REGIONAL WATER SUPPLY PLAN
FOR
THE CITY AND COUNTY OF VICTORIA

June 1992

Prepared by:

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EXECUTIVE SUMMARY

BACKGROUND

All the municipalities in Victoria County currently derive their water supplies from the Gulf Coast Aquifer. Although this aquifer has historically provided a good quality water in sufficient quantities, the county recognized that well levels were falling in response to continued development, and that concentrations of iron, manganese, and barium were increasing. It was determined that the ability of the Gulf Coast Aquifer to continue to meet future water demands while still supplying a good quality water needed to be examined. If the aquifer could not reliably meet the quantity and quality needs of the county, then alternative supply and treatment alternatives were to be examined.

AUTHORIZATION

Only July 2, 1991, the City and County of Victoria authorized Camp Dresser & McKee Inc. (CDM), in association with Michael Sullivan & Associates, Inc. to prepare a regional water supply study. The study was conducted with the financial assistance of the Texas Water Development Board's Regional Water Supply and Wastewater Planning Grant Program, which was initiated as a result of House Bill 2 and House Joint Resolution 6 (passed by the 65th Legislature in 1985) in order to encourage cost-effective regional water and wastewater facility development.

The general scope of the project was to:

1) Determine to the year 2040 the population growth and water demand growth in Victoria County;

2) Determine the occurrence, quantity and quality of groundwater in Victoria County with respect to its ability to meet future demands;

3) Identify feasible future supply and treatment alternatives sufficient to meet current and future demands; and

4) Recommend to the City and County of Victoria the water supply alternative that should be pursued and include time schedules for implementation of the project.

POPULATION AND WATER USE PROJECTIONS

The population of Victoria County was projected from a 1990 base to the year 2040. Both a high growth population projection and a low growth population projection were made. Below is the high growth population projections for selected entities by decade. It is recommended that for water supply planning the high growth population projections be used.

Year	City of Victoria	City of Bloomington	Victoria County
1990	57,733	2,288	77,292
2000	68,558	2,695	88,524
2010	77,880	3,061	98,212
2020	87,299	3,431	113,229
2030	96,356	3,787	130,439
2040	103,440	4,065	140,029

Based on historical water use in Victoria County for municipal, manufacturing, mining, agricultural and steam electric uses, the County's water use was projected by decade. Four water use projections were made as follows:

1) High per capita demand without conservation;
2) High per capita demand with conservation;
3) Average per capita demand without conservation; and
4) Average per capita demand with conservation.

We recommend that the County use water demand projections based upon high per capita demands with conservation. The final water demands by decade for selected categories are shown below.

WATER DEMAND (acre-feet/year)

Year	City of Victoria	Manufac-turing	Irrigation	Steam Electric	Total
1990	10,404	27,036	26,019	26,000	95,087
2000	11,721	52,372	24,794	26,000	120,806
2010	12,595	52,487	23,489	26,000	120,590
2020	13,714	65,587	23,489	26,000	135,643
2030	15,138	76,930	22,184	26,000	148,339
2040	16,251	90,147	22,184	26,000	163,262

The largest growth in water demand takes place in the manufacturing sector.

GROUNDWATER AVAILABILITY

A digital model of the Gulf Coast Aquifer for Victoria County and areas surrounding Victoria County was developed. The model parameters were taken primarily from recent work done on a much larger scale by the USGS. The digital model was calibrated by reproducing historical water level drawdowns based upon well locations and historical pumping data.

The impact future water development would have on the aquifer was modelled by looking at two possible cases. Case A was a growth of 60 percent in water demands throughout the County. Case B was the same as Case A except for the addition of all the increased manufacturing demand was placed south of the City of Victoria.

In Case A, the aquifer experiences an additional 70 feet of drawdown. In Case B, the aquifer experiences an additional 170 feet of drawdown. In both cases, the amount of water demanded from the aquifer was able to be captured, but not without increased drawdowns in the water levels.

These water level declines will lead to problems in the region. One problem is land surface subsidence due to the lower water levels. Based on the drawdowns for Case B, an additional 1.3 feet of subsidence could be experienced in the City of Victoria. The second problem is water quality. As the water levels are lowered, there is more opportunity for water with high levels of iron and manganese to enter the well fields in the county.

WATER DEVELOPMENT SCENARIOS

Because of the subsidence and water quality problems that will result due to continued sole reliance on the Gulf Coast Aquifer, alternative water supply options were investigated. Initially, 23 options were identified as possible water supply alternatives. Through a process of matrix evaluation, the list of 23 was narrowed to the following feasible projects:

1) Continued use of groundwater (short-term);
2) Continued use of groundwater with additional treatment;
3) Conjunctive use of groundwater and surface water appropriated from the Guadalupe River;

4) Purchasing surface water from GBRA; and

5) Purchasing surface water from LNRA.

These five projects were examined in detail using an economic analysis. The economic analysis used a present worth analysis to determine which project was the most economical over the 50-year study period. The results of the present worth analysis are shown below.

Project	Present Worth
1) Groundwater without treatment	$8,314,962
2) Groundwater with treatment	$21,365,637
3) Conjunctive use	$14,064,872
4) Purchase water from GBRA	$22,442,983
5) Purchase water from LNRA	$30,365,261

Based upon that economic analysis, and the fact that groundwater without treatment is not a feasible long-term alternative, the project that is recommended is the conjunctive use of groundwater and surface water appropriated from the Guadalupe River.

RECOMMENDED DEVELOPMENT PLAN

Water availability studies conducted as part of our work show that at least 16,000 acre-feet/year are available for appropriation in the Guadalupe River just downstream of the CP&L power plant in the City of Victoria. This water is available 86 percent of the time. When the water is not available, the groundwater wells will be used to supply water. In addition to being the most economic project, mixing the treated surface water and groundwater at a rate of half surface water and half groundwater produces a good quality water, takes advantage of both resources, and reduces water production costs.

It is recommended that the City and County of Victoria act immediately to appropriate at least 16,000 acre-feet/year from the Guadalupe River. It is also recommended that the groundwater resource be protected. This protection would take the form of the City or County of Victoria, or a newly created district started by measuring water levels and testing water quality on at least a quarterly basis. This information is critical to future water supply planning. Also, if a district is created that is empowered to control the location of new wells and control their pumping rate, then the amount and location of the water level drawdown can be controlled. This will then control land surface subsidence and water quality deterioration.

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1.0 INTRODUCTION

1.1 AUTHORIZATION

In recent years, the City of Victoria and Victoria County have experienced a moderate but steady growth in municipal and industrial development. As a result, the Gulf Coast Aquifer which serves as the principal water supply source for the region has been subjected to increased stress both from higher withdrawals and diminution of water quality. The City of Victoria has in recent years experienced dropping water levels in the wells which serve the City. They have also experienced increasing levels of barium, manganese and iron, which threaten the City's Texas Health Department Public Water Supply Certification. Overdrafting of the aquifer has resulted in considerable land subsidence in portions of the County. Thus, it is imperative that the City of Victoria and other County municipalities begin to examine potential supplementary or alternative water sources.

The Texas Water Development Board (TWDB), through its continuing Regional Water Supply and Wastewater Planning Grant Program, has identified the Victoria area as a regional that should begin developing alternative future water sources. This study, financed in part by the TWDB, was initiated as a result of House Bill 2 and House Joint Resolution 6 (passed by the 65th Texas Legislature in 1985), in order to encourage cost-effective regional water and wastewater facility development.

The City of Victoria has expressed the intent to lead the development of alternative water sources for the City and for other municipalities in the County. Victoria County has only two major cities, Victoria and Bloomington, but has several smaller widely dispersed unincorporated and incorporated communities (Figure 1-1). In addition, Victoria has a

