TRANS-TEXAS WATER PROGRAM

Corpus Christi Study Area

Phase II Report

Volume 1- Summary Report

City of Corpus Christi

Port of Corpus Christi Authority

Corpus Christi Board of Trade

Texas Water Development Board

Lavaca-Navidad River Authority

September, 1995

HDR

HDR Engineering, Inc.
in association with
Naismith Engineering, Inc.
Paul Price Associates, Inc.

TRANS-TEXAS WATER PROGRAM
CORPUS CHRISTI SERVICE AREA

PHASE II
REPORT

VOLUME 1

SUMMARY REPORT

Prepared For
City of Corpus Christi
Port of Corpus Christi Authority
Corpus Christi Board of Trade
Texas Water Development Board
Lavaca-Navidad River Authority

by
HDR Engineering, Inc.
in association with
Naismith Engineering, Inc.
and
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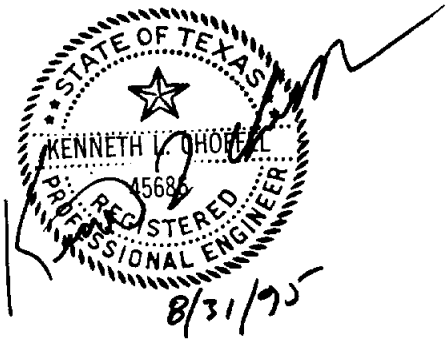

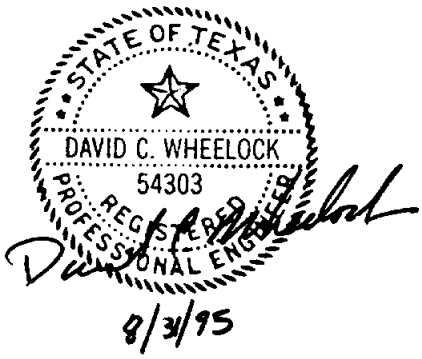

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TRANS-TEXAS WATER PROGRAM
Corpus Christi Service Area
Phase II Report

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TRANS-TEXAS WATER PROGRAM
CORPUS CHRISTI SERVICE AREA
PHASE II EXECUTIVE SUMMARY

ES EXECUTIVE SUMMARY

Background

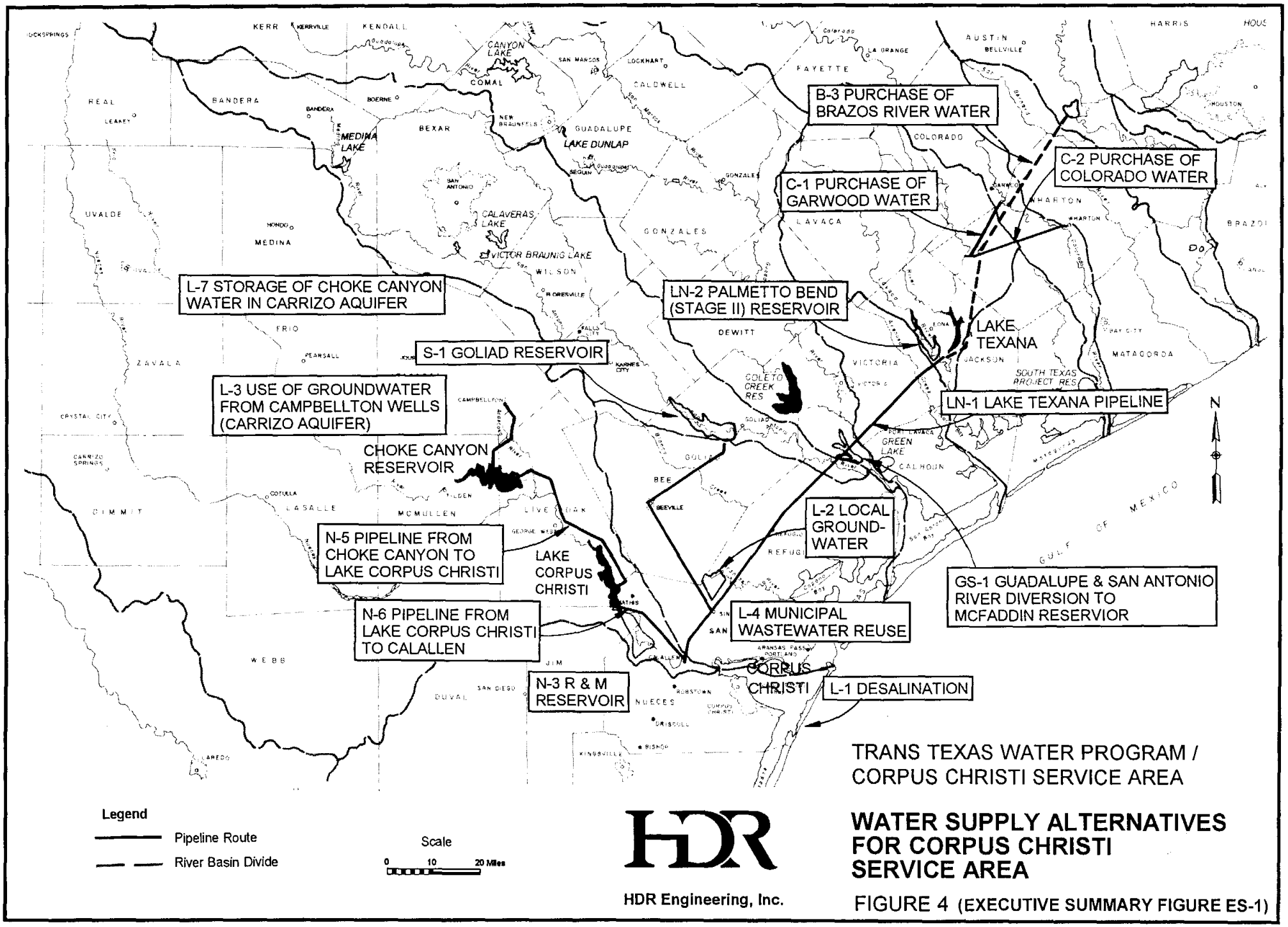
The Corpus Christi Service Area depends upon the Choke Canyon/Lake Corpus Christi Reservoir System operated by the City of Corpus Christi for more than 80 percent of its present water supply. The study area population is projected to increase from 530 thousand in 1990 to more than 975 thousand in 2050 or almost a doubling of the present number of people. A comparison of projected future municipal and industrial water demands with available regional water supplies shows that an additional 100,000 acft (1 acft = 325,851 gallons) of municipal and industrial water will be needed annually by 2050, with shortages beginning to appear in about 2002. The objectives of the Trans-Texas Phase I and Phase II studies were to identify and evaluate water supply alternatives and develop an integrated water supply plan(s) to meet the water needs of the area for the 50-year period from 2000 to 2050.

Water Supply Alternatives

Twenty-two water supply alternatives were identified and evaluated with respect to: quantity and quality of water; cost of water; and environmental advantages and disadvantages; and implementation issues. Figure ES-1 is a map showing the locations of the alternatives and the 22 alternatives are listed in Table ES-1.

Near the conclusion of the Phase 2 studies, the alternatives were classified into four groups: (Group 1) dependable, permanent, and affordable alternatives; (Group 2) stand-by alternatives; (Group 3) potentially dependable, permanent, and affordable alternatives; and (Group 4) potential future alternatives.

Group 1 includes 5 alternatives: Modifications of the Choke Canyon/Lake Corpus Christi Reservoir Operating Policy to incorporate the 1995 TNRCC Agreed Order, Accelerated/Additional Municipal Conservation, Industrial Water Conservation, the Lake Texana Pipeline, and the Purchase and Diversion of Garwood Water Rights via Garwood/Colorado



TRANS TEXAS WATER PROGRAM / CORPUS CHRISTI SERVICE AREA

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WATER SUPPLY ALTERNATIVES FOR CORPUS CHRISTI SERVICE AREA

FIGURE 4 (EXECUTIVE SUMMARY FIGURE ES-1)

Table ES-1 Summary of Water Supply Alternatives	
1	Modification of Choke Canyon/Lake Corpus Christi (CC/LCC) Reservoir Operating Policy (N-1)
2	Diversion from Nueces River to Choke Canyon Reservoir (N-2)
3	R&M Reservoir (N-3)
4	Purchase of Existing Water Rights in Nueces Basin.(N-4)
5	Pipeline from Choke Canyon Reservoir to Lake Corpus Christi (N-5)
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12	Goliad Reservoir (S-1)
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17	Purchase and Diversion of Garwood Water Rights to Corpus Christi through Lake Texana (C-1)
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19	Groundwater Recharge and Recovery (Carrizo/Wilcox) (L-7)
20	Dredging of Lake Corpus Christi (N-7)
21	Purchase of Colorado River Water (C-2)
22	Purchase of Brazos River Water (B-3)

Pipeline. The combined supply available from this group totals about 83,000 acft/yr or about 83 percent of the projected 2050 additional water needs of the area.

Group 2 includes local groundwater alternatives to be kept available on a stand-by basis to meet emergency conditions, including a drought more severe than previous droughts. The Group 2 alternatives include: Existing wells near Nueces River and Lake Corpus Christi,

Potential New Sinton Well Field, and use of the Existing Campbellton Wells (with water delivered to Choke Canyon Reservoir via pipeline). The combined existing stand-by supply available from this group is about 20,000 acft/yr for short periods of time; i.e., about 2 years. The water quality of these alternatives is generally significantly poorer than water available from surface water supplies.

Group 3 includes alternatives which could potentially provide dependable, permanent, and affordable water supplies, pending additional investigation. Group 3 includes the following 7 alternatives: Additional Modification of the Choke Canyon/Lake Corpus Christi Reservoir Operating Policy reduce the Lake Corpus Christi target level below 88 ft-msl elevation; Purchase of Existing Water Rights in the Nueces River Basin; Pipelines from Choke Canyon Reservoir to Lake Corpus Christi and from Lake Corpus Christi to the O.N. Stevens Water Treatment Plant; Diversions of Municipal Wastewater to the Nueces Delta; and Purchase and Diversion of Additional Garwood Water Rights and/or other Colorado River Water. The total quantity potential of these alternatives is approximately 77,000 to 86,000 acft/yr. Group 3 alternatives have small to moderate environmental impacts, and require significant additional planning, permitting, and implementation effort.

Group 4 includes potential future alternatives and consists of the following 10 alternatives: Diversion from Nueces River to Choke Canyon Reservoir; R&M Reservoir; Desalination of Seawater; Goliad Reservoir (San Antonio River Basin); Diversion from Guadalupe/San Antonio Rivers (with or without McFaddin Reservoir); Palmetto Bend (Stage II) Reservoir; Diversion from Lavaca River to Lake Texana; Groundwater Recharge and Recovery (Carrizo/Wilcox Aquifer); Dredging Lake Corpus Christi; and Purchase of Brazos River Water. These alternatives have one or more significant problems or issues (high costs, small quantities of supply, or significant environmental impacts) which limit their feasibility at the present time, but may become viable in the future. For example, if significant technological breakthroughs occur in desalination and/or dredging processes, it may be appropriate to move these options, or others, into Group 3 for further consideration.

Water Supply Plans

Two potential integrated water supply plans (i.e., Plan A and Plan B) were developed, each of which will provide an additional water supply for the South Central Trans-Texas region of 100,940 acft/yr by 2050 (Table ES-2).

Table ES-2
Integrated Water Supply Plans
Corpus Christi Service Area

Plan and Alternatives Included	Year 2050 Permanent Supply (acft/yr)	Estimated Year Water Needs to be Available
Plan A		
• Modification of Choke Canyon/Lake Corpus Christi Operating Policy to incorporate 1995 Agreed Order	9,500	1995
• Accelerated/Additional Conservation (L-5, L-6)	10,000	1996[3]
• Lake Texana Pipeline (60") (LN-1)	41,840[1]	2007
• Garwood-Colorado Pipeline (48") (C-1)	21,600[1]	2029
• Pipeline from Choke Canyon Reservoir to Lake Corpus Christi (96") (N-5)	18,000	2039
Total	100,940	
Plan B		
• Modification of Choke Canyon/Lake Corpus Christi Operating Policy to incorporate 1995 Agreed Order	9,500	1995
• Accelerated/Additional Conservation (L-5, L-6)	10,000	1996[3]
• Lake Texana Pipeline (66") (LN-1)	41,840[1]	2007
• Garwood-Colorado Pipeline (60") (C-1)	21,600[1]	2029
• Additional Garwood or Colorado River Water (C-1 or C-2)	14,000[2]	2039
• Modification of Choke Canyon/Lake Corpus Christi Operating Policy by changing LCC Target Elevation to 87 ft-msl (N-1)	4,000	2046
Total	100,940	

[1] Corpus Christi has acquired 41,840 acft/yr of Lake Texana water, which includes 10,400 acft/yr reserved for potential future demands in Jackson County. The 41,840 acft/yr will meet projected demands of the Corpus Christi Service Area until 2029, at which time additional quantities will be needed. The completion of facilities in 2029 to begin the transfer of 35,000 acft/yr of Colorado River water purchased from Garwood Irrigation Company would yield about 32,000 acft/yr at Lake Texana, of which 10,400 acft/yr would be available to replace the 10,400 acft/yr of Lake Texana water reserved for potential future demands of Jackson County. This is a reasonable "worst case" assumption as water demand projections for Jackson County show that this water will not be needed before 2050. Under these assumptions, the combined availability of Lake Texana and Garwood water for delivery to the Corpus Christi Service Area after 2029 would be 63,440 acft/yr (41,840 + 32,000 - 10,400 = 63,440). If the 10,400 acft/yr is not needed in Jackson County, then implementation of subsequent alternatives could be delayed.

[2] Additional Colorado River water rights of about 16,000 acft/yr would need to be purchased from either Garwood, LCRA, Pierce Ranch, or others.

[3] Begins in 1996, with full implementation by 2020.

All five alternatives of Group 1, which supply about 83,000 acft/yr, are included in each integrated plan. Plan A also includes the Pipeline from Choke Canyon Reservoir to Lake Corpus Christi, which is estimated to provide 18,000 acft/yr. In lieu of the Pipeline from Choke Canyon Reservoir, Plan B includes 14,000 acft/yr of additional Colorado River water and 4,000 acft/yr obtained as a result of modification of the present Lake Corpus Christi target level from 88 ft-msl to 87 ft-msl.

Costs and Impacts on Water Rates

Annual costs of each of the integrated water supply plans were calculated for each year of the period 1995 to 2050 for both raw and treated water costs. Water treatment plant capacity expansion schedule and costs are the same for both plans. Impacts to water rates were estimated by distributing the annual cost increases to all water customers on a uniform basis for each 1,000 gallons of total water use.

Raw Water Rate Increases

For the period 1996 to 2007, the average cost increase above 1995 rates in Corpus Christi for raw water under Plan A is $0.17 per 1,000 gallons and for Plan B is $0.18 per 1,000 gallons. For the 2008 to 2030 period, the average cost increase above 1995 rates for raw water under Plan A is $0.38 per 1,000 gallons, and is $0.43 per 1,000 gallons for Plan B. For the last 20 years of the planning period, the average cost increase above 1995 rates for raw water under Plan A is $0.32 per 1,000 gallons, and for Plan B is $0.20 per 1,000 gallons. All of these estimated rate increases are in terms of 1995 dollars.

Treated Water Rate Increases

For the period 1996 to 2007, the average cost increase for treated water under Plan A is $0.17 per 1,000 gallons and is $0.18 per 1,000 gallons for Plan B. For the 2008 to 2030 period, the average cost increase above 1995 rates for treated water under Plan A is $0.43 per 1,000 gallons and $0.49 per 1,000 gallons under Plan B. For the last 20 years of the planning period, the average cost increase for treated water under Plan A is $0.53 per 1,000 gallons above 1995 rates, and for Plan B is $0.39 per 1,000 gallons above 1995 rates.

Effect of Plan A on Average Monthly Water Bills

Implementation of Plan A would increase the average residential water bill (for 9,000 gal/month consumption in-city) from $16.38 in 1995 to $20.29 in 2007 (1.8 percent per year increase) for an increase of 24 percent. A commercial in-city bill for 70,000 gal/month would increase from $202.03 under Plan A to $232.41 in 2007 (1.2 percent per year increase) for an increase of 15 percent. A wholesale industrial raw water bill for 10,000,000 gal/month would increase from $2,080.43 in 1995 to $5,830.43 in 2007 (1995 dollars). On an annual basis, the wholesale water rate increase would average about 9.0 percent per year for the 1995 to 2007 period for Plan A.

Effect of Plan B on Average Monthly Water Bills

Implementation of Plan B will increase the average residential water bill (for 9,000 gal/month consumption, in-city) from $16.38 in 1995 to $20.78 in 2007 (2.0 percent per year increase) for an increase of 27 percent. A commercial in-city bill for 70,000 gal/month would increase from $202.03 under Plan B to $236.26 in 2007 (1.3 percent per year increase) for an increase of 17 percent above 1995 rates. A wholesale industrial raw water bill for 10,000,000 gal/month would increase from $2,080.43 in 1995 to $6,370.43 in 2007 (1995 dollars). On an annual basis, the wholesale water bill increase would be 9.8 percent per year for the 1995 to 2007 period for Plan B.

Environmental Issues

In terms of acreage affected, streamflows, bay and estuary inflows, and wastewater return flows to Nueces Estuary, effects of implementing either plan will be additive, and will accumulate as the separate alternatives are implemented over time. The effects of installing water pipelines will be greatest on terrestrial habitats during construction. However, agricultural land (range and cropland) can be returned to its original use following construction. The total acreage of terrestrial habitats affected by Plan A during construction would be 2,545 acres, of which 1,804 acres (71%) is grass or cropland. About 666 acres would be maintained ROW after the projects are constructed. Where the pipelines cross brushlands, brush can be expected to become established in areas outside the maintenance ROW in about 10 years. About 190 acres

that were formerly brushland would be maintain as a mowed ROW. The combined alternatives would impact approximately 65 acres of woodland, mostly along river and creek banks. Wetlands in the proposed ROWs total about 145 acres, however, tunneling under several major rivers is expected to significantly reduce impacts to wetlands.

The effects of Plan B on terrestrial habitats are similar to those of Plan A. The construction and maintenance ROWs for Plan B would involve about 2,443 acres and 698 acres, respectively. Impacts to woodlands would be greater by about 34 acres, but impacts to brushland would be less by about 431 acres. Cropland crossed by a proposed pipeline to the Colorado River near Wharton accounts for the remaining difference.

