.5	0.5
October	2.5	0.5
November	3.0	1.0
December	3.5	1.5
Zone 3 Pass-Through Requirement (cfs)		0.2