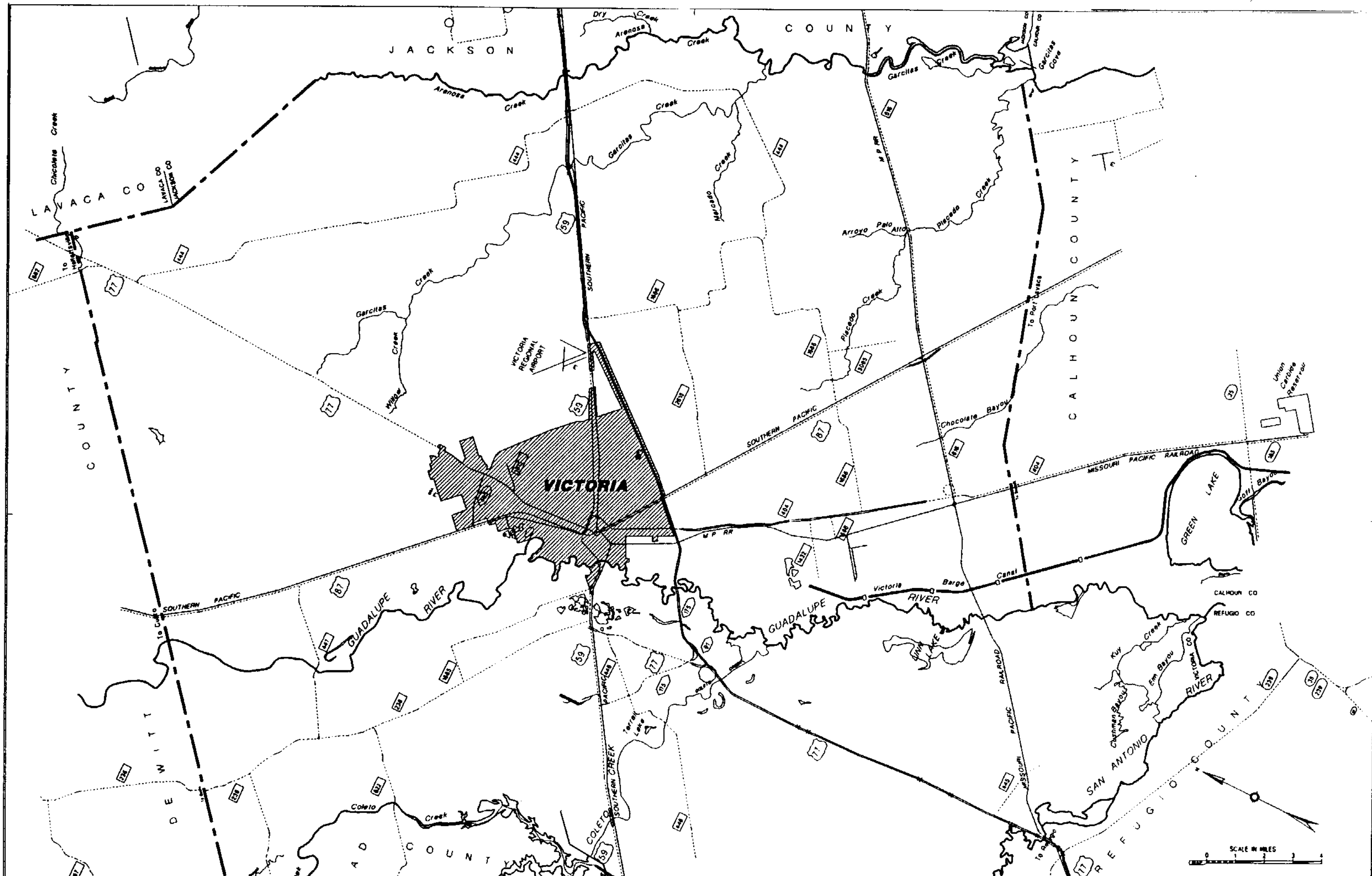

FIGURE 1-1

VICTORIA COUNTY MAP

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well-developed and relatively localized industrial base and one major electric power generation facility operated by Central Power and Light.

The City of Victoria applied for and was awarded a 50% matching fund TWDB planning grant to develop a regional plan to supply the future municipal needs of the service area. Of primary interest was the assessment of the supply and suitability of current Gulf Coast Aquifer resources and the potential for development of alternative supplies, such as surface water, which could either supplement or replace existing sources. Accordingly, the City of Victoria contracted with the consulting firms of Camp Dresser & McKee Inc. (CDM) and Michael Sullivan and Associates, Inc. (MSA) to perform this regional water supply planning study.

1.2 OBJECTIVES AND SCOPE

The study area for this project was limited to the County of Victoria; with a focus on the City of Victoria as the dominant municipal water user in the county. Under the terms of the TWDB Planning Grant, the City of Victoria could plan for additional surrounding areas and cities; however, the City elected to limit supply projections and planning to the confines of the county.

The objective of this study was to project, through the year 2040:

- Populations and water demands within the service area;
- Assess the adequacy of current supplies to meet the current and projected demands within certain quality constraints; and
- Identify feasible future supply and treatment alternatives sufficient to meet the current and projected demands.

Special emphasis was placed on alternatives that would reduce dependence on the Gulf Coast Aquifer as a sole source of supply. However, the search for suitable projects was not limited to local sources but included the Guadalupe and San Antonio River Basins, the San Antonio-Guadalupe and Guadalupe Lavaca Coastal Basins and the Lavaca-Navidad River Basin (Figure 1-2). Infrastructure development was limited to conceptual development of treatment and distribution alternatives, such as major transmission mains, to projected major demand nodes.

The scope of this study is outlined as below:

- Task 1 - Determine the Occurrence, Availability, Quantity and Quality of the Groundwater Resources of the Study Area

  A. Analyze chemical quality of the water in the aquifer.

  B. Compile information on the effects of groundwater pumping on water levels in wells currently operated by the City of Victoria.

  C. Estimate the quantities of groundwater available for development and the effects of groundwater withdrawals on land surface subsidence based upon data provided by City staff.

- Task 2 - Water Conservation Plan

  Prepare a water conservation plan and drought contingency plan for the study area to promote efficient use of water. Submit five copies of these plans to the City of Victoria for review.

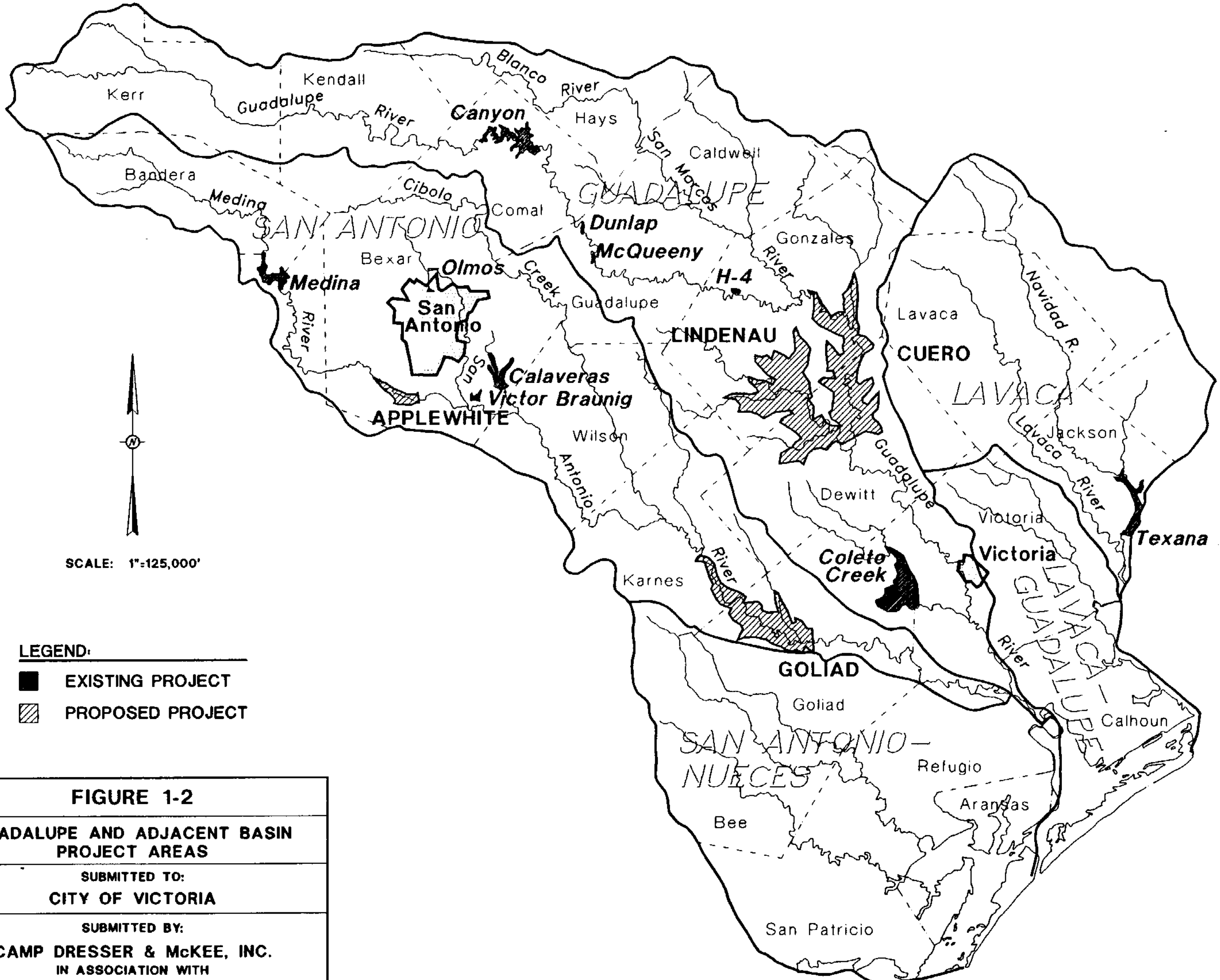

FIGURE 1-2

GUADALUPE AND ADJACENT BASIN PROJECT AREAS

SUBMITTED TO:

CITY OF VICTORIA

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CAMP DRESSER & McKEE, INC.

IN ASSOCIATION WITH

MICHAEL SULLIVAN & ASSOCIATES, INC.

- Task 3 - Projections of Population and Water Use

  A. Review data available for future population and water usage for the study area, including the Texas Water Development Board projections.

  B. Based on the available projections of water usage, the impact of local conservation measures, and engineering judgement, develop projections of future water usage to serve as a basis for the planning of a regional system. The projections will cover the period from 1991 to 2040.

- Task 4 - Development of Scenarios for Water Supply Sources Within the Region

  Based on available information, create at least three scenarios of possible water supply sources within the region. These scenarios will serve as a basis for cost estimates and life cycle costing.

- Task 5 - Layout Development

  A. For each of the three scenarios, develop a layout facility to be constructed initially to serve treated water to the region.