Implementing Plan A will reduce flows downstream of Lake Texana, downstream of the Garwood diversion point on the Colorado River, and in the Nueces River between Choke Canyon Reservoir and Lake Corpus Christi. However, agreements have been made with Texas Parks and Wildlife Department for bay and estuary releases for the Lake Texana project and the TNRCC permit has been amended for bay and estuary releases. Freshwater inflow resulting from interbasin transfer would increase freshwater inflow to Nueces Estuary 10 percent (29,800 acft/yr assuming a water supply of 63,440 acft/yr). For Plan B, additional water diverted from the Colorado River is substituted for the pipeline from Choke Canyon Reservoir to Lake Corpus Christi. Thus, Plan B would divert more water from the Colorado River (an additional 14,000 to 16,000 acft/yr). Return flows resulting from this interbasin transfer would increase freshwater inflow to Nueces estuary, which may benefit estuarine shellfish and finfish fisheries. With respect to the interbasin transfer of organisms, neither plan would appear to present significant problems, since Colorado River Water has been transferred to the Lavaca Basin annually since the early 1900's, and under each of the integrated plans, water from the Colorado and Lavaca Basins would be piped directly from Lake Texana to the O.N. Stevens Water Treatment Plant. Although this issue continues to be studied, appropriate treatment practices at the O.N. Stevens plant will minimize the likelihood of transferred organisms becoming a problem in the receiving river basins.

Implementation Issues

The pipeline projects will require permits from state and federal agencies and other approvals as listed:

- TNRCC permit amendments;
- Coastal Coordinating Council review;
- U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for pipeline crossings of streams classified as navigable waters of the U.S.;
- Texas General Land Office Sand and Gravel Removal permits and stream crossings;
- Texas Parks and Wildlife Sand, Gravel, and Marl permits for river crossings;
- Environmental studies;
- Cultural resource studies;
- Right-of-way and easement acquisition;
- Affected Agency approvals for pipeline crossings:
    - Texas Department of Transportation;
    - County Commissioners' Courts;
    - Cities;
    - Railroads;
    - River Authorities;
    - Gas and electric utilities;
    - Water Utilities;
    - Oil and gas pipeline companies; and
    - Other owners of pipelines; and
- Habitat Mitigation Plan.

Implementation issues of accelerated and additional municipal water conservation will involve public acceptance and willingness to:

- Replace plumbing fixtures in their homes, workplaces, and institutions;
- Change landscaping at homes and public places, including recreation areas; and
- Become more conscious of and directly involved with management of personal water using functions.

The replacement of plumbing fixtures would be a temporary inconvenience; water conservation landscaping would result in views of different types of grasses and plants, and during the dry times, more brown and less green lawns and public areas. A water conscious public would increase care with which plumbing fixtures, water using appliances, and irrigation equipment is used. For some actions under this alternative, the City Council will need to issue new ordinances dealing with specific issues such as landscape requirements for new subdivisions.

Implementation issues associated with modification of Choke Canyon/Lake Corpus Christi operating policy by reducing the target elevation below 88 ft-msl, include the need for:

- Completion of the planned sediment survey of Lake Corpus Christi, in order to make more accurate estimates of the sedimentation rate in the lake, which will result in better estimates of future reservoir capacities. Following the results of the sediment survey, reservoir system yield should be re-computed for both 2010 and 2050 conditions.

- Additional channel loss studies on the river reaches between CCR and LCC and between LCC and Calallen Dam need to be completed to determine how water delivery losses vary with the time of year and the magnitude of the release rates.

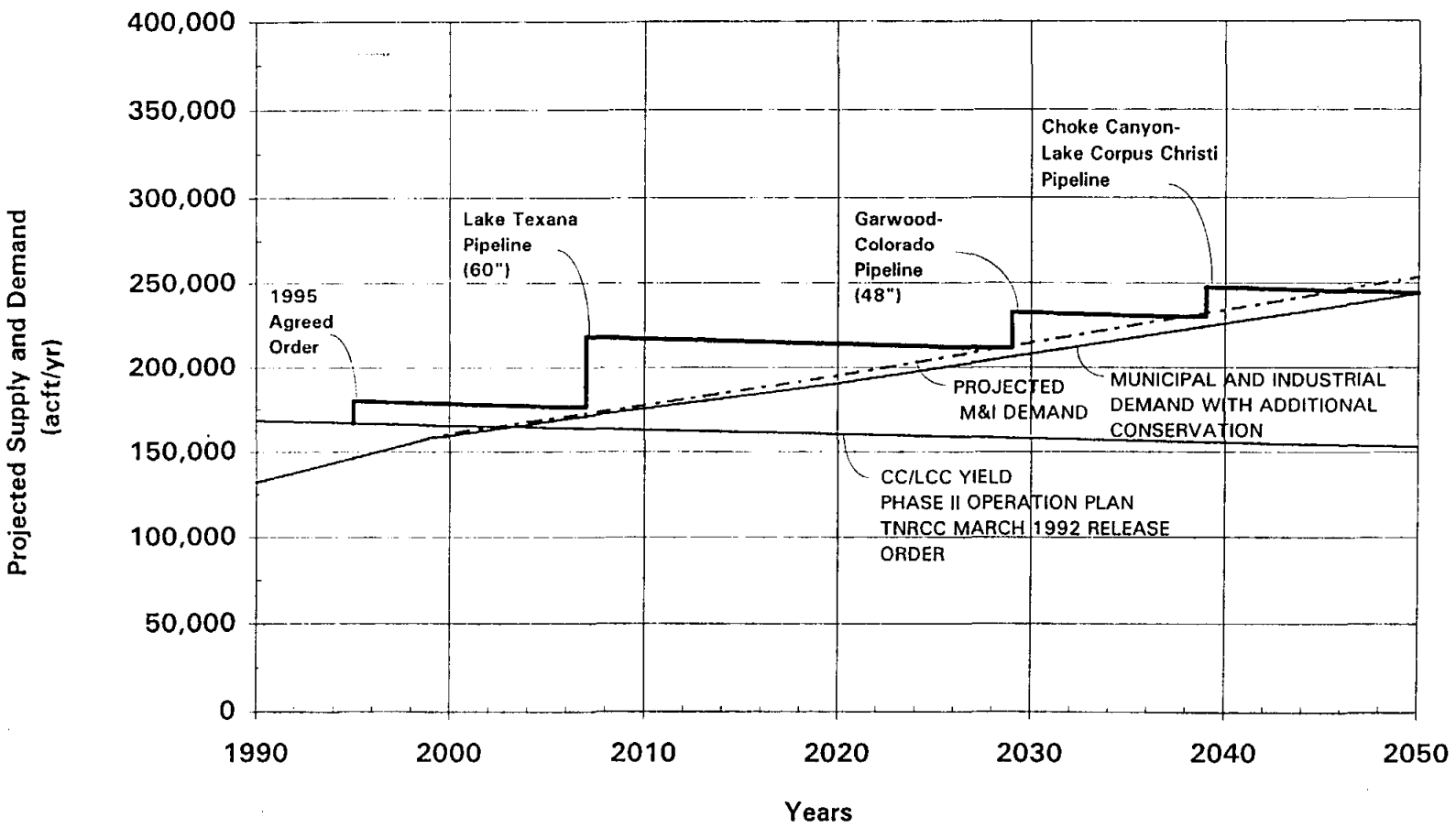
- Consideration of lower target levels at Lake Corpus Christi should continue to address the need to modify water supply intakes in and around Lake Corpus Christi, especially if target levels below 87 ft-msl are considered.

- Modification of the current City Ordinance describing the implementation of operation policy phases as demands increase will be necessary if alternative operating policies are implemented.

Recommendations

Either of the two integrated water supply plans will provide the Corpus Christi service area economical and reliable water supplies to meet the growing needs of the area. Intrinsic to these plans is the flexibility to adjust the implementation schedule as needed. However, significant lead times are needed to conduct studies for permitting, answer the public's concerns, obtain financing, obtain easements, and bring the individual plan elements on-line. Long lead times require an orderly progression of recommended actions, and a commitment to periodically update the area growth trends for decision making. The recommended implementation schedules for Plan A and Plan B are shown in Figures ES-2 and ES-3, respectively.

Integrated Water Supply Plan A



Combined Water Supply with Integrated Plan Alternatives

Projected M & I Demand upon CC/LCC System, High Case, with Conservation

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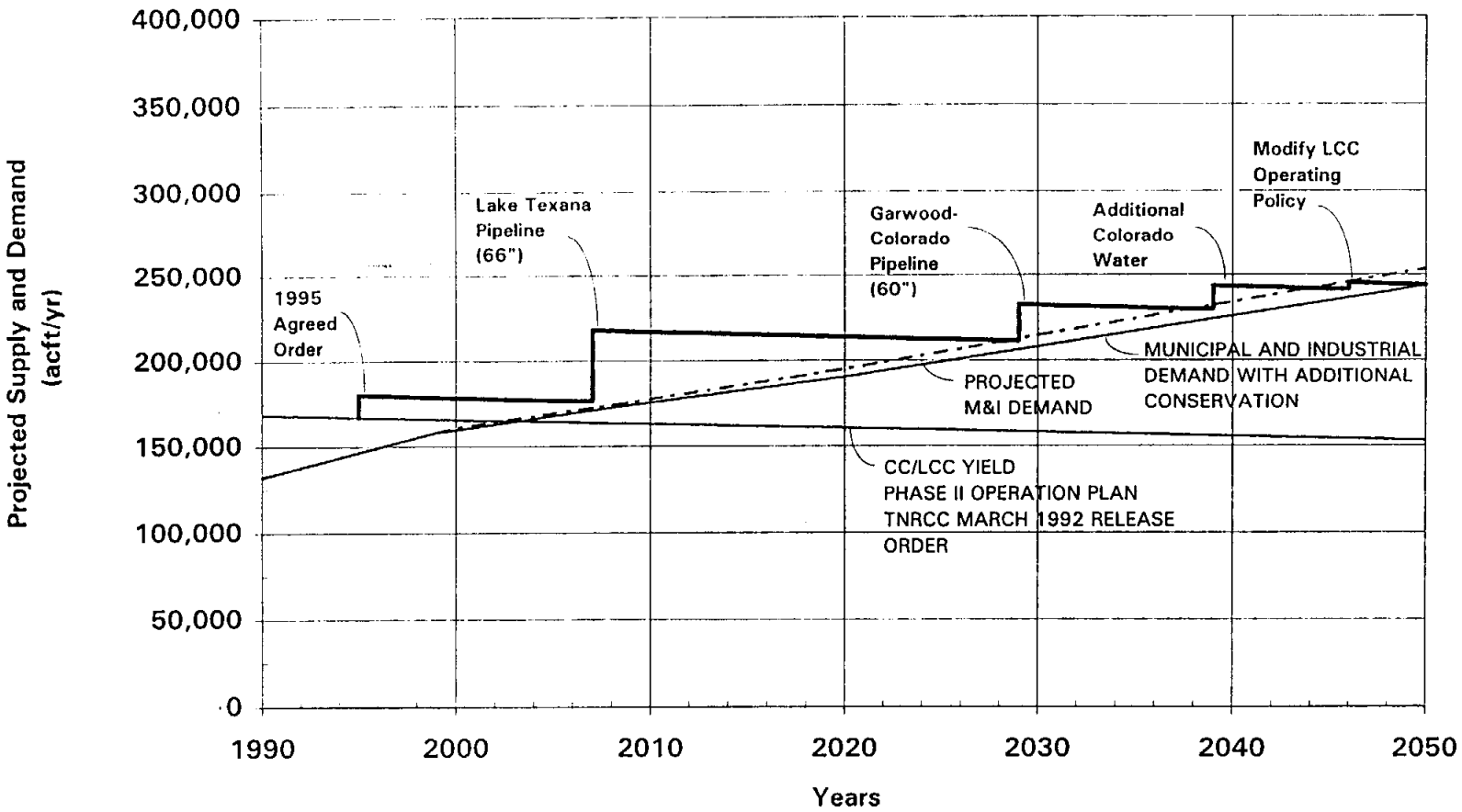
IMPLEMENTATION PLAN FOR INTEGRATED WATER SUPPLY PLAN A

FIGURE ES-2

Integrated Water Supply Plan B



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IMPLEMENTATION PLAN FOR INTEGRATED WATER SUPPLY PLAN B

FIGURE ES-3

Summary Report

TRANS-TEXAS WATER PROGRAM
CORPUS CHRISTI SERVICE AREA
PHASE II SUMMARY REPORT

1.0 INTRODUCTION

In May of 1992, the Texas Water Development Board (TWDB), the state agency responsible for the preparation and maintenance of a comprehensive state water plan, met with leaders of Corpus Christi, San Antonio and Houston, and directors of regional water supply organizations and river authorities of south central, west central, and southeast Texas and initiated the Trans-Texas Water Program. The purpose of the program is to address the water supply needs of the Corpus Christi, San Antonio, Austin and Houston metropolitan areas in a coordinated, logical, cost-effective, and environmentally responsible manner, with emphasis upon improving water use efficiency through water conservation, and to make use of existing, already developed surface water supplies of that area that are surplus to the projected 50-year future needs of the basins in which such supplies exist. This report addresses the water supply needs of the 12-county South Central Trans-Texas study area, which includes the Corpus Christi area, and identifies and evaluates options to meet those needs, and presents integrated water supply plans for the planning period of year 1995 to year 2050.

1.1 Description of Trans-Texas Water Program

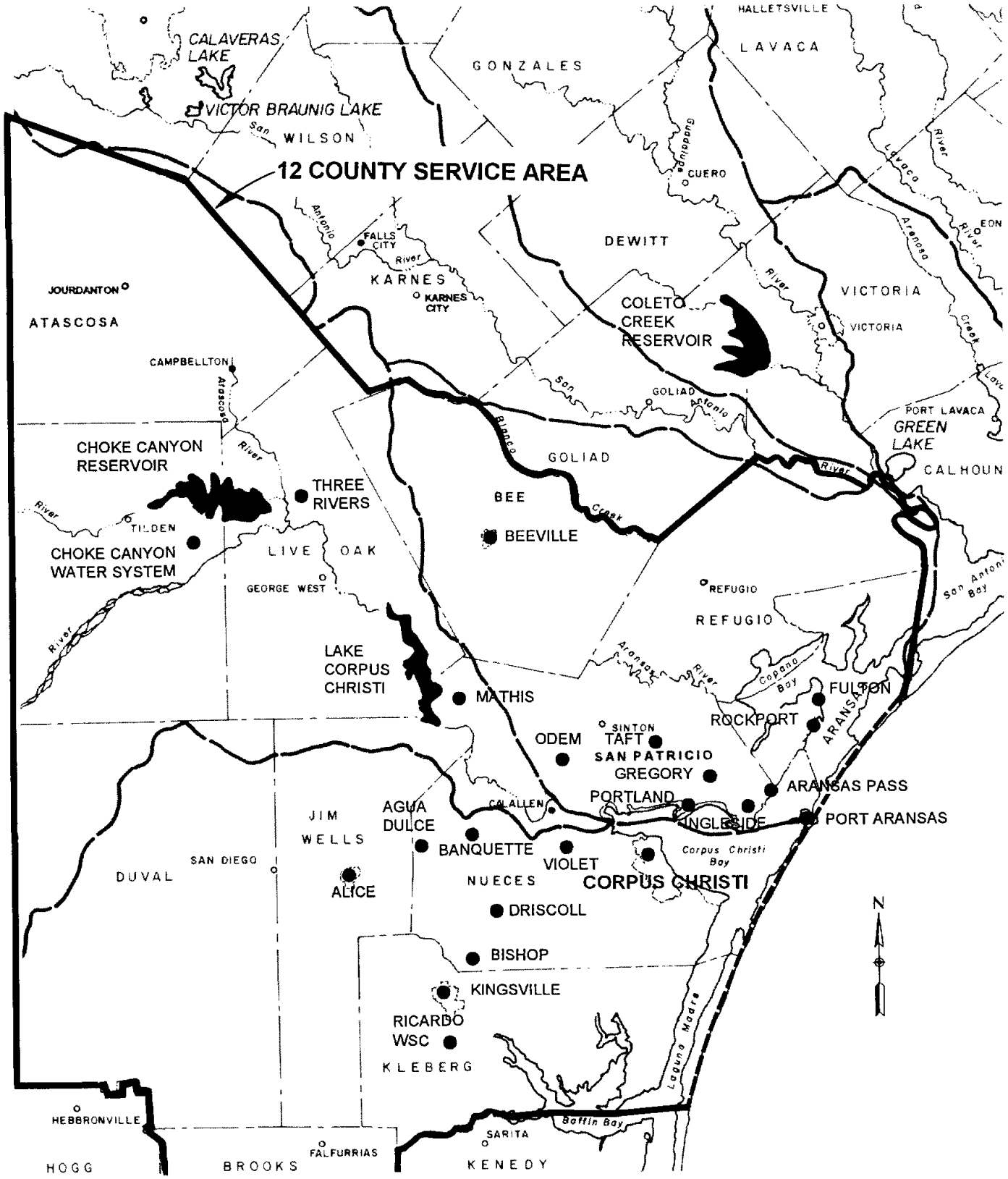
The Trans-Texas Water Program uses a five phase approach as follows: (1) Phase I includes studies to identify water demands of the region for the planning period, and identify and evaluate available options to meet the needs; (2) Phase II includes more detailed evaluation of options studied in Phase I, and the development of integrated water supply plans for the region; (3) Phase III includes preliminary designs and obtaining state and federal permits for options to be implemented; (4) Phase IV includes acquisition of property and rights-of-way and the preparation of final design plans for options to be implemented; and (5) Phase V includes construction, start-up, and operation. This is the Phase II study report for the South Central Trans-Texas study area and it is described below.

1.2 South Central Study Area

The South Central Trans-Texas study area includes the following 12 counties: Aransas, Atascosa, Bee, Brooks, Duval, Jim Wells, Kleberg, Live Oak, McMullen, Nueces, Refugio, and San Patricio (Figure 1). Population of the area was 530,878 in 1990, and is projected to grow to 975,874 in year 2050. The climate of the area is semiarid with average annual precipitation of 32 inches in the east and 24 inches in the west. Water supplies for the rural parts of the study area are obtained from the Carrizo and Gulf Coast aquifers and are limited in relation to present and future needs. In coastal counties (Nueces and San Patricio) municipal and industrial water users led by the City of Corpus Christi developed surface water supplies of the Nueces River Basin beginning in the early 1900's. The present surface water system includes Choke Canyon Reservoir, Lake Corpus Christi, Calallen Diversion Dam, O.N. Stevens Water Treatment Plant, and pipelines to deliver both treated and raw water to neighboring counties. In addition, several cities have their own diversion and treatment facilities and withdraw water from Lake Corpus Christi. At the present time, the Choke Canyon/Lake Corpus Christi System supplies municipal and industrial water to 7 of the 12 study area counties, and is authorized to supply water in 3 additional counties. Groundwater is used to some extent in each of the study area counties, and although groundwater supplied 15 percent of municipal and industrial needs in 1990, supplies are limited and quality is marginal to poor, with high concentration of chlorides, sulfates, and total dissolved solids. Since 1954, 24 cities and water supply entities have converted totally or partially to surface water from the CC/LCC System, and at the present time several additional entities are studying ways to obtain surface water from the system.

1.3 Review of Previous Studies

Information was obtained from numerous reports and studies that have been completed since 1965 pertaining to potential water supply projects of the Nueces, San Antonio, Guadalupe, Lavaca, and Colorado River Basins. The reports included information about costs, quantities, and qualities of water from individual projects, single basin water supply programs, and interbasin water transfers. The literature review is included in Appendix A of this study.