  B. For each of the three scenarios, develop layouts of projected facility expansions for 1991 to 2040.

- Task 6 - Development of Preliminary Cost Estimates

  A. Develop preliminary opinions of initial capital costs for each scenario.

B. Develop preliminary opinions of future capital costs for facility expansions associated with each scenario.

- Task 7 - Development Plan

  Develop preliminary time schedules for design and construction of facility and transmission lines for the recommended scenario.

- Task 8 - Report

  A. Prepare twenty-five (25) copies of a draft report of the results obtained from the study and submit to the City of Victoria for review and comment.

  B. Consider any written review input on the draft report from all interested parties before finalizing the report.

  C. Prepare and print thirty-five (35) copies of the finalized report of the study and submit to the City of Victoria.

1.3 CONTENTS OF REPORT

This report is divided into eight sections.

Section 1 — Introduction

Section 2 — Existing Conditions - Description of the physical features of the study area; historical and current populations, water demands and sources; and existing treatment capacities and distribution infrastructure.

Section 3 — Population and Water Demand Projections - Population and water demand projections and future water planning scenarios.

Section 4 — Water Conservation - Development of long-term water conservation plan elements and implementation and enforcement mechanisms.

Section 5 — Groundwater Evaluation - Application of groundwater availability models to the Gulf Coast Aquifer with current and future regional demands for all use classes.

Section 6 — Water Development Scenarios - Description of scope of supply option search, selection criteria, evaluation criteria, potential options, screening matrix evaluation and best future development option recommendations.

Section 7 — Water Supply Scenario Facilities Plan - Description of proposed phased improvements, construction costs, supply and treatment costs, storage and pumping requirements, and major transmission systems.

Section 8 — Recommended Development Plan

2.0 EXISTING CONDITIONS

2.1 PHYSICAL FEATURES OF STUDY AREA

2.1.1 Geographical Location

The geographical area included in the Regional Water Supply Planning Study includes all of Victoria County. The cities and communities within Victoria County are; Victoria, Bloomington, Placedo, Telferner, Mission Valley, Wood-Hi, Inez, Salem, Raisin, Guadalupe, Dacosta, Fordtran, Nursery and Crescent Valley. Victoria County is located in the southeastern part of Texas. It has an area of approximately 894 square miles, or 572,160 acres of which 2,330 acres is covered by water.

Most of the county is nearly level to gently sloping plain and is crossed by a few well-defined streams and rivers. The area is located within the Guadalupe River Basin, Lavaca-Guadalupe Coastal Basin, and Lavaca River Basin. The Guadalupe River flows to the southeast and dissects the central part of the county. Coleto Creek forms most of the western boundary and the San Antonio River forms part of the southern boundary of the county. Arenosa and Garcitas Creeks form the eastern boundary of the County. The Lavaca River Basin also stretches west to include the northeast portion of Victoria County in its boundaries. Elevation ranges from sea level in the southern part of the county to 200 feet above sea level in the northern and northwestern parts.

2.1.2 Climate

The climate of Victoria County is humid subtropical; winters are mild. Polar Canadian air masses that move southward across Texas and out over the Gulf in winter produce cool, cloudy, rainy weather. Precipitation is most often in the form of slow, gentle rains.

Spring weather is variable, though moderate overall. March is relatively dry, but thundershower activity increases in April and May. Summer weather varies little. Summer months have abundant sunshine and are relatively dry. Occasional slow-moving thunderstorms or other weather disturbances may dump excessive amounts of precipitation on the area. Fall is moderate. In this season, rainfall increases, but frequently there are periods of mild, dry, sunny weather. Heavy rains may occur early in fall in association with disturbances, which move westward from the Gulf. Tropical storms are a threat to the area in summer and fall, but severe storms are rare.

In winter, the average temperatures range from 44°F to 55°F. The lowest temperature on record is 16°F. In summer the average temperature is 83°F and the average daily maximum temperature is 92°F. The highest recorded temperature is 107°F.

The total annual precipitation is 38 inches. Of this, 25 inches, or 65 percent, usually falls between April and September, which includes the growing season for most crops. In two years out of 10, the rainfall in April through September has been less than 20 inches. The heaviest 1-day rainfall during the period of record was 9.3 inches at the City of Victoria. Thunderstorms occur about 50 days each year, and most occur in summer.

Average seasonal snowfall is less than 1 inch. The greatest snow depth at any one time during the period of record was 1 inch. Prevailing winds are from the south-southeast, with average windspeed as high as 12 miles per hour during the spring season. The average relative humidity in mid-afternoon is approximately 60 percent. Humidity is higher at night and the average at dawn is about 90 percent.

2.1.3 Hydrology

The main water course in the area is the Guadalupe River. It originates in Kerr County on the Edwards Plateau and flows southeast some 350 miles to the Gulf of Mexico. Its main tributary is the San Marcos River, which originates from springs within the City of San Marcos, and joins the Guadalupe River near Gonzales. Within the study area, Coleto Creek originates in DeWitt County and joins the Guadalupe River in Victoria County. The Guadalupe River discharges into the Guadalupe Estuary.

The Gulf Coast aquifer covers the entire planning area and is composed of Miocene to Holocene sediments of the Goliad and Willis formation within Victoria County. Consisting of alternating beds of clay, silt, sand and gravel which are hydrologically connected, the aquifer is considered to be a large leaky artesian system. Ground water is used for public supply and irrigation.

2.1.4 Ecological Features

Victoria County is located in the Gulf Coast Prairies and Texas Claypan Major Land Resource Areas. The soils in the Gulf Coast Prairies Area formed under prairie vegetation, are generally dark, loamy, and clayey. The soils in the Texas Claypan Area formed under post oak savannah vegetation and are dominantly light colored, loamy and sandy.

Along the Guadalupe River, the vegetation type depends upon the characteristics of the floodplain. Along minor streams, a narrow band of riparian forest is typical. Wider floodplains are characterized by forests with a dense overstory and a well developed understory and shrub layer. Because the lower levels are frequently flooded, terracing vegetation is common. Significant increases in the withdrawal of water from the river could adversely impact these ecosystems.

Another system sensitive to greater surface water use and/or additional impoundments is the bay and estuary community. Freshwater inflows to bays and estuaries, particularly at certain times of the year, are critical to maintain salinity levels and provide nutrients.

The majority of the gulf fish and shellfish are dependent upon the Texas bays and estuaries at some point in their life cycle. The Guadalupe River discharges into Guadalupe Estuary, contributing approximately 1.81 million acre-feet between 1941 and 1976. TWDB estimates that, of this, 1.62 million acre-feet are required to maintain commercial fishery harvests at average historic levels (Water for Texas v.1).

2.2 POPULATIONS, WATER DEMAND AND SOURCES

2.2.1 Current Conditions

The current population of the Planning Area (City of Victoria and Victoria County) is approximately 74,361 persons. Table 2-1 provides a 1980 and 1990 accounting of population for the planning area as recorded by the PL 94-171 census. Three major population centers are distinguished by the 1990 census. These include: the City of Victoria, the City of Inez, and the City of Bloomington. All water supplies within the study area are obtained from the Gulf Coast Aquifer via water wells. Existing facilities within the study area include groundwater wells and treatment plants operated by the City of Victoria, and water wells and pumping facilities operated by twenty-three additional public suppliers located throughout Victoria County. Table 2-2 shows the major existing water supply systems throughout Victoria County, population served, number of connections and average daily use and per capita use as recorded by the Texas Department of Health (TDH). The City of Victoria water supply system has the highest daily water use as well as the highest per capita use rate. The City of Victoria has approximately 2.83 persons per connection while the other water supply systems average approximately 3.0 persons per tap.

Table 2-1
Population Change in Victoria County
1980-1990

City Name	Population		Change	Percent Change
	1980	1990	1980-1990	1980-1990
Bloomington CDP	(1)	1,888	N/A	N/A
Inez CDP	(1)	1,371	N/A	N/A
Victoria City	51,248	55,076	3,828	7.47
Remainder of County	17,559	16,026	-1,533	-8.73
County Totals	**68,807**	**74,361**	**5,554**	**8.07**

(1) CDP didn't exist in 1980

Source: 1990 Census PL94-171

Table 2-2
Water Supply System Populations and Water Uses a/

Water Supply System	Population Served	Number of Connections	Persons per Connection	Average Daily Use (mgd)	Average Daily per Capita Use (gcd)
City of Victoria	50,700	17,903	2.83	9.000	177.51
Victoria County WCID #1	1,800	625	2.88	0.206	114.44
Victoria County WCID #2	550	182	3.02	0.048	87.27
Quail Creek MUD	1,500	270	5.56	0.130	87.00
E.I. Dupont Company	1,400	25	56.00	0.034	24.00
Wagner Utility Company	465	143	3.25	0.044	94.62
Bloomington I.S.D. High School	400	6	66.67	0.010	24.00
Inez Elementary School	227	4	56.75	0.005	24.00
Mission Valley Elementary School	250	5	50.00	0.006	24.00
Coleto Water Company, Inc.	200	74	3.00	0.019	95.00
Devereux Foundation	122	12	10.17	0.015	120.00
Nursery Elementary School	120	3	40.00	0.003	24.00
Kincer's Inc.	100	1	100.00	0.002	18.00
Linden Hill Motel	69	23	3.00	N/A	N/A
Victoria Machine Works	60	2	30.00	0.001	24.00
Chubby's	50	1	50.00	0.001	18.00
Carnes Mobile Home Park	43	18	2.39	N/A	N/A
Coleto Creek Mobile Home Park	32	13	2.46	N/A	N/A
Arenosa Creek States	21	6	3.50	N/A	N/A
Spring Creek R.V. Park	18	9	2.00	N/A	N/A
River Ranch States b/	8	2	4.00	N/A	N/A
Lord's Land Trailer Park b/	30	7	4.29	N/A	N/A
Guadalupe Elementary School b/	143	1	143.00	N/A	N/A
Wood-Hi Elementary School b/	143	3	47.67	N/A	N/A
Total	58,451	19,338	3	10	163
Average					

a/ Source: Texas Department of Health Sanitary Survey System

b/ Declared inactive by TDH

2.2.2 Historical Uses

TWDB records were examined to established historical use patterns for each water supply system. Monthly data were used to establish such variables as: total water self-supplied; maximum and minimum use months; maximum to average month use ratios; and rates of consumption per service connection. These data will be important in the design phase of future growth planning for the City of Victoria and Victoria County (CV/VC) area.

TWDB records were obtained for seven of the 24 water supply corporations that exist within the planning area. These seven corporations supplied 94.3% of the water used in the county during 1989. Tables 2-3 through 2-9 contain the historical water use and Figures 2-1 through 2-7 contain the schematic representation for this data. Table 2-3 and Figure 2-1 show that City of Victoria usage increased approximately 25% during the 1981-1982 period and its usage has been relatively level during the last 7 years.

Out of these seven water supply corporations, Victoria County WCID #2 (Table 2-5 and Figure 2-3) and Coleto Water Company (Table 2-8 and Figure 2-6) have shown at one point, a dramatic increase. Coleto Water Company has doubled their rate during the last ten years, while Victoria County WCID #2 has increased its use by approximately 50% during the same period.

2.3 EXISTING TREATMENT CAPACITIES AND INFRASTRUCTURE

2.3.1 General Description

The identified water supply systems which comprise the CV/VC service area currently provide service to an estimated 58,127 persons within the County. All of the water supply systems obtain water from groundwater sources to provide service to their respective service areas. Table 2-10 provides a general description for all of the water

Table 2-3
City of Victoria Historical Water Use (Acre-Feet)

Year	January	February	March	April	May	June
1980	558.40	512.03	621.95	648.83	642.33	956.19
1981	555.63	597.00	651.03	765.71	699.30	657.71
1982	719.34	700.04	648.26	674.98	700.76	1,012.98
1983	705.52	635.53	673.75	782.22	826.83	853.72
1984	700.43	643.74	647.94	911.20	918.98	983.99
1985	821.22	671.55	728.70	754.76	926.35	987.24
1986	721.01	620.24	829.14	1,016.14	892.21	807.09
1987	659.00	583.47	712.89	1,007.59	849.98	757.92
1988	587.81	555.73	770.08	766.96	920.77	1,051.49
1989	534.62	540.50	672.62	708.62	872.56	928.82

Year	July	August	September	October	November	December
1980	1,140.10	706.31	614.83	558.54	537.92	522.49
1981	719.76	936.17	748.41	661.54	643.13	636.75
1982	1,387.15	1,157.40	992.71	772.87	680.14	673.59
1983	900.44	884.17	754.83	695.00	614.98	725.18
1984	1,164.06	1,059.23	853.55	861.90	653.74	690.84
1985	1,148.82	1,430.61	900.54	752.66	663.56	679.57
1986	1,247.77	988.11	745.51	736.88	678.03	652.53
1987	882.91	1,191.94	876.22	859.43	651.41	600.12
1988	1,152.47	1,206.35	962.78	859.56	701.97	608.57
1989	961.25	1,290.28	1,077.26	863.38	749.11	720.50

Source: Texas Water Development Board

Table 2-4

Victoria County WCID # 1 Historical Water Use (Acre-Feet)

Year	January	February	March	April	May	June
1980	17.75	14.91	15.88	16.67	22.05	23.02
1981	16.83	16.46	18.76	17.81	18.19	20.10
1982	21.08	17.46	19.51	19.80	19.41	24.54
1983	19.79	15.64	17.56	17.75	19.01	20.79
1984	19.62	15.35	17.56	19.93	19.85	20.98
1985	20.02	18.19	16.57	17.21	19.16	20.75
1986	19.73	16.37	19.99	22.04	18.22	18.20
1987	16.33	14.10	14.62	16.43	15.22	16.48
1988	15.19	7.11	15.57	17.10	21.22	23.67
1989	16.79	16.79	16.59	17.29	22.79	19.74

Year	July	August	September	October	November	December
1980	29.11	21.59	19.12	18.47	17.33	17.79
1981	18.66	18.49	19.50	18.78	17.99	18.07
1982	28.89	28.47	22.38	21.53	19.36	20.07
1983	17.47	19.71	17.67	16.97	16.44	21.02
1984	20.73	21.73	20.08	19.16	16.42	17.27
1985	22.19	29.97	21.67	19.15	17.62	19.24
1986	26.53	22.27	18.94	18.04	16.19	15.75
1987	18.36	25.64	17.85	17.20	14.55	15.69
1988	29.33	25.39	19.65	19.63	17.17	16.42
1989	18.73	23.39	21.99	20.41	17.65	21.55

Source: Texas Water Development Board

Table 2-5
Victoria County WCID # 2 Historical Water Use (Acre-Feet)

Year	January	February	March	April	May	June
1980	2.60	2.66	3.23	3.76	3.76	5.72
1981	3.26	2.88	3.35	4.06	3.49	3.62
1982	3.86	2.96	3.55	3.44	3.82	5.00
1983	3.54	3.02	3.63	3.89	4.29	4.50
1984	3.26	3.14	3.35	4.55	4.54	4.39
1985	4.59	3.46	3.73	3.51	4.17	4.25
1986	5.00	3.59	5.51	6.05	4.73	5.84
1987	5.00	7.56	4.46	5.27	7.04	6.13
1988	4.32	4.65	3.90	5.38	5.37	5.71
1989	4.44	6.92	4.26	4.81	5.39	7.08

Year	July	August	September	October	November	December
1980	6.00	4.26	3.84	3.67	3.17	2.85
1981	4.15	4.37	3.89	3.57	3.91	3.16
1982	5.97	5.57	4.51	3.89	3.64	3.38
1983	4.13	4.45	4.06	3.42	3.90	3.87
1984	4.25	4.22	3.64	3.36	3.33	3.53
1985	4.28	5.67	4.44	3.63	3.51	3.60
1986	7.97	6.36	5.65	4.86	4.94	5.88
1987	5.69	9.58	5.72	6.55	4.90	5.56
1988	6.76	5.32	4.68	7.24	3.77	5.10
1989	5.08	5.31	5.65	4.91	3.51	5.32

Source: Texas Water Development Board

Table 2-6
Quail Creek MUD Historical Water Use (Acre-Feet)

Year	January	February	March	April	May	June
1980	11.78	10.81	13.89	15.31	15.39	23.25
1981	11.69	10.94	13.04	17.87	13.03	14.03
1982	13.98	12.47	14.65	14.94	15.55	23.12
1983	19.00	14.58	19.40	20.99	21.52	19.49
1984	14.66	13.38	16.11	19.71	18.62	18.98
1985	21.63	21.28	16.41	15.83	20.45	21.85
1986	13.86	12.53	17.54	22.36	16.25	13.14
1987	13.61	12.41	15.74	22.34	21.99	16.64
1988	19.63	13.16	14.88	16.60	22.08	23.05
1989	12.70	13.42	14.97	12.80	17.40	14.56

Year	July	August	September	October	November	December
1980	24.58	13.38	12.71	12.14	11.80	12.06
1981	16.52	22.77	20.05	13.09	12.06	12.99
1982	31.32	25.70	22.23	25.22	14.62	15.33
1983	17.29	18.26	18.83	16.08	14.81	16.25
1984	24.96	18.33	18.76	16.21	14.59	15.18
1985	22.62	32.46	22.62	17.30	16.02	15.04
1986	21.76	17.82	13.55	13.39	12.78	13.87
1987	19.39	25.02	15.00	14.62	14.09	19.86
1988	23.87	22.93	18.94	19.09	15.62	15.64
1989	13.81	24.68	19.16	15.50	10.99	12.99

Source: Texas Water Development Board

Table 2-7
Wagner Utility Company Historical Water Use (Acre-Feet)

Year	January	February	March	April	May	June
1980	2.52	1.82	1.97	3.02	3.39	3.68
1981	3.06	4.42	2.87	3.35	3.19	3.89
1982	2.95	3.16	2.66	3.18	3.21	6.13
1983	2.92	2.55	2.66	3.13	3.60	3.78
1984	2.95	2.34	2.55	4.20	2.83	4.29
1985	4.03	3.69	2.30	2.41	3.92	4.39
1986	3.17	3.59	3.57	6.23	4.05	3.71
1987	2.97	3.34	3.24	5.78	4.90	4.12
1988	3.16	3.21	3.49	4.27	4.39	6.17
1989	3.27	3.60	3.48	3.79	5.18	7.75

Year	July	August	September	October	November	December
1980	8.19	4.91	5.31	2.00	2.60	3.12
1981	3.41	2.83	3.23	3.01	3.04	2.94
1982	6.29	7.13	4.36	3.79	2.74	2.71
1983	3.43	3.53	3.94	3.51	3.18	2.93
1984	6.80	4.74	4.46	3.71	2.83	3.60
1985	4.30	6.47	5.35	2.47	3.37	3.28
1986	5.65	7.87	4.32	3.19	2.75	2.68
1987	4.09	5.97	3.80	4.59	4.02	2.95
1988	6.74	6.76	6.00	3.74	4.47	3.20
1989	4.26	6.83	4.47	5.04	3.08	3.34