Legend

- Entities Supplied from Lake Corpus Christi/ Choke Canyon Reservoir System
- River Basin Divide

Scale

0 10 20 Miles

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TRANS TEXAS WATER PROGRAM / CORPUS CHRISTI SERVICE AREA

12 - COUNTY SERVICE AREA FOR LAKE CORPUS CHRISTI/ CHOKE CANYON RESERVOIR SYSTEM

FIGURE 1

2.0 POPULATION AND WATER DEMAND PROJECTIONS

The Texas Water Development Board's high case population and water demand, with conservation, projections are the information used to determine the quantities of water that will be needed at each decadal point in the planning period between year 2000 and 2050. The projections for both the 12-county study area and the Choke Canyon/Lake Corpus Christi System service area are summarized below.

2.1 Population Projections--12-County and Choke Canyon/Lake Corpus Christi System Service Area.

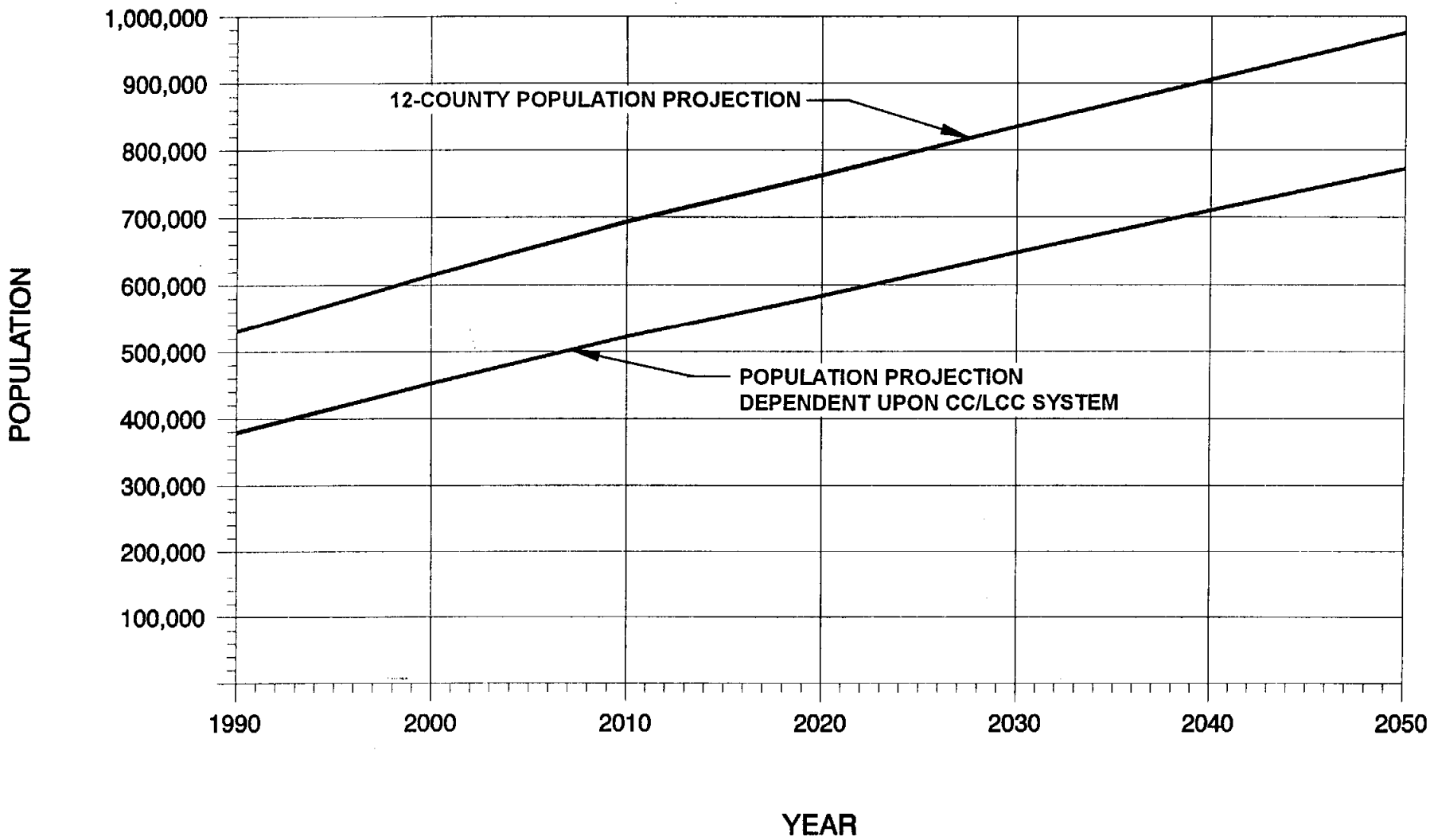
For the 60-year period of 1930 to 1990, the population of the 12-county study area increased from 171,206 to 530,878. The population of the 12-county area is projected to increase to 614,529 in 2000, to 762,768 in 2020 and 975,874 in 2050. The projected compound annual growth rate for the period 1990 through 2050 is 1.02 percent, which is 20 percent less than the projected statewide growth rate of 1.27 percent for Texas (Figure 2).

In 1990, population of the Choke Canyon/Lake Corpus Christi System service area was 379,293 or 71 percent of the 12-county total. For the Choke Canyon/Lake Corpus Christi (CC/LCC) System service area, the population projection in year 2000 is 452,815, in 2020 is 583,585, and in 2050 is 772,291 (Figure 2).

2.2 Water Demand Projections for the 12-county Water Demand Area

Total fresh water use in 1990 in the 12-county area was 248,004 acft,[1] of which 46.5 percent was for municipal purposes, 17.6 percent was for industry, 24.8 percent was for irrigation, and 11.1 percent was for steam-electric power generation, mining, and livestock. The projected high case (dry year), with conservation, total water demand for the 12-county study area in year 2000 is 293,838 acft, in 2020 is 324,524 acft, and in 2050 is 403,646 (Figure 3). Of the projected demands in 2050, 46.1 percent is for municipal use, 24.8 percent is for industry, 13.7 percent is for irrigation, and 15.4 percent is for steam-electric power generation, mining, and livestock water. Neither the 1990 water use statistics nor the projections include the large quantities of seawater that are used, or will be used, by the electric power industry for

[1] 1 acft contains 325,851 gallons.



TRANS TEXAS WATER PROGRAM /
CORPUS CHRISTI SERVICE AREA

POPULATION PROJECTIONS

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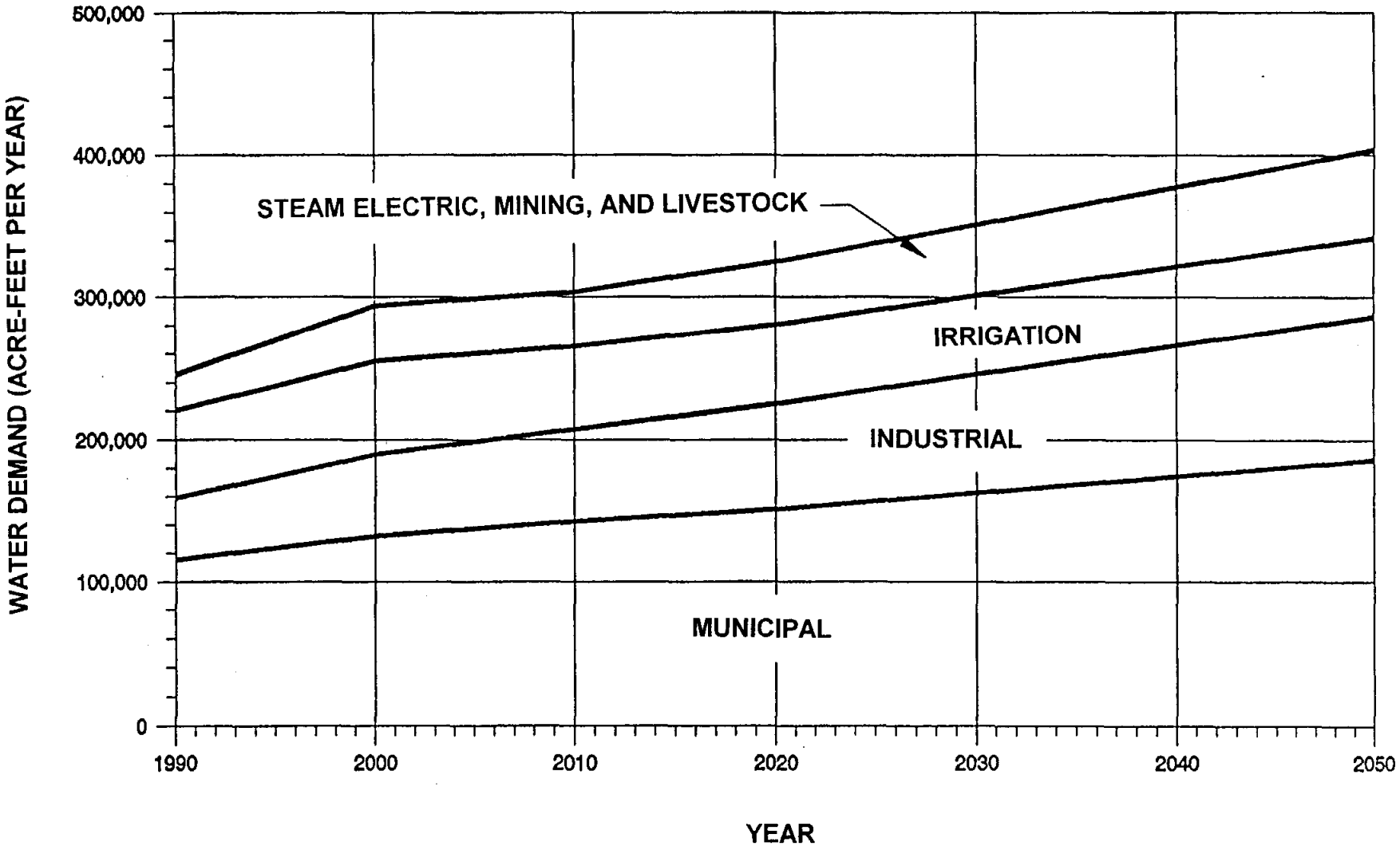
FIGURE 2



TRANS TEXAS WATER PROGRAM /
CORPUS CHRISTI SERVICE AREA

WATER DEMAND PROJECTIONS
REGION TOTAL

DEMAND PROJECTIONS ARE FOR THE CHOKE CANYON/LAKE CORPUS CHRISTI SYSTEM

HDR Engineering, Inc.

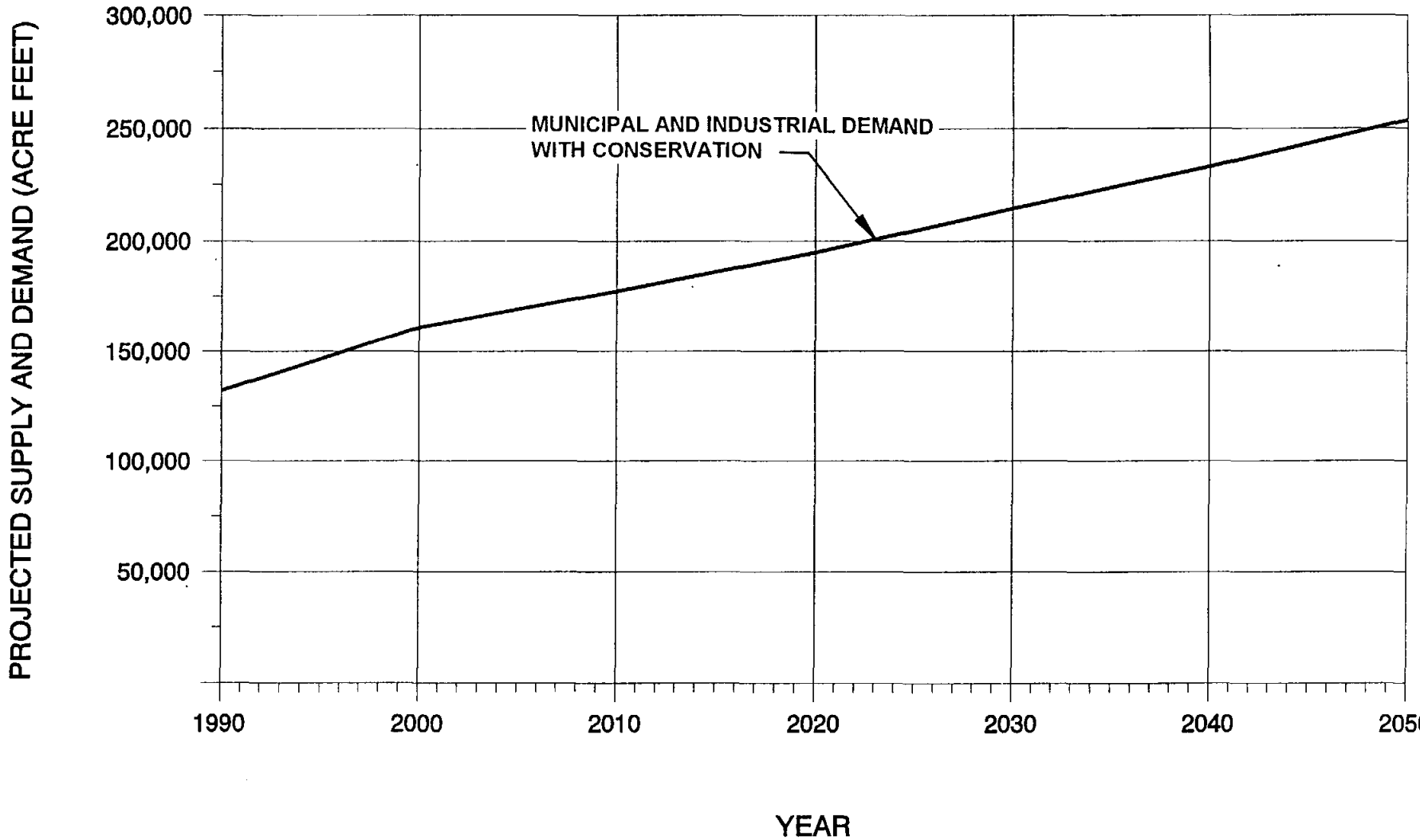
FIGURE 3

cooling the steam-electric power plants that are located on Corpus Christi Bay. However, it is important to note that over 72 percent of water projected to be used within the 12-county area for irrigation is estimated to be obtained from the Carrizo Aquifer for use within Atascosa County. In 1990, irrigation water use within the 12-county area was 61,445 acft, with projected irrigation demands in 2050 declining to 55,315 acft, due to projected increases in irrigation water use efficiency.

Even though water conservation efforts are expected to occur, municipal and industrial water demands are projected to increase significantly over the 50-year period due to an approximate doubling of the population and industrial growth of the area. The portion of the total demand which depends upon the CC/LCC System for water supply is presented in the following section of this report.

2.3 Municipal and Industrial Water Demand Projections for the Choke Canyon/Lake Corpus Christi System Service Area

In 1990, total municipal and industrial (M&I) water use in the study area was 159,084 acft, of which 132,086 acft (83 percent) was from the CC/LCC System, 2,429 acft (1.5 percent) was directly from the Nueces River, and 24,569 acft (15.4 percent) was from groundwater sources. M&I demands upon the CC/LCC System for dry year conditions are projected to increase to 160,887 acft in year 2000, 194,950 acft in 2020, and 253,284 acft in 2050 (Figure 4). The projections of future M&I water demands for the CC/LCC System are based on the assumption that water conservation programs will be continued and that communities within the area that were being supplied from groundwater in 1990 will be able to continue using groundwater in the future at the same level as was being used in 1990. The projections are based upon groundwater supply information from the Texas Water Development Board (TWDB). In those counties which relied wholly upon groundwater in 1990 (Atascosa, Brooks, Duval, McMullen, and Refugio), the TWDB groundwater supply information indicates adequate quantities of groundwater within these counties to meet their projected M&I demands. However, in study area counties that are supplied both from groundwater and the CC/LCC System, the projections of future M&I demands are based upon the assumption that historical trends of cities to shift from groundwater to CC/LCC System water will continue, and that although groundwater will continue to be used by some communities to meet a part of their needs, that



TRANS TEXAS WATER PROGRAM /
CORPUS CHRISTI STUDY AREA

MUNICIPAL AND INDUSTRIAL WATER DEMAND AND SUPPLY PROJECTIONS

DEMAND AND SUPPLY PROJECTIONS ARE FOR THE CHOKE CANYON RESERVOIR/LAKE CORPUS CHRISTI SYSTEM

HDR Engineering, Inc.

FIGURE 4

the part needed to supply population and industrial growth after 1990 will be obtained from the CC/LCC System. It is important to note, however, that poor groundwater quality and declining water tables may hasten the trend to shift to CC/LCC supplies, in which case the projections of demand upon the CC/LCC System in 2050 could increase by about 30,000 acft annually. For example, since 1954, 24 public water suppliers have found it necessary to totally or partially convert to surface water from the CC/LCC System, and in 1994, three communities located in Duval County initiated a planning study to investigate the feasibility of supplementing their groundwater supplies with surface water from the CC/LCC System. In each of these, the reasons for the conversion from groundwater to surface water have been declining quantities and deteriorating quality of groundwater, a trend which is projected to continue.

3.0 CURRENT WATER SUPPLY

The South Central Trans-Texas area's primary water supply source is the Choke Canyon Reservoir and Lake Corpus Christi reservoir system located in the Lower Nueces River Basin. The area also has some limited back-up groundwater supplies available from the Carrizo and Gulf Coast Aquifers. Each source of supply is described below.

3.1 Choke Canyon/Lake Corpus Christi Reservoirs Supply

In the late 1800's, the Corpus Christi Water Supply company built a small dam near Calallen, Texas, to keep the saline waters of Nueces Bay from intruding into the fresh waters of the Nueces River and began to develop surface water supplies from the Nueces River. As the City grew and more and more water was needed, the dam at Calallen was raised several times and today the dam has a height of 3.5 ft-msl and a capacity of about 1,175 acft. The City continued to expand and, in 1934, Mathis Dam was constructed on the Nueces River about 35 miles upstream of Calallen Dam. Initially, it impounded approximately 60,000 acft of water. In 1958, Wesley Seale Dam was completed just downstream of the old Mathis Dam, and the new Lake Corpus Christi (LCC) was formed, which engulfed the old dam and reservoir and expanded storage to about 302,000 acft. In the late 1960's, following an extreme drought which occurred from 1961-63, planning was begun for an additional water supply for the City and its growing number of water customers. For more than a decade, studies were performed to evaluate alternative water supply options, and, following considerable debate, Choke Canyon Reservoir (CCR), located on the Frio River about 63 river miles upstream of LCC, was constructed by the United States Bureau of Reclamation (USBR). The dam was completed in 1982 and the 691,000 acft capacity reservoir filled in 1987, more than 20 years following initial planning efforts.