Source: Texas Water Development Board

Table 2-8
Coleto Water Company Historical Water Use (Acre-Feet)

Year	January	February	March	April	May	June
1980	0.44	0.53	0.62	0.51	0.83	0.85
1981	1.05	1.24	1.07	1.23	1.54	1.04
1982	0.87	1.03	0.89	1.02	1.28	0.86
1983	2.01	1.48	1.27	1.98	1.72	1.95
1984	2.34	1.72	1.48	2.31	2.01	2.27
1985	2.00	1.29	1.28	1.44	1.80	2.03
1986	1.42	1.47	2.37	2.19	1.86	1.62
1987	1.23	1.20	1.43	2.36	2.03	2.17
1988	1.39	1.39	2.01	1.90	2.45	1.94
1989	1.61	1.53	1.61	1.79	2.78	2.68

Year	July	August	September	October	November	December
1980	1.36	1.19	0.90	1.21	0.92	0.79
1981	1.35	1.50	1.32	0.85	0.80	0.77
1982	1.12	1.24	1.09	0.70	0.66	0.64
1983	1.88	1.68	1.55	1.73	1.18	1.63
1984	2.19	1.96	1.80	2.02	1.38	1.90
1985	2.80	2.02	1.79	1.43	1.30	1.57
1986	2.47	2.16	1.94	1.57	1.18	1.54
1987	1.86	2.82	1.56	1.64	1.43	1.48
1988	2.37	2.33	1.77	1.55	1.30	1.53
1989	3.09	3.29	2.37	2.47	1.83	1.93

Source: Texas Water Development Board
1982 Values estimated by TDWR
1984 Values estimated by TWDB

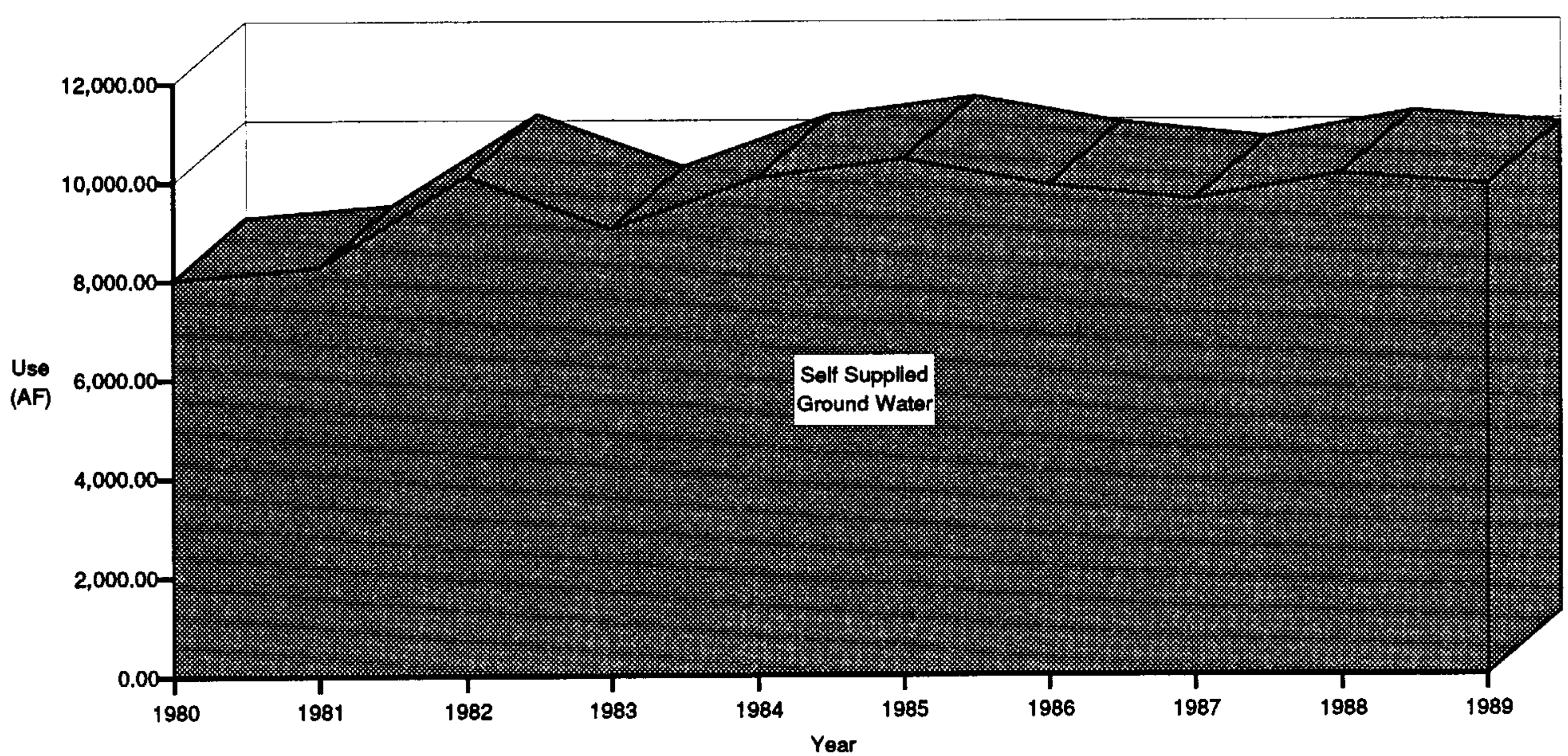
Table 2-9
Bloomington High School Historical Water Use (Acre-Feet)

Year	January	February	March	April	May	June
1984	0.03	0.03	0.03	0.03	0.03	0.01
1985	0.04	0.04	0.04	0.04	0.04	0.01
1986	0.04	0.04	0.04	0.04	0.04	0.02
1987	0.03	0.03	0.03	0.03	0.03	0.02
1988	0.03	0.03	0.03	0.04	0.04	0.02
1989	0.03	0.03	0.03	0.03	0.03	0.02

Year	July	August	September	October	November	December
1984	0.01	0.01	0.03	0.03	0.03	0.03
1985	0.01	0.01	0.04	0.04	0.04	0.04
1986	0.02	0.02	0.04	0.04	0.04	0.04
1987	0.02	0.03	0.05	0.05	0.03	0.03
1988	0.02	0.02	0.04	0.03	0.03	0.03
1989	0.02	0.02	0.03	0.03	0.03	0.03

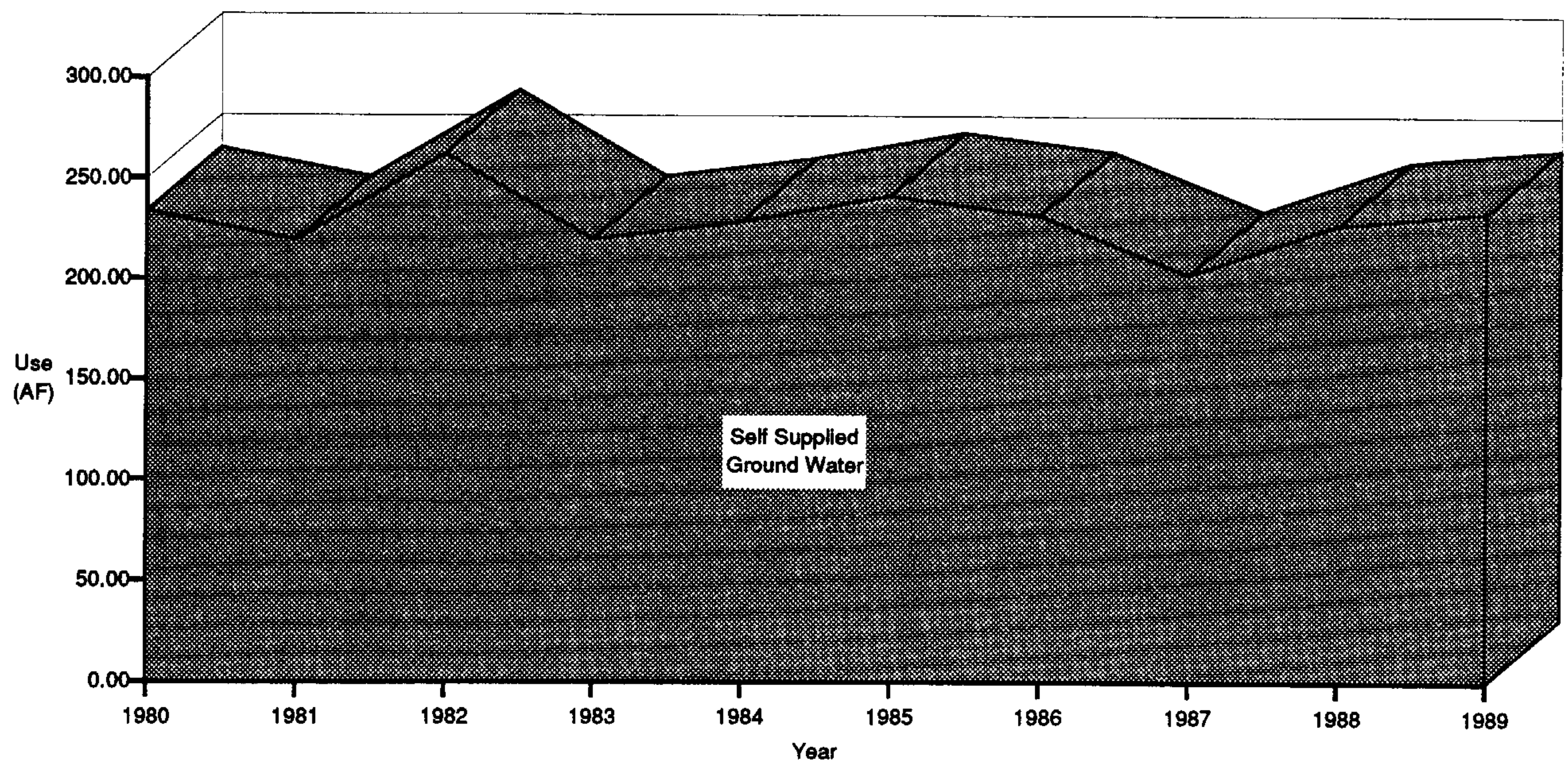
Source: Texas Water Development Board
1985 Values estimated by TWDB

Figure 2-1
City of Victoria Historical Water Use



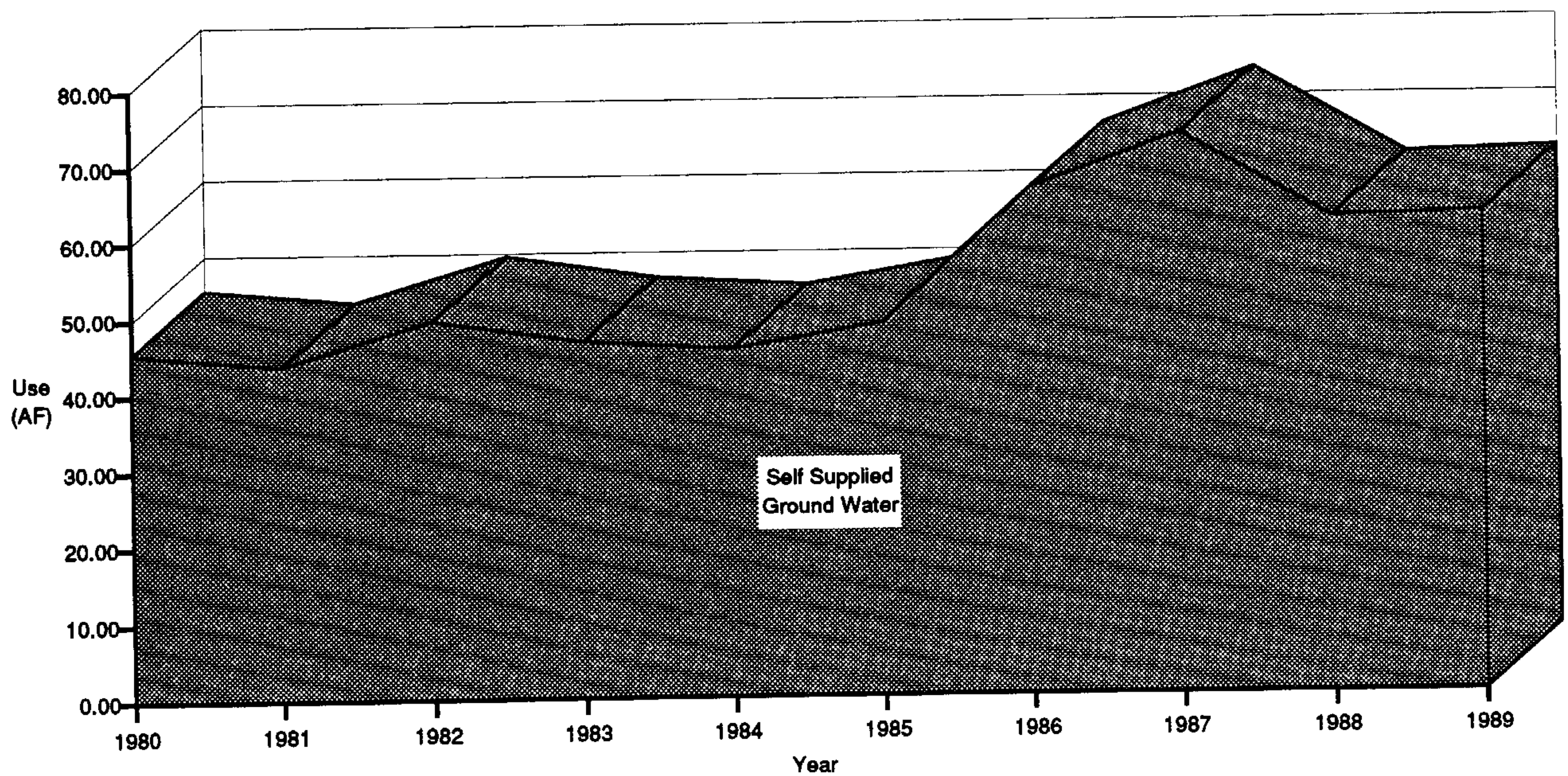
Source: Texas Water Development Board

Figure 2-2
Victoria County WCID #1 Historical Water Use



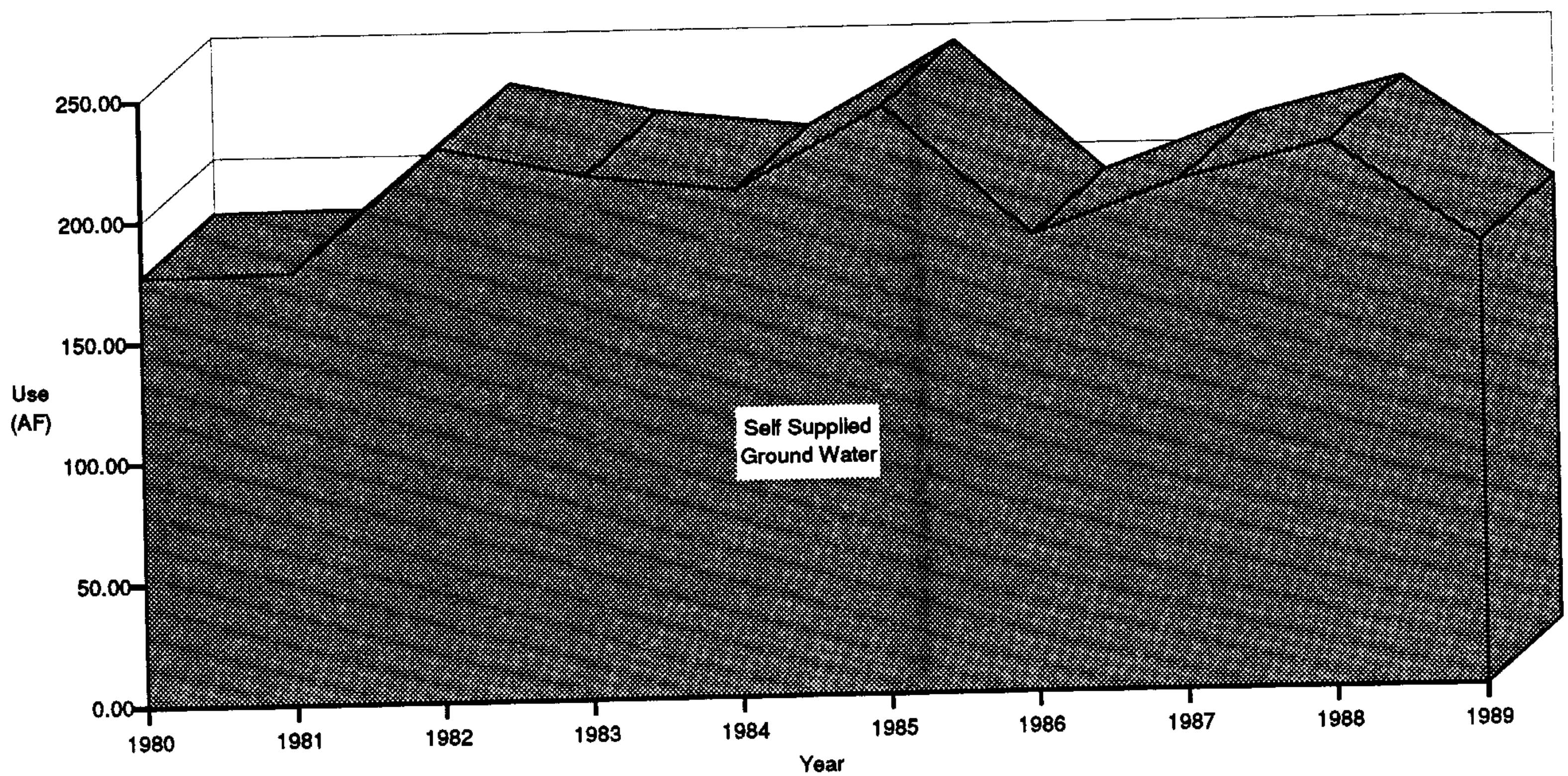
Source: Texas Water Development Board

Figure 2-3
Victoria County WCID #2 Historical Water Use



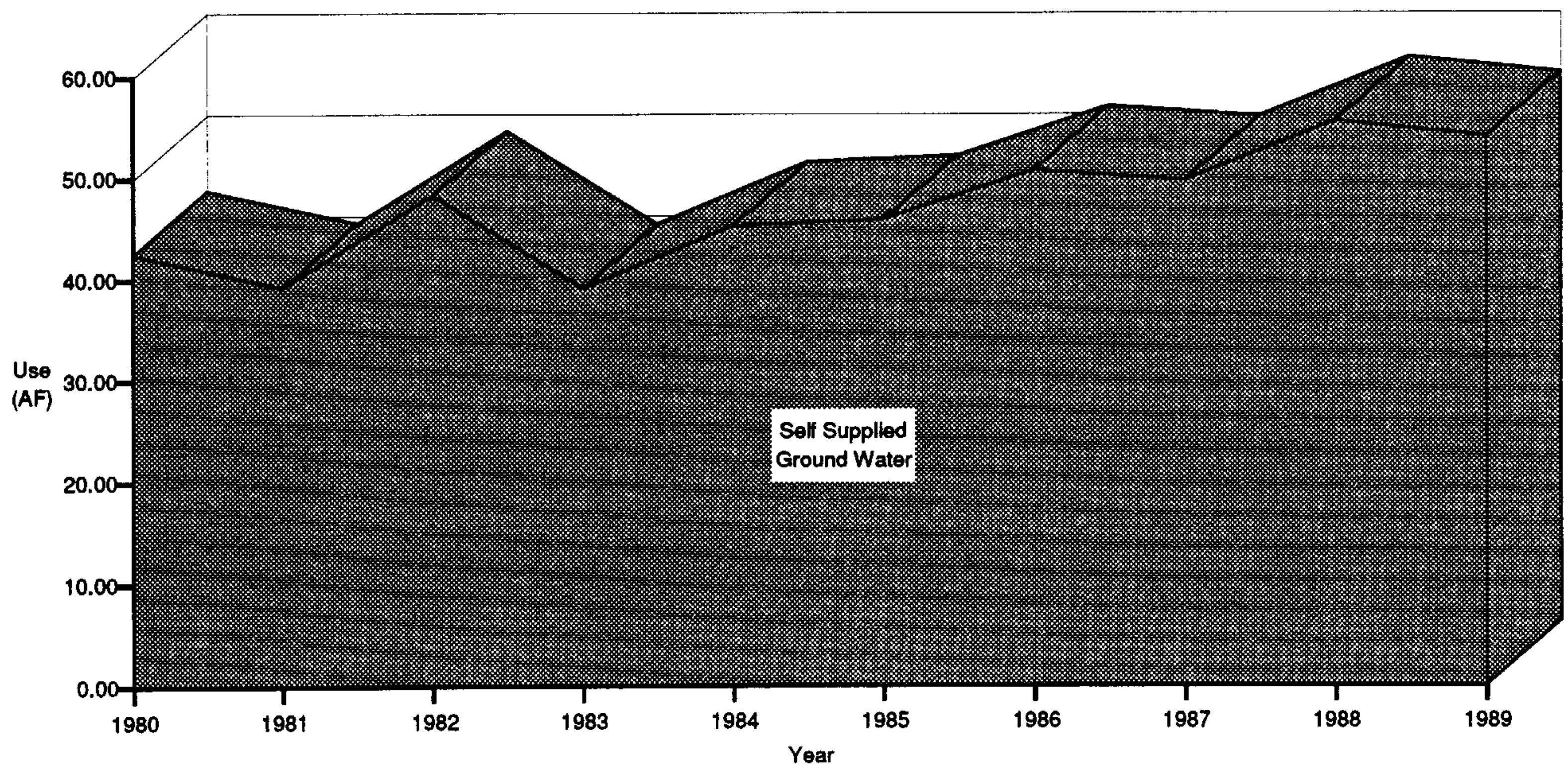
Source: Texas Water Development Board

Figure 2-4
Quail Creek MUD Historical Water Use



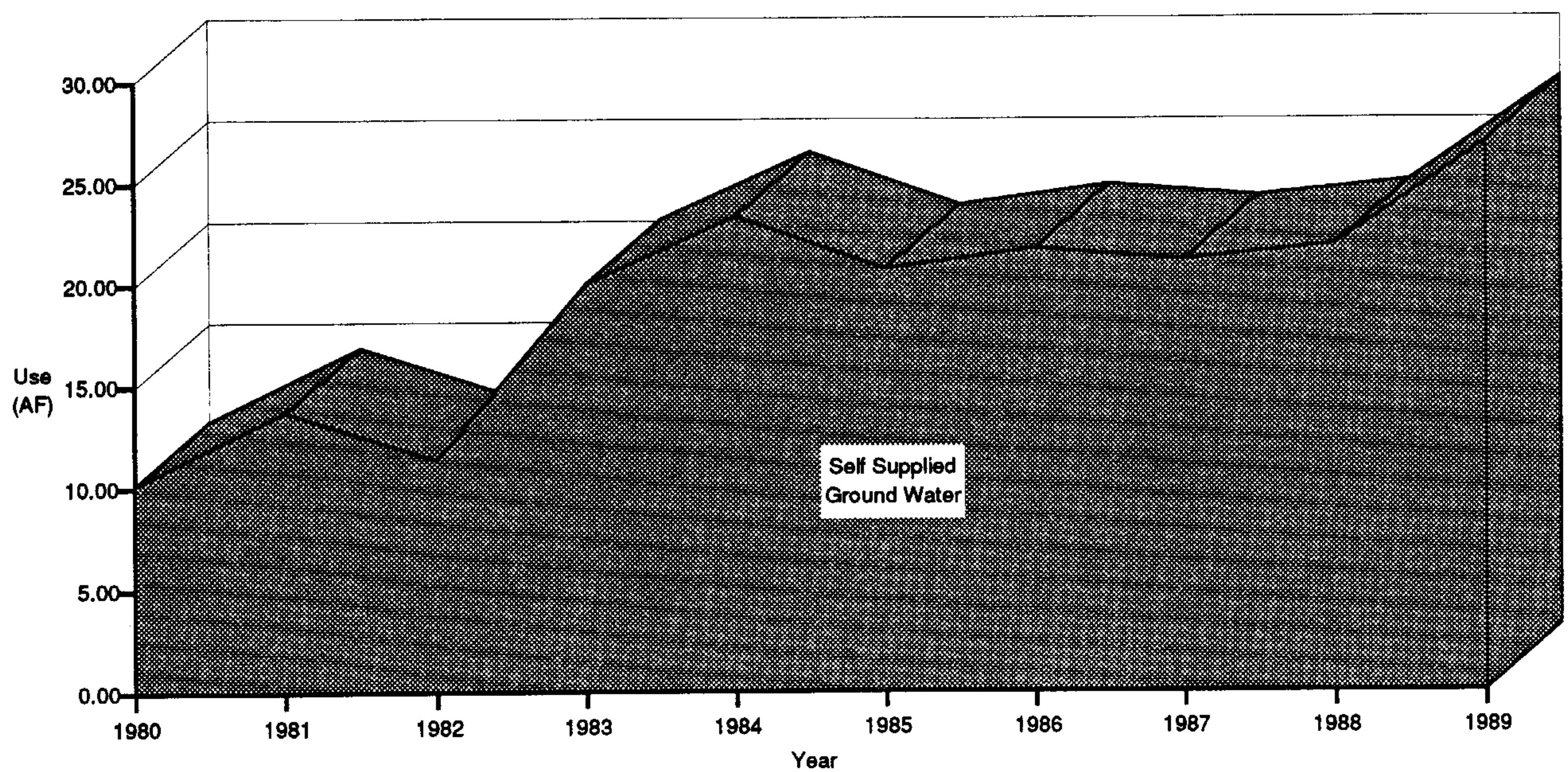
Source: Texas Water Development Board

Figure 2-5
Wagner Utility Company Historical Water Use



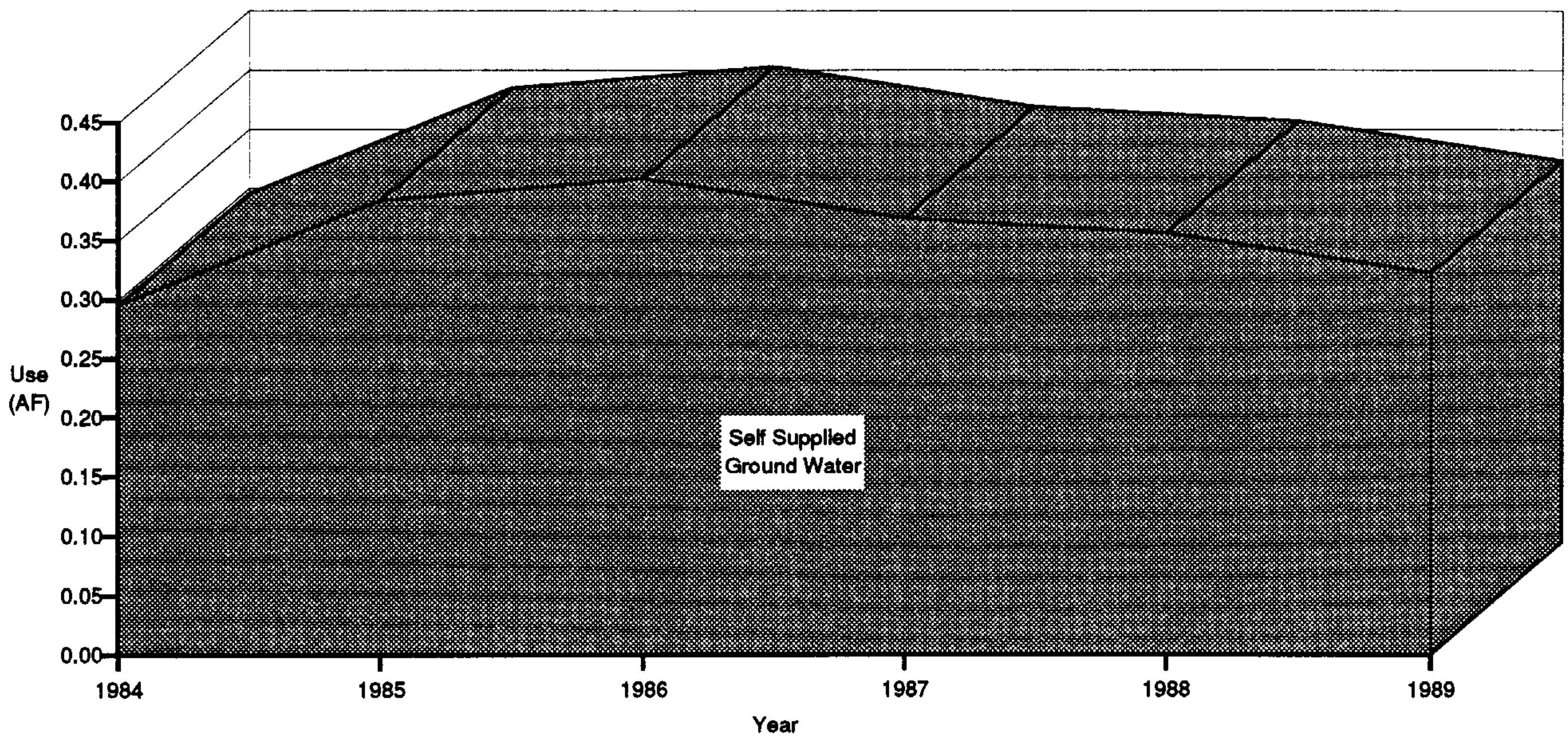
Source: Texas Water Development Board

Figure 2-6
Coleto Water Company Historical Water Use



Source: Texas Water Development Board

Figure 2-7
Bloomington High School Historical Water Use



Source: Texas Water Development Board

Table 2-10
General Description of the Water Supply Systems in Victoria County a/

Water Supply System	Total Number of Wells	Total Well/Raw Water Pump Capacity b/ (gpm)	Total High Pressure Pump Capacity b/ (gpm)	Total Storage Capacity c/ (Gal)	Total Number of Connections Served	Pressure Range (psi)	Date of Most Recent Sanitary Survey
City of Victoria	15	23,550	22,750	10,700,000	17,903	40-70	23-May-90
Victoria County WCID #1	2	700	1,000	352,000	625	42-55	22-Jun-90
Victoria County WCID #2	1	150	90	39,000	182	35-45	22-Jun-90
Quail CreekMUD	2	1,140	1,250	410,000	270	40-60	15-Oct-90
E.I. Dupont Company	3	3,500	4,500	54,000	25	65-120	15-May-90
Wagner Utility Company	2	480	300	52,800	143	36-52	15-May-90
Bloomiongton I.S.D. High School	3	150	175	18,315	6	45-60	3-Dec-90
Inez Elementary School	1	20	N/A	225	4	40-60	3-Dec-90
Mission Valley Elementary School	1	15	20	1,865	5	30-45	4-Oct-90
Coleto Water Company Inc.	1	150	N/A	6,609	74	40-60	6-Jul-90
Devereux Foundation	1	160	480	25,000	12	45-60	6-Jul-90
Nursery Elementary School	2	10	N/A	220	3	28-50	3-Oct-90
Kincer's Inc.	1	18	N/A	320	1	45-50	4-Oct-90
Linden Hill Motel	2	30	N/A	86	23	35-40	6-Jul-90
Victoria Machine Works	1	50	50	1,240	2	35-50	11-Dec-90
Chubby's	1	50	N/A	320	1	40-60	4-Dec-90
Carnes Mobile Home Park	3	45	N/A	840	18	40-60	15-May-90
Coleto Creek Mobile Home Park	2	115	N/A	2,000	13	40-50	28-Sep-90
Arenosa Creek States	2	45	N/A	2,000	6	35-80	11-Dec-90
Spring Creek R.V. Park	1	24	N/A	545	9	30-70	15-May-90
River Ranch States d/	1	150	N/A	2,500	2	30-45	27-Sep-90
Lord's Land Trailer Park d/	1	88	N/A	150	7	40-60	27-Sep-89
Guadalupe Elementary School d/	1	15	135	3,010	1	40-52	5-Dec-89
Wood-Hi Elementary School d/	1	15	20	2,157	3	30-55	5-Dec-89
Total	**51**	**30,670**	**30,770**	**11,675,202**	**19,338**		

a/ Source: Texas Department of Health Sanitary Survey System

b/ Rated capacity of wells

c/ Includes elevated and ground storage