The City of Corpus Christi operates Choke Canyon Reservoir and Lake Corpus Christi as a system (CC/LCC System) to supply water for municipal and industrial purposes in the South Central Trans-Texas Region. Of total system storage (927,962 acft), 689,314 acft (74.3 percent) is in Choke Canyon Reservoir, 237,473 acft (25.6 percent) is in Lake Corpus Christi, and 1,175 acft (0.1 percent) is in the Calallen pool. Water stored in Choke Canyon Reservoir and Lake Corpus Christi is released into the river channel and delivered to the Calallen pool, from which

the City and some of its customers divert raw water to their respective treatment plants, from which it is then distributed for use. About 94 percent of the raw water supplied by the CC/LCC System is diverted from the Calallen pool. It is important to note that water quality deteriorates below Lake Corpus Christi as river flows reach the Calallen pool. As shown in Figure 5, the chloride concentration at Calallen has ranged from 25 to 225 mg/l higher than that measured at Mathis, just downstream of the Lake Corpus Christi outlet works.

The yield of the system in 1990, which was computed taking into account estimates of channel losses in the river reaches between the lakes, reservoir evaporation, the 1992 TNRCC Interim Release Order and the City's Phase II Reservoir Operation Policy to maintain a target lake level at Lake Corpus Christi of 88 ft-msl elevation, was 168,500 acft. Under the new TNRCC Agreed Bay and Estuary Release Order issued on April 28, 1995, and the City of Corpus Christi's "Phase II Operations Policy", the 1990 CC/LCC System yield would have been increased by approximately 13,500 acft/yr for 1990 sediment conditions to a total of 181,500 acft. Under the 1995 order, the system yield is projected to decline to 178,000 acft/yr in 2000 and to 162,500 acft/yr in 2050, which is 9,500 acft greater than the 153,000 acft/yr under the 1992 TNRCC Interim Order. The decline in yield in future years is due to sedimentation which reduces the storage volumes of Choke Canyon and Lake Corpus Christi.[2]

3.2 Groundwater Supply

The Gulf Coast Aquifer is the source of groundwater in all of the counties of the South Central Trans-Texas area except Atascosa County and northwestern McMullen and Live Oak counties. In these counties, the Carrizo Aquifer is the source of groundwater. Groundwater supplies from the Gulf Coast Aquifer in the study area are limited in relation to demand, and quality is poor, with high concentrations of chlorides, sulfates, and total dissolved solids. In local areas, groundwater is being overdrafted, water tables are declining and poor quality water is migrating into dewatered zones of freshwater aquifers.

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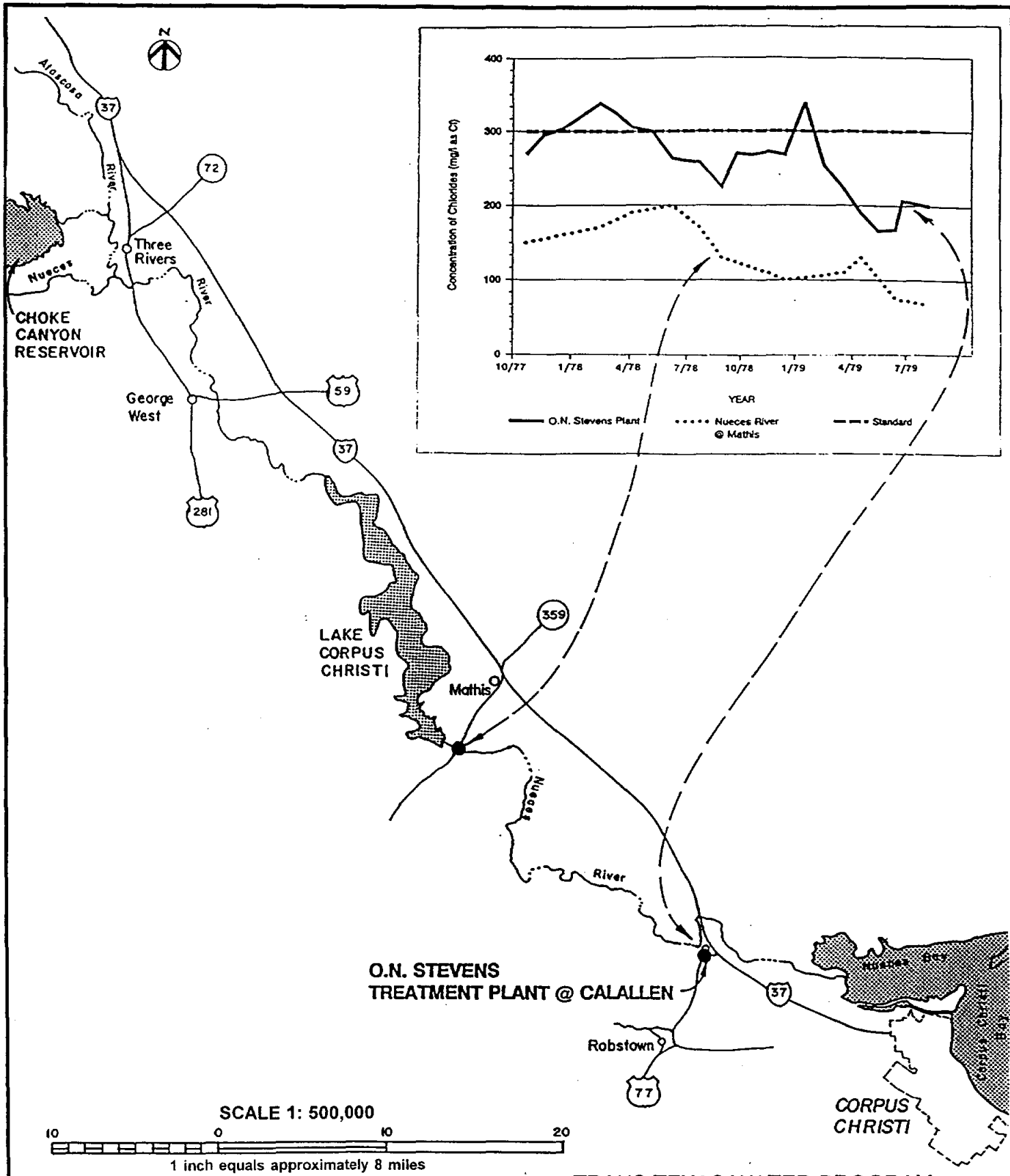
[2] Deposition of silt in the lakes is a significant problem at Lake Corpus Christi which has an annual sedimentation rate of 1,256 acft/yr. At this rate, by 2050, Lake Corpus Christi will have lost 67,824 acft of its present capacity.



TRANS TEXAS WATER PROGRAM
CORPUS CHRISTI SERVICE AREA

HISTORICAL CHLORIDE CONCENTRATIONS IN LOWER NUECES RIVER

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FIGURE 5

In 1990, groundwater supplies of the 12-county area were approximately 193,800 acft/yr, with 165,237 acft/yr being the estimated long-term average annual quantity of recharge, and 28,563 acft/yr being withdrawn from storage or aquifer overdrafting. Most of these supplies consist of poor quality groundwater which do not meet all drinking water standards. Projected annual withdrawals for municipal and industrial purposes increase from 26,823 acft/yr in 2000 to 30,455 acft/yr in 2050. Withdrawals for irrigation were approximately 71,300 acft/yr, with about 51,600 acft, or 72 percent of irrigation being located in Atascosa County, where groundwater use in 1990 was 57,324 acft. In Duval county, static water levels at the town of Freer have declined 300 feet since 1961, and most of the water does not meet drinking water standards for public supply. A regional plan is being developed to bring surface water from the CC/LCC System to cities in Duval and parts of neighboring Jim Wells counties.

In study area counties which relied wholly upon groundwater in 1990 (Atascosa, Brooks, Duval, McMullen, and Refugio), it is estimated that the future needs (26,800 acft/yr in 2000, growing to 30,455 acft/yr in 2050) for municipal and industrial purposes can continue to be met from groundwater, unless quality deterioration forces a shift to surface water, as appears to be happening in Duval and parts of Jim Wells counties. In the study area counties that are supplied both with surface water and groundwater, it is estimated that groundwater can continue to be used at present levels, but that growth in water demand will have to be supplied from surface sources through the CC/LCC System. Thus, the total expected demands for groundwater for the 12-county area increase from 26,800 acft/yr in 2000 to 30,455 acft/yr in 2050. However, if groundwater quality deterioration continues to force the communities that now use groundwater to shift to surface water from the CC/LCC System, then the projected demands for groundwater are less than stated here and the demands for surface water are greater than those stated in Section 2.0 of this study.

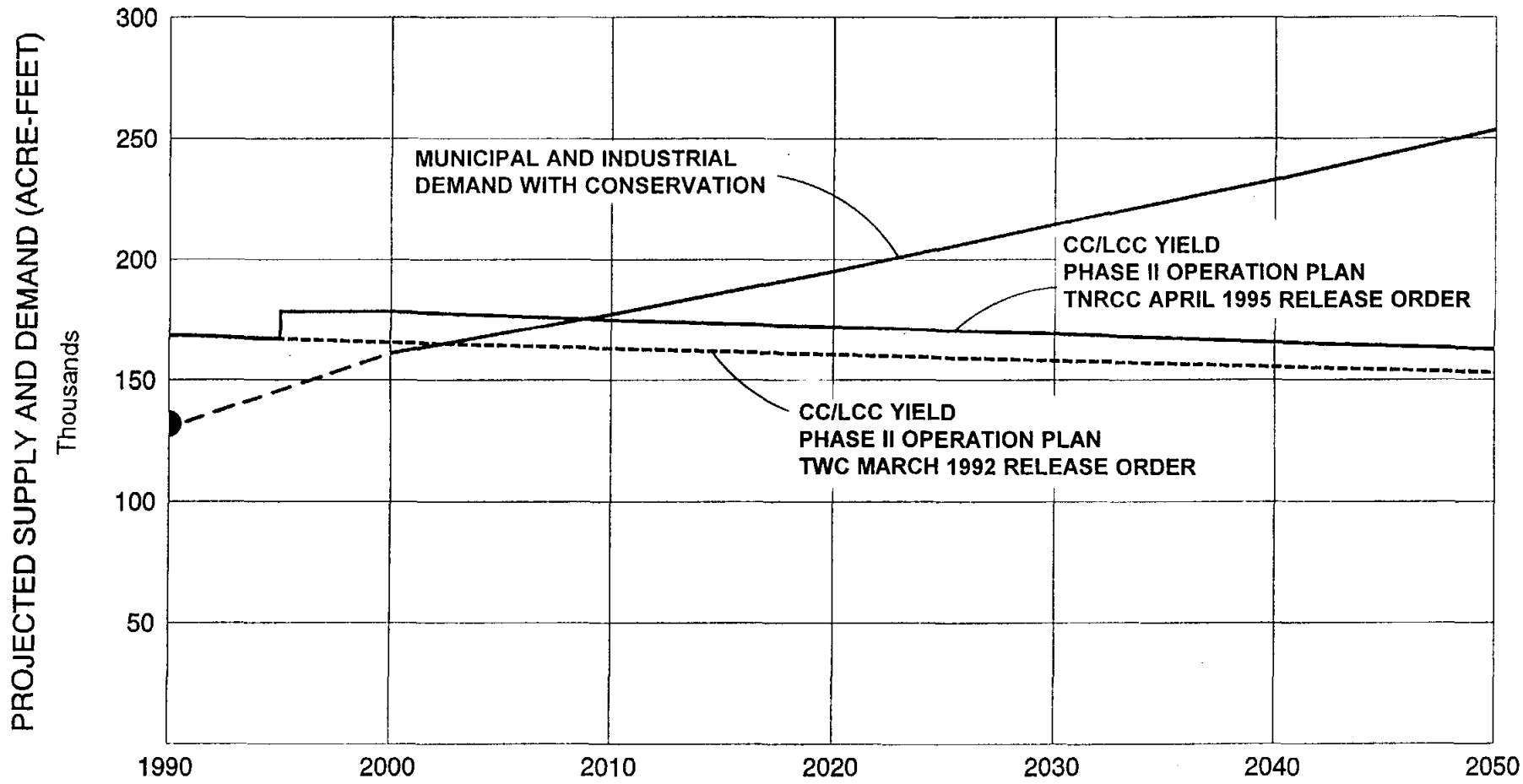
4.0 ADDITIONAL WATER REQUIREMENTS

A comparison of projected water demands for the period 2000 through 2050, with available regional water supplies shows that the area which depends upon the CC/LCC Reservoir System for its municipal and industrial water will need an additional 91,500 acft/yr by 2050, given that the alternative to modify the CC/LCC Reservoir Operating Policy to implement the TNRCC 1995 Agreed Bay and Estuary Release Order was implemented in May of 1995. This alternative increases the CC/LCC System yield by 13,000 acft/yr in 2000 and 9,500 acft/yr in 2050 (Figure 6). Prior to the 1995 TNRCC Release Order, the M&I water shortage was 100,500 acft in 2050, with shortages beginning to appear in 2002 during dry weather conditions. The schedule of projected additional supply that is needed is as follows:

Year	Additional Water Supply Needed (acft/yr)*
2000	0
2010	2,500
2020	23,000
2030	45,500
2040	68,500
2050	91,000

* With 1995 TNRCC Agreed Order for Bay and Estuary Releases

The projections presented above are based upon the assumption that a part of water demands of communities of the inland counties of the study area can continue to be met from local groundwater supplies. However, recent problems with groundwater quality deterioration and water table declines in Duval and Jim Wells Counties indicate that communities of these counties may need to obtain surface water from the CC/LCC System within a few years. If this trend occurs in other parts of the study area, then projections of additional supplies needed would be greater than those shown above, and although a schedule of additional needs for the areas is difficult to estimate, the potential additional need in 2050 would be a maximum of about 30,000 acft/yr bringing the total additional need at that time to 121,000 acft/yr.



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TRANS TEXAS WATER PROGRAM /
CORPUS CHRISTI STUDY AREA

MUNICIPAL AND INDUSTRIAL WATER DEMAND AND WATER SUPPLY PROJECTIONS

CHOKE CANYON/LAKE CORPUS CHRISTI RESERVOIR SYSTEM

FIGURE 6

5.0 FUTURE WATER SUPPLY ALTERNATIVES

In the South Central Trans-Texas Phase II study, 22 water supply alternatives, were identified and evaluated with respect to yield, cost, potential environmental impacts, water quality, and water treatability. All of these alternatives are listed on Table 5-1, which includes a summary of environmental issues and special concerns for each alternative as well as the additional water supply provided and a listing of unit costs. A comparison of how each alternative compares to the others with respect to four areas of concern is shown in Figure 7. This comparison resulted in a relative ranking of alternatives with respect to (a) unit cost; (b) additional water supply quantity; (c) total acres of land impacted; and (d) water quality. These rankings together with other issues (such as degree of certainty, willingness of others to sell water rights, basin of origin supply/demand balances, and back-up supplies in case of a more severe drought), resulted in grouping the twenty-two alternatives into four categories or groups. These four groups are discussed here:

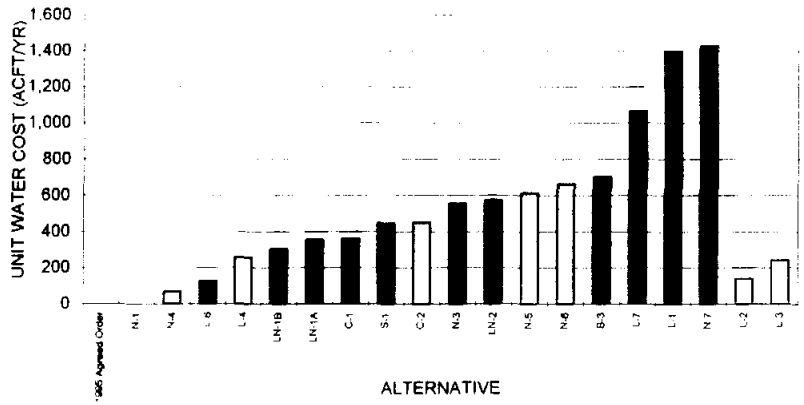
Group 1 Alternatives include those that are reasonably developable and that provide a permanent, dependable and affordable source of good quality water to the area, with minimal environmental impacts (Table 5-2). Group 1 includes five alternatives: modifications of the Choke Canyon/Lake Corpus Christi Reservoir Operating Policy to incorporate the TNRCC 1995 Agreed Order,[3] Accelerated/Additional Municipal Conservation, Industrial Water Conservation, the Lake Texana Pipeline, and the Purchase and Diversion of Garwood Water Rights via Garwood/Colorado Pipeline. The combined supply available from this group totals 82,940 acft/yr or about 83 percent of the projected 2050 additional water needs of the area.

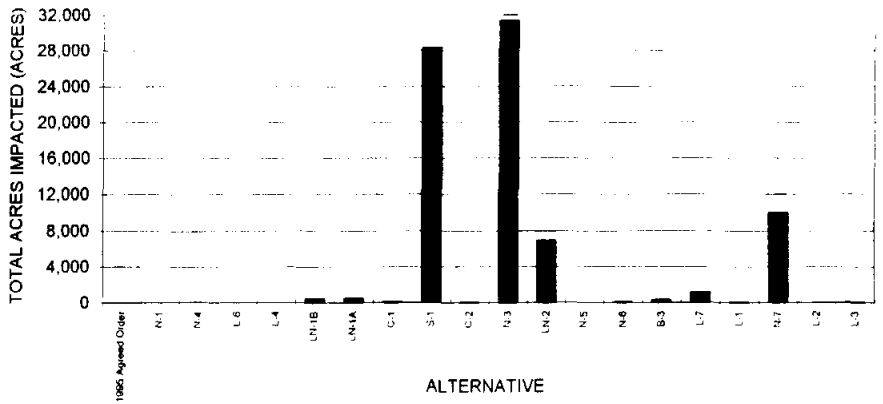
Group 2 Alternatives are stand-by supplies available to meet emergency conditions. These consist of affordable groundwater supplies which are presently or potentially available to the area in the event a drought more severe than previous droughts were to occur. These alternatives generally have low environmental impacts, provided pumpage of groundwater is limited so as to not overdraft the aquifer systems. The water quality

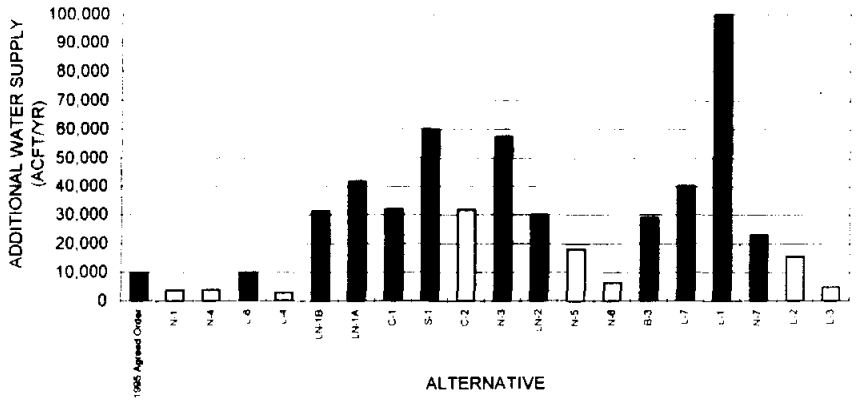
[3] This option was implemented in May of 1995.

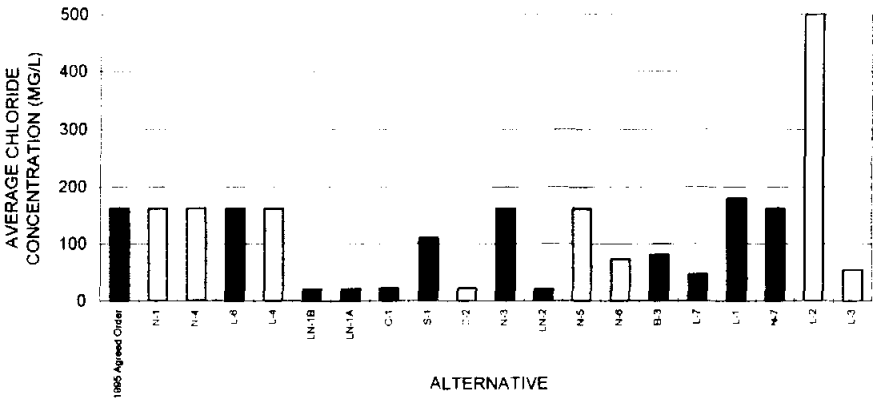
Table 5-1 - Summary of Potential Water Supply Alternatives for Corpus Christi Service Area			
Alternative	**Additional Water Supply (acft/yr)**	**Unit Cost of Additional Water ($ per acft/yr)**	**Environmental Issues/Special Concerns**
Group 1 Alternatives: Dependable, Permanent, and Affordable Supply Options			
N-1 Modify Reservoir Operating Policy 1995 Agreed Order	9,500	$0	City is in process of implementing this alternative.
L-6 Accelerated and Additional Municipal Water Conservation	10,000	$128	Degree of participation uncertain/reduction of wastewater flow will require additional reservoir releases and/or reduce freshwater inflows to estuary.
L-5 Industrial Water Conservation	--	--	Corpus Christi industries lead the State in water conservation measures already implemented/future conservation effects are included in water demand projections.
LN-1 Lake Texana Pipeline to Corpus Christi A. Total LNRA Contract Quantity (stand-alone) B. Permanent LNRA Contract Quantity (combined with other alternatives)	 41,840 31,440	 355 305	504 acres for permanent easement/interbasin transfer/permit contains final release provisions for Lavaca Estuary inflow/increase in Nueces Estuary inflows/existing reservoir with long-term water available/good quality water available for blending with other water sources.
C-1 Purchase and Diversion of Garwood Water Rights to Corpus Christi Existing Garwood water (combined with LN-1B)	 32,000[1]	 360	Additional 144 acres for permanent easement/interbasin transfer/reduction of Colorado Estuary inflow/increase in Nueces Estuary inflows.
Group 2 Alternatives: Stand-By Water Supply Options			
L-2 Local Groundwater Options (Gulf Coast Aquifer) A. Existing Wells Near LCC B. New Sinton Well Field	 15,600[2] 33,600[2]	 $142-314[3] $285-998[3]	Potential for degradation of water quality and saltwater intrusion could limit long-term dependability/possible subsidence/brine disposal/ability to secure lease rights to develop well field/ impact on neighboring wells/ uncertain dependability/continue to use as emergency back-up.
L-3 Use of Groundwater from Campbellton Wells (Carrizo Aquifer)	4,800	$250	118 acres for permanent easement/lowering of groundwater levels near Campbellton.
Group 3 Alternatives: Potentially Dependable, Permanent, and Affordable Options (need further investigation)			
N-1 Modify Reservoir Operating Policy Lower LCC Target from 88 ft-msl to 87 ft-msl (60 days of storage)	4,000	$0	Impact to Recreational Users from following average lake level changes: - 2 inches @ Lake Corpus Christi and +9 inches @ Choke Canyon Reservoir.
N-4 Purchase of Existing Water Rights in Nueces Basin A. Lower Basin Rights; purchase of 4,940 acft/yr B. Upper Basin Rights; purchase of 34,000 acft/yr	 3,260 3,500	 < $70 $431	Uncertainty of owner's willingness to sell rights/value of rights vary depending on location relative to CC/LCC System/relatively small increase in system yield.
N-5 Pipeline from Choke Canyon to Lake Corpus Christi	18,000	$633	145 acres for permanent easement/reduction in Nueces River flows below Choke Canyon Reservoir.
N-6 Pipeline from Lake Corpus Christi to O.N. Stevens W.T.P.	6,500	$686	113 acres for permanent easement/reduction in Nueces River flows below Lake Corpus Christi.
L-4 Municipal Wastewater Reuse (Nueces Delta)	1,100-5,500[4]	$197-710[4]	Degree of credit for diversions to Nueces Bay and Delta are highly uncertain/wastewater permitting requirements uncertain/data needed from demonstration projects.
C-1 Purchase Additional Colorado River Water and Deliver through upsized Garwood and Lake Texana pipelines (combine with LN-1.B)	14,000	$309	No additional easement required/interbasin transfer/reduction of Colorado Estuary inflow/increase in Nueces Estuary inflow
C-2 Purchase of Colorado River Water other than Garwood (combine with LN-1.B)	32,000[1]	454	Additional 116 acres for permanent easement/interbasin transfer/reduction of Colorado Estuary inflow/increase in Nueces Estuary inflows.
Group 4 Alternatives: Potential Future Options			
N-2 Diversion from Nueces River to Choke Canyon	900	$3,488	No significant increase in system yield.
N-3 R&M Reservoir	57,500	$557	Large environmental impact with 31,400 acres inundated/reduction of Nueces Estuary inflow.
N-7 Dredging Lake Corpus Christi A. Maintenance Program (25-years) B. Accelerated Program (25-years)	 7,200 23,000	 $1,667 $1,430	Cost prohibitive/permit needed for spoil disposal/disposal area will cover 6,800 acres to 20,000 acres, depending on depth.
L-1 Desalination of Seawater	5,000-100,000	$1,400-2,000	Cost prohibitive based on cost data from few existing U.S. plants/permitting for large brine disposal uncertain/very high plant maintenance and replacement costs.
S-1 Goliad Reservoir	0-60,000	$447	Large environmental impact with 28,000 acres inundated/reduction of Guadalupe Estuary inflows/347 acres for easements/water quality studies needed/interbasin transfer/increase in Nueces Estuary inflows/ future San Antonio in-basin needs exceed available supplies.
GS-1 Diversion from Guadalupe & San Antonio Rivers (McFaddin Reservoir)	0	--	1,200 acres inundated/interbasin transfer/future San Antonio-Guadalupe in-basin needs exceed available supplies/reduction of Guadalupe Estuary inflow/increase in Nueces Estuary inflows.
LN-2 Palmetto Bend (Phase II) Reservoir (combined with LN-1.B)	30,000	$575	6,900 acres inundated/permit contains provisions for Lavaca Estuary inflow/increase in Nueces Estuary inflow/interbasin transfer.
LN-3 Diversion from Lavaca River to Lake Texana	<3,000	--	No significant increase in system yield.
L-7 Groundwater Recharge and Recovery (Carrizo/Wilcox Aquifer)	40,300	$1,066	Permit needed from Evergreen Underground Water District and TNRCC/ownership of recharge water and effect of ownership rights on other well owners in recharge area is uncertain.
B-3 Purchase of Brazos River Water (combined with LN-1.B)	29,000	$704	Additional 335 acres for permanent easement/interbasin transfer/reduction of Brazos Riverine Estuary inflow/increase in Nueces Estuary inflows/water quality studies needed.

[1] Costs for Alternative C-1 and C-2 are for diversion of water from the Colorado River to Lake Texana delivered through 12-mile reach of Sandy Creek.
[2] Additional water supply amount listed is only for a two-year drought period and is not a sustainable amount.
[3] Approximate range with minimum cost indicating cost if groundwater is blended with good quality surface water. If treatment of groundwater is required to remove dissolved minerals then the cost would be closer to the maximum cost indicated.
[4] Additional water supply and unit costs are dependent on degree of credits for diversions to Nueces Delta.









Group 1: Dependable, Permanent, and Affordable Supply Options

Group 2: Stand-by Water Supply Options (Two-Year Drought Supply)

Group 3: Potentially Dependable, Permanent, and Affordable (Needs Further Investigation)

Group 4: Potential Future Supply Options

L-1 Desalination
L-2 Local Groundwater - Gulf Coast Aquifer
L-3 Use of Groundwater from Campbellton Wells- Carrizo Aquifer
L-4 Municipal Wastewater Reuse
L-6 Accelerated/Additional Municipal Water Conservation
L-7 Groundwater Recharge and Recovery (Carrizo/Wilcox Aquifer)
N-1 Modify Reservoir Operating Policy
N-3 R & M Reservoir
N-4 Purchase of Existing Water Rights in Nueces Basin
N-5 Pipeline from Choke Canyon to Lake Corpus Christi
N-6 Pipeline from Lake Corpus Christi to O.N. Stevens W.T.P.
N-7 Dredging of Lake Corpus Christi
LN-1A Lake Texana Pipeline (Stand-Alone)
LN-1B Lake Texana Pipeline (Combined w/other Alternatives
LN-2 Palmetto Bend (Phase II) Reservoir
S-1 Goliad Reservoir
C-1 Garwood Irrigation Water (w/ LN-1)
C-2 Purchase of Colorado River Water (w/ LN-1)
B-3 Purchase of Brazos River Water (w/ LN-1)

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UNIT WATER COSTS, ADDITIONAL WATER SUPPLY, TOTAL ACRES IMPACTED AND WATER QUALITY FOR WATER SUPPLY ALTERNATIVES

FIGURE 7

Table 5-2
Group 1 Alternatives
(Dependable, Permanent, & Affordable Options)

Alternative	Long-Term Permanent Supply (acft/yr)
Modification of Choke Canyon/Lake Corpus Christi Reservoir Operating Policy to incorporate 1995 Agreed Order (N-1)	9,500[1]
Accelerated and Additional Municipal Conservation (L-6)	10,000[2]
Industrial Water Conservation (L-5)	--- [3]
Lake Texana Pipeline (LN-1)	31,440[4]
Purchase and Diversion of Garwood Water Rights via Garwood/Colorado Pipeline (C-1)	32,000[4]
TOTAL	82,940

[1] The 1995 Agreed Order was issued by the TNRCC on 4/28/95. This order resulted in releases from the City's reservoirs being limited to measured monthly reservoir inflows, thereby increasing the system yield. Under 1990 sediment conditions, the yield is increased by 13,500 acft/yr and under 2050 sediment conditions, the yield is increased by 9,500 acft/yr under the City's Phase II reservoir operating policy.

[2] Start in 1996 and fully effective by 2020.

[3] Corpus Christi industries lead the state in water conservation measures already implemented. Future conservation effects are included in water demand projections.

[4] Corpus Christi has acquired 41,840 acft/yr of Lake Texana water, which includes 10,400 acft/yr reserved for potential future demands in Jackson County. The 41,840 acft/yr will meet projected demands of the Corpus Christi Service Area until 2029, at which time additional quantities will be needed. The completion of facilities in 2029 to begin the transfer of 35,000 acft/yr of Colorado River water purchased from Garwood Irrigation Company would yield about 32,000 acft/yr at Lake Texana, of which 10,400 acft/yr would be available to replace the 10,400 acft/yr of Lake Texana water reserved for potential future demands of Jackson County. This is a reasonable "worst case" assumption as water demand projections for Jackson County show that this water will not be needed before 2050. Under these assumptions, the combined availability of Lake Texana and Garwood water for delivery to the Corpus Christi Service Area after 2029 would be 63,440 acft/yr (41,840 + 32,000 - 10,400 = 63,440). If the 10,400 acft/yr is not needed in Jackson County, then implementation of subsequent alternatives could be delayed.

associated with these alternatives is generally poorer than existing surface water supplies, but is acceptable for drinking purposes if blended with the better quality surface water. Included in this group are the existing wells near Lake Corpus Christi, the Campbellton Well Field, and a potential new well field north of Sinton. Table 5-3 lists the water supply alternatives included in Group 2, as well an estimate of the annual water supply that could be obtained from each option during a 2-year drought period.

Table 5-3 Group 2 Alternatives (Stand-By Options)	
Alternative	**Two-Year Drought Supply** (acft/yr)
Existing Wells near Nueces River and Lake Corpus Christi[1] (L-2)	15,600
Potential New Sinton Well Field[2] (L-2)	33,600
Existing Campbellton Wells (L-3) - Delivered to Choke Canyon Reservoir via pipeline	4,800[3]

[1] Could be combined with proposed pipeline from LCC to O.N. Stevens WTP (i.e., Alternative N-6), if pipeline were constructed.
[2] Potential stand-by option for either San Patricio County or Nueces County entities. However, considerable additional study is needed to further determine the feasibility of this alternative.
[3] Sustainable beyond 2 years.

Group 3 Alternatives include water supply options that, with additional investigation, could potentially become part of the Group 1 Alternatives and provide a permanent, dependable, and affordable water supply. However, these options require a significant additional planning, permitting, or implementation effort. Generally these alternatives have reasonably small to moderate environmental impacts relative to the other alternatives in this study. Table 5-4 lists the possible long-range options comprising Group 3, the estimated range of additional annual supply available, as well as a list of issues needing additional investigation. Included in this group are: Modification of the Choke Canyon/Lake Corpus Christi Reservoir Operating Policy to use a Lake Corpus Christi lake target level below 88 ft-msl elevation; Purchase of Existing Water Rights in the Nueces River Basin; Pipelines from Choke Canyon Reservoir to Lake Corpus Christi and from Lake Corpus Christi to the O.N. Stevens Water Treatment Plant; Diversions of Municipal Wastewater to the Nueces Delta; and Purchase and Diversion of Additional Garwood Water Rights and/or other Colorado River Water.

Group 4 Alternatives include potential future water supply options that have one or more significant issues that limit present feasibility. Limiting issues include a large degree of uncertainty, limited permanent water available, high costs, and/or significant environmental impacts as compared to the other alternatives. Table 5-5 lists the potential future supply options, the estimated range of additional water supply available from each,

Table 5-4 Group 3 Alternatives (Potentially Dependable, Permanent, and Affordable Options)		
Alternative	**Range of Potential Long-Term Permanent Supply** (acft/yr)	**Issues Needing Additional Investigation**
Modification of Choke Canyon/Lake Corpus Christi Reservoir Operating Policy (N-1)	4,000	Reservoir Sedimentation Survey and Water Delivery Loss Study
Purchase of Existing Water Rights in Nueces River Basin (N-4) A. Lower Basin Rights B. Upper Basin Rights	 0 - 3,261 0 - 3,500	Willingness of owners to sell water rights
Pipeline from Choke Canyon Reservoir to Lake Corpus Christi (N-5)	18,000 ±	Water Delivery Loss Study
Pipeline from Lake Corpus Christi to O.N. Stevens Water Treatment Plant (N-6)	6,500 ±	Water Delivery Loss Study and Water Quality Evaluation
Municipal Wastewater Reuse (L-4) (Diversions to Nueces Delta)	1,100 - 5,500	Establishment of Biological Productivity Credits and Relief of TNRCC Effluent Standards
Purchase and Diversion of Additional Garwood Water Rights and/or other Colorado River Water through upsized Garwood Pipeline (C-1) and (C-2)	14,000	Willingness of owners to sell water rights and other water rights issues.
Purchase of Colorado River Water (other than Garwood) (C-2)	32,000	Willingness of owners to sell water rights and other water rights issues.

as well as a listing of the present limiting issue(s) for each option. The following options are included in this group: Diversion from Nueces River to Choke Canyon Reservoir; R&M Reservoir; Desalination of Seawater; Goliad Reservoir (San Antonio River Basin); Diversion from Guadalupe/San Antonio rivers (with or without McFaddin Reservoir); Palmetto Bend (Stage II) Reservoir; Diversion from Lavaca River to Lake Texana; Groundwater Recharge and Recovery (Carrizo/Wilcox Aquifer); Dredging Lake Corpus Christi; and Purchase of Brazos River Water.

Table 5-5
Group 4 Alternatives
(Potential Future Options[1])

Alternative	Range of Potential Long-Term Permanent Supply (acft/yr)	Present Limiting Issues
Diversion from Nueces River to Choke Canyon Reservoir (N-2)	900	Supply limited; high cost.
R & M Reservoir (N-3)	57,000±	High costs; Large environmental impact.
Desalination of Seawater (L-1)	5,000 - 100,000	Very high cost; Uncertainty in permitting brine disposal.
Goliad Reservoir (S-1) (San Antonio River Basin)	0 - 60,000	Large environmental impact; highly uncertain water rights issues.
Diversion from Guadalupe/San Antonio Rivers (GS-1) (with or without McFaddin Reservoir)	0 - 39,500	Highly uncertain water rights issues.
Palmetto Bend (Stage II) Reservoir (LN-2)	30,000	Determination of estuary releases.
Diversion from Lavaca River to Lake Texana (LN-3)	< 3,000	Supply limited.
Groundwater Recharge and Recovery (L-7) (Carrizo/Wilcox Aquifer)	40,300	Uncertain legal issues; high cost.
Dredging Lake Corpus Christi (N-7)	7,200 - 23,000	High cost; uncertain environmental permitting issues.
Purchase of Brazos River Water (B-3)	29,000	High cost.

[1] Includes options which have either a large degree of uncertainty, high environmental impact, high unit costs or provide limited firm water supply.

Some of the alternatives in Group 4 could potentially become viable alternatives if limiting issues are resolved in the future. For example, if significant technological breakthroughs occur in desalination and/or dredging processes, it may be appropriate to move these options, or others, into Group 3 for additional investigations.

6.0 INTEGRATED WATER SUPPLY PLANS

From a review of the four alternative water supply groups, two potential integrated water supply plans have been formulated which will provide an additional 100,940 acft/yr by 2050. Each plan includes alternatives which have a high degree of certainty, and provide permanent, dependable and affordable good quality water to the area, with minimal environmental impacts. Each plan includes the five alternatives contained in Group 1. These alternatives are: Modification of Choke Canyon/Lake Corpus Christi Reservoir Operating Policy to incorporate TNRCC 1995 Agreed Order;[4] Accelerated and Additional Municipal Conservation (start in 1996 and fully effective by 2020); Industrial Water Conservation; Lake Texana Pipeline; and Purchase and Diversion of Garwood Water Rights via Garwood/Colorado Pipeline.

These alternatives provide a total permanent supply of about 83,000 acft/yr which is about 17,500 acft/yr short of the year 2050 projected shortfall of 100,500 acft/yr.[5] Considering the six alternatives from Group 3 (see Table 5-4), it was decided that alternatives from this group with a reasonable degree of certainty and reasonable cost would be included in the two plans. For Plan A, this included the Pipeline from Choke Canyon Reservoir to Lake Corpus Christi (Alternative N-5) which is estimated to supply about 18,000 acft/yr as indicated on Table 5-4. For Plan B, Modifications of the Choke Canyon/Lake Corpus Christi Reservoir Operating Policy (Alternative N-1) which would supply an estimated additional 4,000 acft/yr (2050 conditions) as well as the Purchase and Diversion of Additional Colorado River water (either Alternatives C-1 or C-2) which would supply an additional 14,000 acft/yr were included.