d/ Declared inactive by TDH

supply systems within the planning area. Appendix A contains a more detail description for each water supply system.

The information used in establishing the service area for individual water supply systems was obtained from the Texas Water Commission (TWC). The inventory of existing production, treatment, and storage capacities was compiled from the most recent sanitary surveys of the water systems, as conducted by the Texas Department of Health.

The City of Victoria, Victoria County WCID #1, Victoria County WCID #2, and Quail Creek MUD are the four major water supply systems within the planning area and a more detail description is provided in sections 2.3.2 through 2.3.5.

2.3.2 City of Victoria

General Description

City of Victoria Water Supply System provides service to approximately 50,700 persons through 17,903 connections within the City of Victoria. The system obtains all of its water from 15 groundwater sources.

Facilities Description

City of Victoria owns and operates 15 well sites and four water treatment plants located within the City's boundaries. The 15 wells have a combined rated capacity of 23,550 gpm (Table 2-10). In addition to the well sites, the City of Victoria operates 13 high service booster pumps at four stations, with a total rated capacity of 22,750 gpm. Ground storage facilities are located at each of the four treatment plants. The ground storage capacity is 7.2 MG. Pressure maintenance is provided through the use of elevated storage. Elevated storage in the system is 3.5 MG. Total system storage capacity is 10.7 MG.

A summary of the City of Victoria water system is presented in Appendix A. According to TDH records, the average daily usage within the system is approximately 9.0 million gallons. Maximum daily usage is reported to be 18.4 million gallons. System pressures range from 40 psi to 70 psi.

The City is adding 1.5 MG ground storage and 8,000 gpm in high service pumping capacity at Plant No. 3. The city is also adding 1.0 MG ground storage and 1,875 gpm in high service pumping at Plant No. 4.

System Evaluation

Based upon the results of the most recent sanitary survey conducted by TDH, dated May 23, 1990, the City of Victoria meets or exceeds State requirements, for well capacity, ground and elevated storage. The system is found to be deficient in high service pump capacity by 13,056 gpm. With the addition of 8,000 gpm high service pumping capacity at Plant No. 3 and 1,875 gpm in high service pumping capacity at Plant No. 4, the City of Victoria is actually 3,181 gpm deficient in high service pumping capacity.

2.3.3 Victoria County WCID #1

General Description