Under Plan B it would be necessary to upsize the Lake Texana pipeline and the Garwood/Colorado pipeline to convey the additional 14,000 acft/yr of future supply. For the Lake Texana pipeline, this means upsizing from a 60-inch diameter line to a 66-inch diameter line. For the Garwood/Colorado pipeline this means upsizing from a 48-inch diameter line to a 60-inch diameter line, although the diameter of this line is subject to change depending on the final outcome of the Garwood water rights permit amendment process.

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[4] Implemented in May of 1995, and meets 9,500 acft of the projected year 2050 shortfall of 100,500 acft.

[5] Ibid.

The dates at which each of the individual water supply or demand management components of each plan needs to be available are indicated in Table 6-1. These dates are flexible depending on actual growth. For example, if growth exceeds the projected rates, the components of each plan need to be brought on-line sooner and if growth is less than projected,

Table 6-1
Integrated Water Supply Plans
Corpus Christi Service Area

Plan and Alternatives Included	Year 2050 Permanent Supply (acft/yr)	Estimated Year Water Needs to be Available
Plan A		
• Modification of Choke Canyon/Lake Corpus Christi: Operating Policy to incorporate 1995 Agreed Order	9,500	1995
• Accelerated/Additional Conservation (L-5 and L-6)	10,000	1996
• Lake Texana Pipeline (60") (LN-1)	41,840[1]	2007
• Garwood-Colorado Pipeline (C-1)	21,600[1]	2029
• Pipeline from Choke Canyon Reservoir to Lake Corpus Christi (96") (N-5)	18,000	2039
Total	100,940	
Plan B		
• Modification of Choke Canyon/Lake Corpus Christi: Operating Policy to incorporate 1995 Agreed Order	9,500	1995
• Accelerated/Additional Conservation (L-5 and L-6)	10,000	1996
• Lake Texana Pipeline (66") (LN-1)	41,840[1]	2007
• Garwood-Colorado Pipeline (60") (C-1)	21,600[1]	2029
• Additional Garwood or Colorado River Water (C-1 or C-2)	14,000[2]	2039
• Modification of Choke Canyon/Lake Corpus Christi Operating Policy by changing LCC Target Elevation to 87 ft-msl (N-1)	4,000	2046
Total	100,940	

[1] Corpus Christi has acquired 41,840 acft/yr of Lake Texana water, which includes 10,400 acft/yr reserved for potential future demands in Jackson County. The 41,840 acft/yr will meet projected demands of the Corpus Christi Service Area until 2029, at which time additional quantities will be needed. The completion of facilities in 2029 to begin the transfer of 35,000 acft/yr of Colorado River water purchased from Garwood Irrigation Company would yield about 32,000 acft/yr at Lake Texana, of which 10,400 acft/yr would be available to replace the 10,400 acft/yr of Lake Texana water reserved for potential future demands of Jackson County. This is a reasonable "worst case" assumption as water demand projections for Jackson County show that this water will not be needed before 2050. Under these assumptions, the combined availability of Lake Texana and Garwood water for delivery to the Corpus Christi Service Area after 2029 would be 63,440 acft/yr (41,840 + 32,000 - 10,400 = 63,440). If the 10,400 acft/yr is not needed in Jackson County, then implementation of subsequent alternatives could be delayed.

[2] Additional Colorado River water rights of about 16,000 acft/yr would need to be purchased from either Garwood, LCRA, Pierce Ranch, or others, in order to provide a firm yield increase of 14,000 acft/yr at Lake Texana.

then the implementation of some projects can be delayed. However, one of the most significant items that affects the ultimate cost of each alternative is the interest rate on the necessary bond issue. It would be prudent to allow ample flexibility in the timing of construction so that financing for each project can be obtained at the lowest possible interest rate. The approximate dates each alternative needs to be on-line are shown graphically on Figure 8 for Plan A and on Figure 9 for Plan B.

As shown in both Figures 8 and 9, implementation of the new 1995 Agreed Order occurs in 1995 while Accelerated/Additional Conservation efforts begin in 1996. Construction of the Lake Texana Pipeline would need to begin no later than 2004 in order to have the project on line by 2007. The Garwood/Colorado pipeline would be needed by about 2029 if growth occurs as projected, although water rights for the Garwood pipeline need to be acquired by the end of 1996 to ensure future availability[6] and to properly size the initial Lake Texana pipeline. For Plan A the pipeline from Choke Canyon Reservoir to Lake Corpus Christi would be needed by about 2039. And for Plan B, by 2039 either the modification of the operating policy of the two reservoirs needs to occur, or additional Colorado water brought in via the Garwood/Colorado and Lake Texana pipeline.

In some water supply systems it has been shown to be feasible to delay construction by tieing implementation of a major water transmission pipeline to drought conditions based on key reservoir levels and water demands. However, in the case of the Corpus Christi System, this type of triggering mechanism is not feasible due to a combination of several factors. While the length of the critical drought for the CC/LCC System is only about 42 months, obtaining financing, bidding and construction of the pipeline could easily require 30 months or more. This means that construction would need to start with the Lakes relatively full in order to have water available from the pipeline (which will initially be delivering less than 25 percent of the service area's demands) for a meaningful length of time during the drought. A more appropriate way to time construction of the Lake Texana pipeline is to periodically review records of actual water demands and project these demands forward in time on the basis of estimates of future growth.

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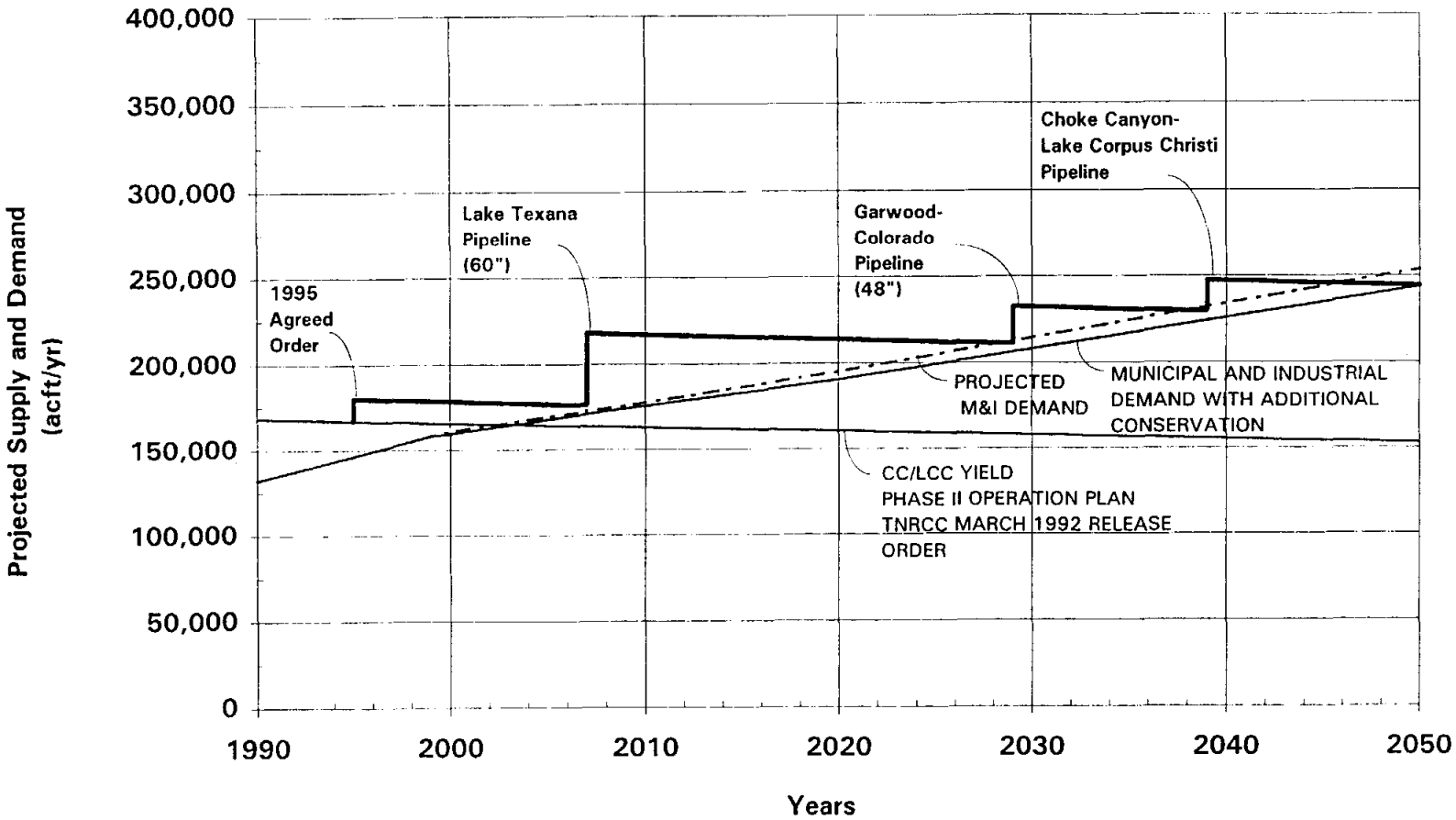
[6] Acquisition of water rights from the Colorado River is a key issue which needs to be considered at the earliest possible date since competition for these rights by other entities could eliminate their availability in the future.

Integrated Water Supply Plan A



Combined Water Supply with Integrated Plan Alternatives

Projected M & I Demand upon CC/LCC System, High Case, with Conservation

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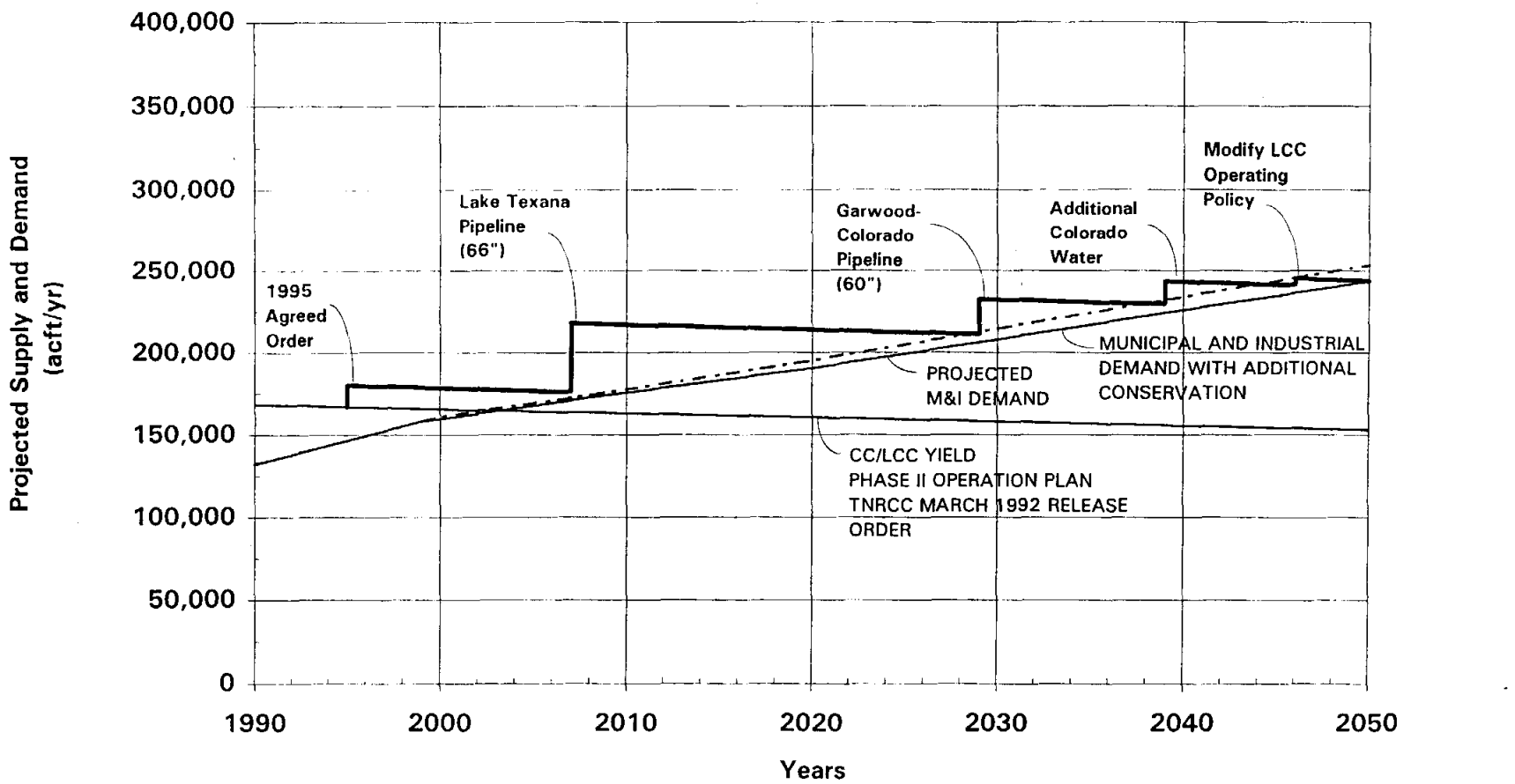
IMPLEMENTATION PLAN FOR INTEGRATED WATER SUPPLY PLAN A

FIGURE 8

Integrated Water Supply Plan B



Combined Water Supply with Integrated Plan Alternatives

Projected M & I Demand upon CC/LCC System, High Case, with Conservation

HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM / CORPUS CHRISTI SERVICE AREA

IMPLEMENTATION PLAN FOR INTEGRATED WATER SUPPLY PLAN B

FIGURE 9

When these projections indicate that demands are likely to exceed available supply within a 10-year timeframe, then a financing plan for construction should be initiated. As soon as favorable market conditions occur (i.e., low interest rates), financing should be procured, bids obtained, and construction initiated. This type of managed approach will result in minimizing the cost of the pipeline to rate payers in the service area while maintaining a reasonable degree of system reliability. A discussion of each alternative contained in the two water supply plans is included in Section 3.0 of Volume 2.

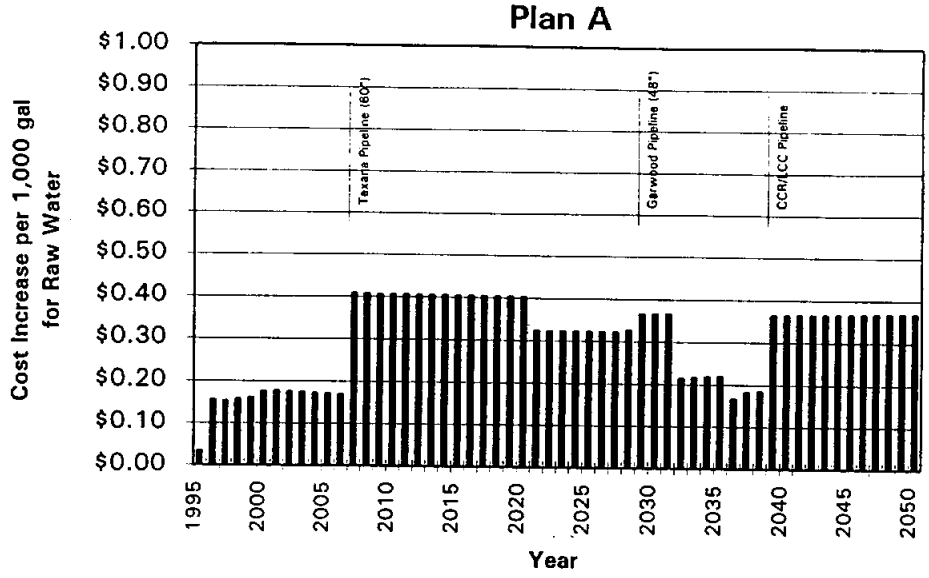
6.1 Summary of Annual Costs and Impacts on Water Rates

Cost components for each of the two integrated water supply plans were tabulated by year for the period 1995 to 2050. Projected cost increases per 1,000 gallons for raw and treated water under Plan A are plotted on Figure 10 for the 1995 to 2050 time period. Projected cost increases per 1,000 gallons for raw and treated water under Plan B are plotted on Figure 11 for the same period. Water treatment plant capacity upgrades, including schedule and cost, are the same for both plans. Impacts to water rates were estimated by distributing the annual cost increases to all water customers on a uniform basis for each 1,000 gallons of total water use.

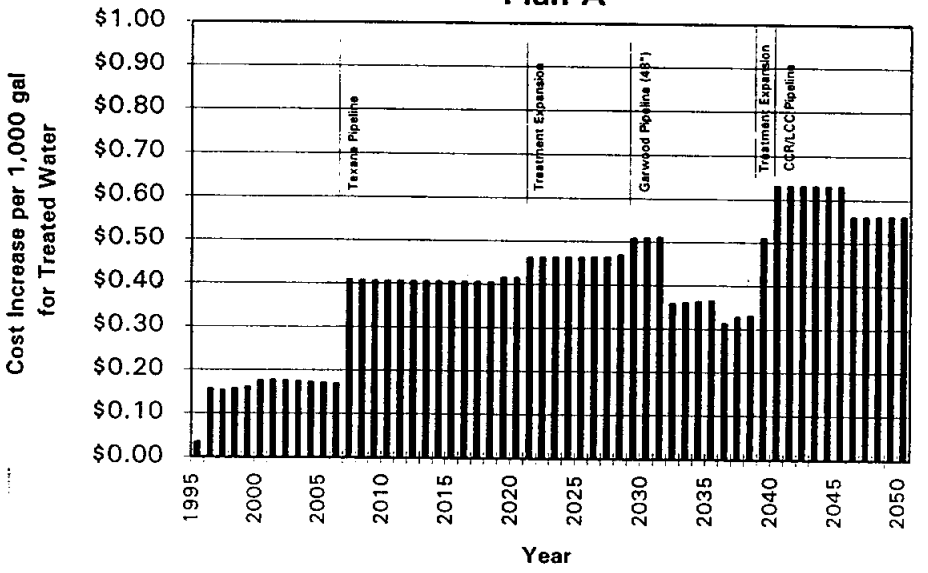
For the period 1996 to 2007, the average cost increase for raw water under Plan A is $0.17 per 1,000 gallons and is $0.18 per 1,000 gallons under Plan B (see Figures 10 and 11). For the 2008 to 2030 period, the average cost increase above 1995 rates for raw water under Plan A is $0.38 per 1,000 gallons and $0.43 per 1,000 gallons under Plan B. For the last 20 years of the planning period, the average cost increase above 1995 rates for raw water under Plan A is $0.32 per 1,000 gallons, and for Plan B is $0.20 per 1,000 gallons above 1995 rates. The unit costs for both Plan A and Plan B in the 2031 to 2050 period actually decrease for raw water compared to the 2007 to 2030 cost.

For the period 1996 to 2007, the average cost increase for treated water under Plan A is $0.17 per 1,000 gallons and is $0.18 per 1,000 gallons under Plan B. For the 2008 to 2030 period, the average cost increase above 1995 rates for treated water under Plan A is $0.43 per 1,000 gallons and $0.49 per 1,000 gallons under Plan B. For the last 20 years of the planning period, the average cost increase for treated water under Plan A is $0.53 per 1,000 gallons above 1995 rates, and for Plan B is $0.39 per 1,000 gallons above 1995 rates. The unit cost

Cost Increases for Raw Water
Plan A



Cost Increases for Treated Water
Plan A



1. Debt service component calculated for 25 years at 8% interest.
2. Cost increases are 1995 dollars.
3. Revenue requirement increase needed per year to pay for integrated plan.

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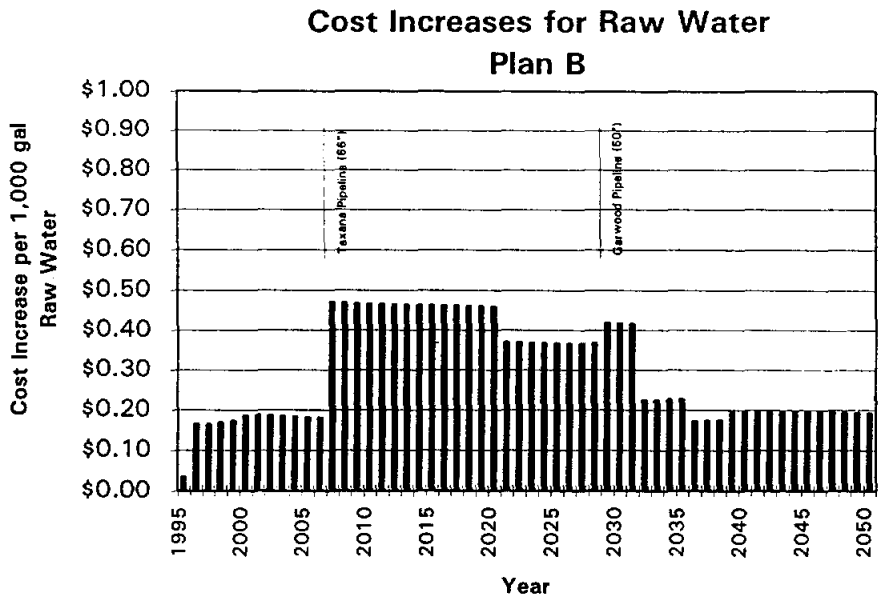
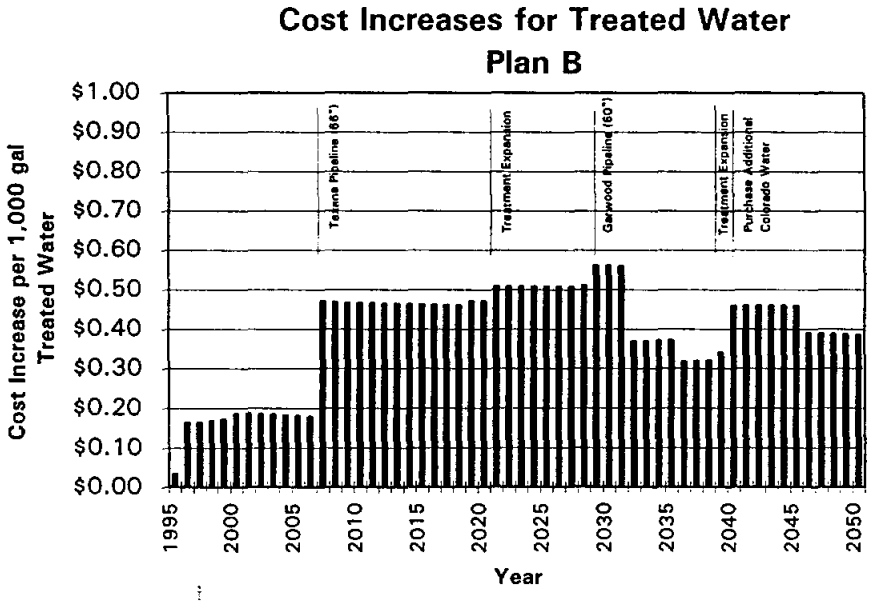
INCREASED COST OF WATER WITH INTEGRATED WATER SUPPLY PLAN A

FIGURE 10





1. Debt service component calculated for 25 years at 8% interest.
2. Cost increases are 1995 dollars.
3. Revenue requirement increase needed per year to pay for integrated plan.

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INCREASED COST OF WATER WITH INTEGRATED WATER SUPPLY PLAN B

FIGURE 11

increase for Plan B in the 2031 to 2050 period ($0.39/1,000 gal) actually decreases compared to the 2007 to 2030 cost ($0.49/1,000 gal).

Potential effects on typical monthly water bills for residential, commercial, and wholesale customers in the near term (i.e., 1995 through 2007) from implementing the integrated plans is demonstrated in Table 6-2 for both Plans A and B. As shown in Table 6-2, implementation of Plan A will increase the average residential water bill (for 9,000 gal/month consumption in-city) from $16.38 in 1995 to about $20.29 by 2007 (1.8 percent per year increase), an increase of 24 percent. A commercial in-city bill for 70,000 gal/month would increase from $202.03 under Plan A to $232.41 in 2007 (1.2 percent per year increase), for an increase of 15 percent. A wholesale industrial raw water bill for 10,000,000 gal/month would increase from $2,080.43 to $5,830.43 in 2007 (1995 dollars). On an annual basis, the wholesale raw water rate increase would average about 9.0 percent per year for the 1995 to 2007 period for Plan A.

Table 6-2
Typical Monthly Water Bills with Integrated Supply Plans

Rate Category	Present Monthly Bill	Estimated Monthly Bill[1]--Year 2007	
		Plan A	Plan B
Residential In-City (9,000 gal/month)	$16.38	$20.29	$20.78
Commercial In-City (70,000 gal/month)	$202.03	$232.41	$236.26
Wholesale Raw Water (10,000,000 gal/month)	$2,080.43	$5,830.43	$6,370.43

[1] Values are 1995 dollars and based on uniform price increase for each 1,000 gallons used by each customer.

As shown in Table 6-2, implementation of Plan B will increase the average residential water bill (for 9,000 gal/month consumption, in-city) from $16.38 in 1995 to $20.78 in 2007 (2.0 percent per year increase) for an increase of 27 percent. A commercial in-city bill for 70,000 gal/month would increase from $202.03 under Plan B to $236.26 in 2007 (1.3 percent per year increase) for an increase of 17 percent above 1995 rates. A wholesale industrial raw

water bill for 10,000,000 gal/month would increase from $2,080.43 in 1995 to $6,370.43 in 2007 (1995 dollars). On an annual basis, the wholesale water rate increase would be 9.8 percent per year for the 1995 to 2007 period for Plan B.

Because Plan B includes up-sized facilities to be built early in the plan to transport future water from the Colorado River, the impact on water rates early in the plan are higher when compared to Plan A. However, Plan B has a lower potential impact on water rates at the end of the planning period when the plan facilities become fully utilized. For instance, for the 2007 to 2030 period, the average cost increase for treated water under Plan B is $0.06 per 1,000 gallons higher than Plan A, a difference of 11 percent (Table 6-2). However, for the 2031 to 2050 period, cost increases for Plan B are $0.14 lower than Plan A, a difference of 34 percent.

Financing factors (i.e., interest rates and alternative financing plans offered by TWDB) could affect the above rate increases if TWDB funds are available. Discussion of these financing issues is found in Sections 4.9.2 and 4.9.3 of Volume 2.

6.2 Environmental Issues

In terms of acreage affected, streamflows, bay and estuary inflows, and wastewater return flows to Nueces Estuary, effects of implementing either plan will be additive, and will accumulate sequentially as the separate alternatives are implemented over time. The effects of installing water pipelines will be greatest on terrestrial habitats during construction. However, agricultural land can be returned to its original use following construction. The total acreage of terrestrial habitats affected by Plan A during construction would be 2,545 acres, of which 1,804 acres (71%) is grass or cropland. About 666 acres would be maintained ROW after the projects are constructed. Where the pipelines cross brushlands, brush can be expected to become established in areas outside the maintenance ROW in about 10 years. About 190 acres that were formerly brushland would be maintain as a mowed ROW. The combined alternatives would impact approximately 65 acres of woodland, mostly along river and creek banks. Wetlands in the proposed ROWs total about 145 acres, however, tunneling under several major rivers is expected to significantly reduce impacts to wetlands to below this amount.

The effects of Plan B on terrestrial habitats are similar to those of Plan A. The construction and maintenance ROWs for Plan B would involve about 2,443 acres and 698 acres,

respectively. Impacts to woodlands would be greater by about 34 acres, but impacts to brushland would be less by about 431 acres. Cropland crossed by a proposed pipeline to the Colorado River near Wharton accounts for the remaining difference.

Implementing Plan A will reduce flows below Lake Texana, below the Garwood diversion point on the Colorado River, and in the Nueces River between Choke Canyon Reservoir and Lake Corpus Christi. Freshwater inflow resulting from interbasin transfer considered alone would increase freshwater inflow to Nueces Estuary 10 percent (29,800 acft/yr assuming a water supply of 63,440 acft/yr). For Plan B, additional water diverted from the Colorado River is substituted for the pipeline from Choke Canyon Reservoir to Lake Corpus Christi. Thus, Plan B would divert more water from the Colorado River (an additional 14,000 to 16,000 acft/yr). Return flows resulting from this interbasin transfer would further increase freshwater inflow to Nueces estuary. Local alternatives common to both plans (Modification of Choke Canyon/Lake Corpus Christi, Accelerated and Additional Conservation) and Modification of Choke Canyon/Lake Corpus Christi Operating Policy by changing to a target elevation of 87 ft-msl in Plan B would appear to result in only minor deviations in inflows from that expected from the interbasin transfers.

Increasing freshwater inflow to Nueces Estuary can be expected to have generally positive effects on the ecology of the estuary. Increasing flow to Nueces Estuary would mitigate against the historical trend of reducing freshwater inflows for human use and increased flows. Also, increased freshwater inflows may benefit estuarine shellfish and finfish fisheries.[7,8] With respect to the interbasin transfer of organisms, neither plan would appear to present significant problems, since Colorado River Water has been transferred to the Lavaca Basin annually since the early 1900's, and under each of the integrated plans, water from the Colorado and Lavaca Basins would be piped directly from Lake Texana to the O.N. Stevens Water Treatment Plant.

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[7] Texas Department of Water Resources. 1981. Nueces and Mission-Aransas Estuaries: A Study of the Influence of Freshwater Inflows. LP-108. TDWR. Austin, Texas.

[8] Longley, W.L. ed. 1994. Freshwater Inflows to Texas Bays and Estuaries: Ecological Relationships and Methods for Determination of Needs. TWDB and TPWD. Austin, Texas.

Although this issue continues to be studied,[9] appropriate treatment practices at the O.N. Stevens WTP will minimize the likelihood of transferred organisms becoming a problem in the receiving river basin. Furthermore, the close proximity of the Colorado River Basin and the Lavaca-Navidad River in Wharton, Matagorda, and Jackson Counties makes it unlikely that species inhabiting either basin are isolated from the other basin. In addition to species transfers due to human activities, natural events such as large storms which lower estuarine salinities provide a corridor favorable for the natural interbasin transfer of organisms.

6.3 Implementation Issues

Implementation issues of the components of the integrated water supply plans are described in Section 4.11, Volume 2. In summary, the pipeline projects will require permits from state and federal agencies and other approvals as listed:

- TNRCC permit amendments;
- Coastal Coordinating Council review;
- U.S. Army Corps of Engineers Sections 10 and 404 dredge and fill permits for pipeline crossings of streams classified as navigable waters of the U.S.;
- Texas General Land Office Sand and Gravel Removal permits and stream crossings;
- Texas Parks and Wildlife Sand, Gravel, and Marl permits for river crossings;
- Environmental studies;
- Cultural resource studies;
- Right-of-way and easement acquisition;
- Affected Agency approvals for pipeline crossings:
    - Texas Department of Transportation;
    - County Commissioners' Courts;
    - Cities;
    - Railroads;
    - River Authorities;
    - Gas and electric utilities;
    - Water Utilities;
    - Oil and gas pipeline companies; and
    - Other owners of pipelines; and
- Habitat Mitigation Plan.

[9] U.S. Army Corps of Engineers. 1995. Technical Memorandum, Potential Ecological Effects of Two Proposed Interbasin Transfers in the South-Central Study Area. Fort Worth District.

Implementation issues of accelerated and additional municipal water conservation will involve public acceptance and willingness to:

- Replace plumbing fixtures in their homes, workplaces, and institutions;
- Change landscaping at homes and public places, including recreation areas; and
- Become more conscious of and directly involved with management of personal water using functions.

The replacement of plumbing fixtures would be a temporary inconvenience; water conservation landscaping would result in views of different types of grasses and plants, and during the dry times more brown and less green lawns and public areas. A water conscious public would increase care with which plumbing fixtures, water using appliances, and irrigation equipment is used. For some actions under this alternative, the City Council will need to issue new ordinances dealing with specific issues such as landscape requirements for new subdivisions.

Implementation issues associated with modification of Choke Canyon/Lake Corpus Christi operating policy by changing from a target elevation of 88 ft-msl, include the need for:

- Completion of the planned sediment survey of Lake Corpus Christi in order to provide more accurate estimates of the sedimentation rate in the lake, which will result in better estimates of future reservoir capacities. The capacities of the lakes play an important role in the firm yield of the system. Following the results of the sediment survey, reservoir system yield should be re-computed for both 2010 and 2050 conditions.

- Additional channel loss studies on the river reaches between CCR and LCC and between LCC and Calallen Dam need to be completed to determine if losses vary significantly with the time of year and the magnitude of the release rates. Any new operating policy must consider losses from all sources in order to fully maximize the yield of the reservoir system while attempting, to the extent possible, to minimize impacts to recreational users.

- Consideration of lower target levels at Lake Corpus Christi should continue to address the need to modify water supply intakes in and around Lake Corpus Christi, especially if target levels below 87 ft-msl are considered.

- Modification of the current City Ordinance describing the implementation of operation policy phases as demands increase will be necessary if alternative operating policies are implemented.

7.0 RECOMMENDATIONS

Either of the two integrated water supply plans provide the Corpus Christi service area with the opportunity to develop economical and reliable water supplies to meet the growing needs of the area, provided that an orderly and flexible implementation plan is followed and key decision points are maintained. Intrinsic to the plan is the flexibility to adjust the implementation schedule as needed to meet the water needs of the service area. The decision-making framework to give the City full advantage of this flexibility is discussed here. However, significant lead times are needed to conduct studies for permitting, answer the public's concerns, obtain financing, obtain easements, and bring the individual plan elements on-line. Long lead times require long-range planning, an orderly progression of recommended actions, and a commitment to periodically update the area growth trends for decision making.

The planning framework set forth below contains the action-item recommendations for implementation of an integrated water supply plan. Figures 12 and 13 present bar chart timelines of the recommended implementation schedule for Plan A and Plan B, respectively.

The Trans-Texas Water Program defines the following project phases and these designations are used in the recommended implementation plan and schedule:

Phase I:	Program Initiation/Conceptual Planning (Phase I has been completed)
Phase II:	Feasibility Studies (This report when finalized will conclude the Phase II work on Group 1 alternatives.)
Phase III:	Preliminary Project Design/State and Federal Permitting
Phase IV:	Property Acquisition/Final Design
Phase V:	Project Construction, Start-up, and Operation.

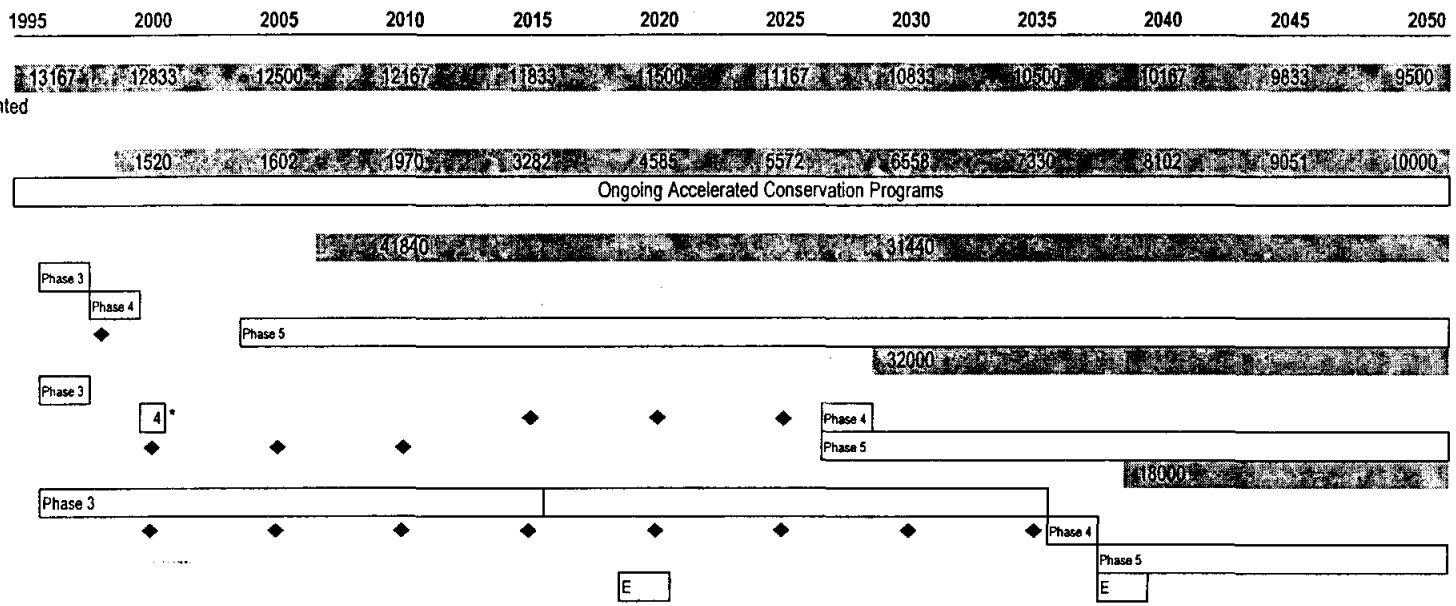
Recommended actions that are included in both Plan A and Plan B are discussed below:

Year 1996 to 2000

1. Accelerated and Additional Water Conservation (L-5, L-6)
   Phase III and IV: These Phases are not applicable to this alternative.
   Phase V:
   a. Continue and Enhance Public Information Program
   b. Begin Water Audit Program (Municipal and Industrial)
   c. Continue and Enhance Plumbing Retrofit Kit Program
   d. Evaluate potential to revise city ordinances to require the use of drought tolerant grasses and landscaping in new subdivisions.
   e. City staff to work with Industry to implement additional conservation measures.

Integrated Water Supply Plan A

PLAN A - PHASING SCHEDULE



Sum of Additional New Water Supplies (acft/yr)	13167	14353	14102	55977	56955	57925	58578	80831	81270	99709	100324	100940
New Water Supply Needed (acft/yr)	0	0	0	14500	24500	34500	45400	56500	67500	78500	89500	100500

Phases of the Trans-Texas Water Program Are:

- Phase 3: Preliminary Design / State and Federal Permitting / Further Investigations
- Phase 4: Final Design / Property Aquisition
- Phase 5: Project Construction, Start-Up, and Operation

Legend:

Numbers in shaded bars indicate new water supply from the alternative.

Outlined areas indicate duration of phase

E 35 MGD Water Treatment Plant Expansion

◆ Milestone review by Corpus Christi to update growth projections, adjust integrated supply plan implementation schedule, and consider milestone decisions.

* Easement Acquisition Only

HDR Engineering, Inc.

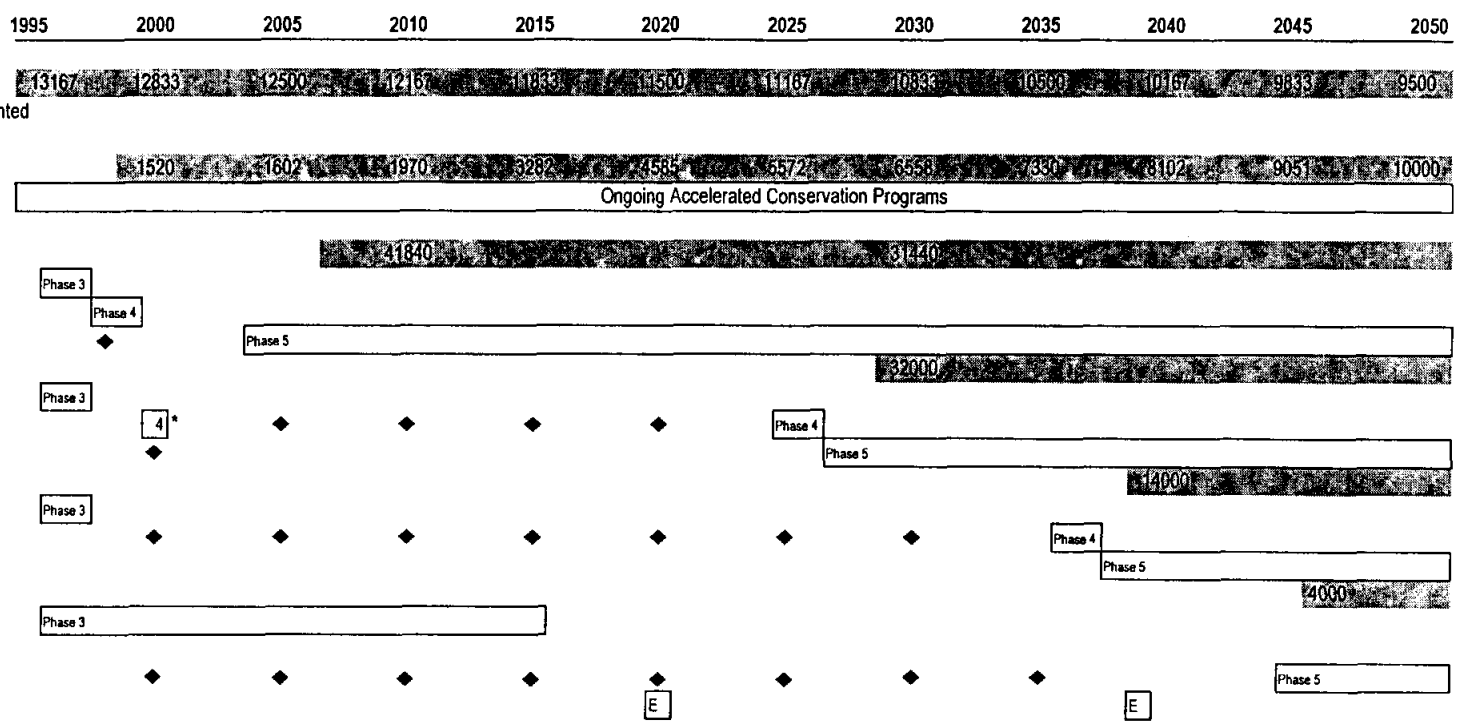
TRANS TEXAS WATER PROGRAM / CORPUS CHRISTI SERVICE AREA

PHASING SCHEDULE INTEGRATED WATER SUPPLY PLAN A

FIGURE 12

Integrated Water Supply Plan B

PLAN B - PHASING SCHEDULE



Sum of Additional New Water Supplies (acft/yr)	13167	14353	14102	55977	56955	57925	58578	80831	81270	95709	96324	100940
New Water Supply Needed (acft/yr)	0	0	0	14500	24500	34500	45400	56500	67500	78500	89500	100500

Phases of the Trans-Texas Water Program Are:

- Phase 3: Preliminary Design / State and Federal Permitting / Further Investigations
- Phase 4: Final Design / Property Aquisition
- Phase 5: Project Construction, Start-Up, and Operation

Legend:

Numbers in shaded bars indicate new water supply from the alternative

Outlined areas indicate duration of phase

E 35 MGD Water Treatment Plant Expansion

◆ Milestone review by Corpus Christi to update growth projections, adjust integrated supply plan implementation schedule, and consider milestone decisions.

* Easement Acquisition Only

HDR Engineering, Inc.

TRANS TEXAS WATER PROGRAM / CORPUS CHRISTI SERVICE AREA

PHASING SCHEDULE INTEGRATED WATER SUPPLY PLAN B

FIGURE 13

2. Lake Texana Pipeline (LN-1)

Initiate Phase III by 1996:

a. Make application to TNRCC for amendment to Lake Texana Permit, authorizing interbasin transfer of water from Lake Texana.
b. Prepare Preliminary Engineering Report.
c. Continue detailed route studies to avoid environmentally sensitive areas, wetlands, and cultural resources.
d. Prepare habitat mitigation plan.

Initiate Phase IV in 1997:

a. Finalize pipeline alignment.
b. Plan easement acquisition.
c. Perform rate study and financing plan.
d. Pursue possible alternative financing with TWDB.

Decision Milestone: By 1998, using information developed from this and other studies (i.e., rate studies, permitting issues, growth rates, and public input) consider and decide on capacity of Texana Pipeline (i.e. Plan A: 60" pipeline or Plan B: 66" pipeline).

e. Complete Phase IV Final Design by 2000.

3. Purchase of Garwood Water Right (C-1)

Initiate Phase III in 1996:

a. Prepare Preliminary Engineering Report
b. Make application to TNRCC for amendment to Garwood Permit, authorizing transfer of water from Colorado River to the Corpus Christi service area through Lake Texana.
c. Continue detailed route studies to avoid environmentally sensitive areas, wetlands, and cultural resources.
d. Prepare habitat mitigation plan.

Decision Milestone: Upon obtaining permit amendment, purchase 35,000 acft/yr of Garwood water rights.

a. Financing and payment methods.
b. Based on decision made for Texana Pipeline capacity, (i.e. Plan A: 60" or Plan B: 66"), consider option to pursue purchase of additional Colorado River water, if favorable.

4. Purchase of Additional Garwood Water or other Colorado River water (C-1) or (C-2)

a. Begin discussions with water right owners by 1996 to determine feasibility of obtaining an option contract for future purchase of an additional 15,000 to 16,000 acft of Colorado River water.

Decision Milestone: By 1998, decide on capacity and size of Texana Pipeline considering the results of efforts to obtain additional Colorado River water under favorable contract terms. If efforts are not successful, then proceed with 60" pipeline.

5. Pipeline from Choke Canyon to Lake Corpus Christi (N-5)
   a. Initiate long-term study of channel losses in river reaches and install additional stream gages downstream of Choke Canyon Reservoir and upstream of Lake Corpus Christi.
   b. Perform detailed evaluation of impacts of reduced flows on the by-passed reach

6. Modification of Choke Canyon/Lake Corpus Christi Operating Policy
   a. Complete TWDB Sedimentation Survey of Lake Corpus Christi next time lake fills.
   b. Following completion of Sedimentation Survey, recalculate future estimates of elevation-area-capacity relationships for Lake Corpus Christi and then re-evaluate alternative reservoir operation policies.
   c. Continue channel-loss studies on two reaches (Choke Canyon to Lake Corpus Christi and Lake Corpus Christi to Calallen Dam) of Nueces River to determine how loss rates vary by season and by release rates.

7. Other Group 2 and Group 3 Alternatives Requiring Further Investigation
   a. Purchase of water rights in Nueces River Basin (N-4). Contact owners and decide by 1998 on availability of water.
   b. Pipeline from Lake Corpus Christi to O.N. Stevens Water Treatment Plant (N-6); Continue channel loss studies and water quality monitoring to further evaluate project feasibility.
   c. Wastewater Diversions to Nueces Delta (L-4) - Implement demonstration project by 1996 to determine biological productivity factors and pursue relief of higher TNRCC effluent standards.
   d. Use of Campbellton wells (and/or San Antonio river water) delivered to Choke Canyon Reservoir (L-3); Continue negotiations with entities in the San Antonio area concerning the possibility of the joint construction of this project to offset impacts of Edwards Aquifer recharge projects.
   e. Potential New Sinton Well Field (L-2); Consider additional groundwater modeling studies to determine the long-term reliability and stability of the water quality from this potential source.

Year 2000 to 2005

1. Accelerated and Additional Municipal Water Conservation (L-5, L-6)
   Phase V items:
   a. Continue Public Information Program
   b. Continue Water Audit Program (Municipal and Industrial)

c. Continue Plumbing Retrofit Kit Program
d. Implement Landscape Standards for New Development by adoption of appropriate city ordinances.
e. City staff to work with Industry to implement additional conservation measures.

2. Lake Texana Pipeline (LN-1)
Phase IV items:
a. Obtain construction permits:
U.S. Army Corps of Engineers, Sections 10 and 404 permits
Texas General Land Office Sand and Gravel Removal permit
Texas Parks and Wildlife Department Sand, Gravel and Marl permit
Coastal Coordinating Council review
b. Obtain approvals for river, roads, and utility crossings

Decision Milestone: Project financing needs to be complete and construction of Texana Pipeline needs to be initiated prior to 2004 considering favorable financial markets and projected growth in water demands. Upon favorable conditions:
a. Issue bonds for project financing
b. Initiate construction by 2004

3. Purchase of Garwood Water Right (C-1)
Initial Phase IV in about 2000:
a. Finalize pipeline alignment
b. Initiate easement acquisition

4. Purchase of Additional Garwood Water or Other Colorado River Water (C-1) or (C-2)
a. No significant actions required.

5. Pipeline from Choke Canyon to Lake Corpus Christi (N-5)
a. Continue channel-loss studies.

6. Modification of Choke Canyon/Lake Corpus Christi Operating Policy (N-1)
a. Perform Sedimentation Survey (if not yet completed)
b. Continue channel-loss studies.

7. Other Group 2 and Group 3 Alternatives Requiring Further Investigation
a. Continue investigations and implement individual alternatives, if appropriate.

Year 2006 to 2020

1. Accelerated and Additional Water Conservation (L-5, L-6)
Phase V items:
a. Continue Public Information Program
b. Continue Water Audit Program (Municipal and Industrial)

c. Possibly end Plumbing Retrofit Kit Program
d. Continue Landscape Standards for New Development
e. Evaluate New Water Conservation Methods

2. Lake Texana Pipeline (LN-1)
Phase V: construction to be completed and operation to begin by 2007

3. Purchase of Garwood Water Right (C-1)
Phase IV: complete any remaining permitting studies and finalize easement acquisition

Decision Milestone: By year 2020, update water demand projections and assess financial markets to plan implementation date for Garwood pipeline.

4. Purchase of Additional Garwood Water or Other Colorado River Water (C-1) or (C-2)
a. If additional Garwood and/or Colorado River water has been obtained, include amounts in planning of Garwood pipeline in Item 3. above.

5. Pipeline from Choke Canyon Reservoir to Lake Corpus Christi (N-5)
a. Continue channel-loss studies until about 2015 and when adequate data has been obtained re-evaluate yield increases possible if a pipeline were constructed.

6. Modification of Choke Canyon/Lake Corpus Christi Operating Policy (N-1)
a. Continue channel-loss studies until about 2015 and when adequate data has been obtained, re-evaluate alternative reservoir operating policies for possible implementation.

7. Other Group 2 and Group 3 Alternatives Requiring Further Investigation
a. Continue investigations and implement individual alternatives, if appropriate (refer to page 5-5 for list of alternatives.)

8. Water Treatment Plant Capacity:

Decision Milestone: Water Treatment Plant Capacity: at years 2010 and 2015, update water demand projections and assess need to increase plant capacity. Decision will be influenced by projected peak demands and financial markets. A 35 mgd expansion is currently projected to be needed by 2020.

Year 2021 to 2025

1. Accelerated and Additional Water Conservation (L-5, L-6)
Phase V items:
a. Continue Public Information Program
b. Continue Water Audit Program (Municipal and Industrial)
c. Continue Landscape Standards for New Development

d. Evaluate New Water Conservation Methods

2. Lake Texana Pipeline (LN-1)
Phase V: Continue project operation

3. Purchase of Garwood Water Right and Possibly Other Colorado River Water (C-1) and (C-2)

Decision Milestone: after assessment of updated water demand projections and financial markets, begin final design for pipeline by 2025 and review construction schedule for Garwood diversion and pipeline.

4. Pipeline from Choke Canyon to Lake Corpus Christi (N-5)
Phase III items:
a. Continue channel loss studies (if not yet conclusive).

5. Modification of Choke Canyon/Lake Corpus Christi Reservoir Operating Policy (N-1)
a. Periodically assess need to revise reservoir operating policy considering on-going channel loss studies and updated reservoir sedimentation survey data.
b. Perform new sedimentation survey for Lake Corpus Christi.

6. Other Group 2 and Group 3 Alternatives Requiring Further Investigation
a. Continue investigations and implement individual alternatives, if appropriate. (Refer to page 5-5 for list of alternatives.)

Year 2026 to 2030

1. Accelerated and Additional Water Conservation (L-5, L-6)
Phase V items:
a. Continue Public Information Program
b. Continue Water Audit Program (Municipal and Industrial)
c. Continue Landscape Standards for New Development
d. Evaluate New Water Conservation Methods

2. Lake Texana Pipeline (LN-1)
Phase V: Continue project operation

3. Purchase of Garwood Water Rights and Possibly Other Colorado River Water (C-1) and (C-2)
Phase V: Construction initiation is estimated to be needed by about 2027 and project should be operational by about 2029.

4. Pipeline from Choke Canyon to Lake Corpus Christi (N-5)
a. Continue channel loss studies (if not yet conclusive).

Decision Milestone: At year 2030, update water demand projections and assess financial markets to plan implementation date for CCR/LCC pipeline if determined to be a viable alternative.

5. Modification of Choke Canyon/Lake Corpus Christi Reservoir Operation Policy (N-1)
   a. Periodically assess need to revise reservoir operating policy considering on-going channel loss studies and updated reservoir sedimentation survey data.

6. Other Group 2 and Group 3 Alternatives Requiring Further Investigation
   a. Continue investigations and implement individual alternatives, if appropriate (refer to page 5-5 for list of alternatives).

Year 2031 to 2035

1. Accelerated and Additional Water Conservation (L-5, L-6)
   Phase V items:
   a. Continue Public Information Program
   b. Continue Water Audit Program (Municipal and Industrial)
   c. Continue Landscape Standards for New Development
   d. Evaluate and Implement New Water Conservation Methods

2. Lake Texana Pipeline (LN-1)
   Phase V: Continue project operation

3. Purchase of Garwood Water Rights and Other Colorado River Water (C-1) and (C-2)
   Phase V: Continue project operation

4. Pipeline from Choke Canyon to Lake Corpus Christi (N-5)
   Phase III: Complete any remaining permitting studies or issues.
   Phase IV: Begin final design by about 2035.

5. Modification of Choke Canyon/Lake Corpus Christi Reservoir Operation Policy (N-1)
   a. Periodically assess need to revise reservoir operating policy considering on-going channel loss studies and updated reservoir sedimentation survey data.

6. Other Group 2 and Group 3 Alternatives Requiring Further Investigation
   a. Continue investigations and implement individual alternatives, if appropriate (refer to page 5-5 for list of alternatives).

7. Water Treatment Plant Capacity

Decision Milestone: Water Treatment Plant Capacity: At years 2030 and 2035 update water demand projections and assess need to construct increased plant capacity. Decision will be influenced by projected peak demands and financial markets. A 35 mgd expansion is currently projected to be needed by about 2039.

Year 2036 to 2040

1. Accelerated and Additional Water Conservation (L-5, L-6)
   Phase V items:
   a. Continue Public Information Program
   b. Continue Water Audit Program (Municipal and Industrial)
   c. Continue Landscape Standards for New Development
   d. Evaluate and Implement New Water Conservation Methods

2. Lake Texana Pipeline (LN-1)
   Phase V: Continue project operation

3. Purchase of Garwood Water Rights and Other Colorado River Water (C-1) and (C-2)
   Phase V: Continue project operation

4. Pipeline from Choke Canyon to Lake Corpus Christi (N-5)
   Phase IV: Complete final design by about 2037

Decision Milestone: After assessment of updated water demands and financial markets, schedule construction for CCR/LCC pipeline by about 2037. Begin operation by about 2039.

5. Modification of Choke Canyon/Lake Corpus Christi Reservoir Operation Policy (N-1)
   a. Periodically assess need to revise reservoir operating policy considering on-going channel loss studies and updated reservoir sedimentation survey data.

6. Other Group 2 and Group 3 Alternatives Requiring Further Investigation
   a. Continue investigations and implement individual alternatives, if appropriate (refer to page 5-5 for list of alternatives).

7. Water Treatment Plant Capacity:
   Construct 35 mgd water treatment plant expansion by about 2039.

Year 2041 to 2050

1. Accelerated and Additional Water Conservation (L-5, L-6)
   Phase V items:
   a. Continue Public Information Program
   b. Continue Water Audit Program (Municipal and Industrial)

c. Continue Landscape Standards for New Development
d. Evaluate and Implement New Water Conservation Methods

2. Lake Texana Pipeline (LN-1)
Phase V: Continue project operation

3. Purchase of Garwood Water Rights and Other Colorado River Water (C-1) and (C-2)
Phase V: Continue project operation

4. Pipeline from Choke Canyon to Lake Corpus Christi (N-5)
Phase V: Continue project operation (under Plan A)

5. Modification of Choke Canyon/Lake Corpus Christi Reservoir Operation Policy (N-1)
a. Periodically assess need to revise reservoir operating policy considering on-going channel loss studies and updated reservoir sedimentation survey data.

6. Other Group 2 and Group 3 Alternatives Requiring Further Investigation
a. Continue investigations and implement individual alternatives, if appropriate (refer to page 5-5 for list of alternatives).