Victoria County WCID #1 Supply System provides service to approximately 1,800 persons through 625 connections to the City of Bloomington. The system obtains water from two groundwater sources.

Facilities Description

Victoria County WCID #1 owns and operates 2 well sites, located at the intersection of Hachett and Commerce streets and the intersection of Indiana and Second streets, in the City of Bloomington. The two wells have a combined rated capacity of 700 gpm. In addition to the well sites, Victoria County WCID #1 operates two high service booster stations, with a total rated capacity of 1,000 gpm. Ground storage facilities are located at each of the two well sites. Total system ground storage capacity is 252,000 gallons. Pressure maintenance is provided through the use of elevated storage. Total elevated storage in the system is 100,000 gallons.

A summary of the Victoria County WCID #1 water system is presented in Appendix A. According to TDH records, the average daily usage within the system is approximately 206,000 gallons. Maximum daily usage is reported to be 249,000 gallons. System pressures range from 42 psi to 55 psi.

System Evaluation

Based upon the results of the most recent sanitary survey conducted by TDH, dated June 22, 1990, the Victoria County WCID #1 meets or exceeds State approved requirements, for well capacity, ground and elevated storage.

2.3.4 Victoria County WCID #2

General Description

Victoria County WCID #2 Supply System provides service to approximately 550 persons through 182 connections to the Placedo Community. The system obtains water from one groundwater source.

Facilities Description

Victoria County WCID #2 owns and operates one well site, located at the water treatment plant on Broadway Street in Placedo, Texas. The well has a rated capacity of 150 gpm. In addition to the well site, Victoria County WCID #2 operates three high service booster stations, with a total rated capacity of 900 gpm. Ground storage facility is located at the water treatment plant site. Total system ground storage capacity is 31,500 gallons. Pressure maintenance is provided through the use of pressure tanks with a capacity of 7,500 gallons.

A summary of the Victoria County WCID #2 water system is presented in Appendix A. According to TDH records, the average daily usage within the system is approximately 48,000 gallons. Maximum daily usage is reported to be 75,000 gallons. System pressures range from 35 psi to 45 psi.

System Evaluation

Based upon the results of the most recent sanitary survey conducted by TDH, dated June 22, 1990, the Victoria County WCID #2 meets or exceeds State requirements, for well capacity pressure storage.

2.3.5 Quail Creek MUD

General Description

Quail Creek MUD Supply System provides service to approximately 1500 persons through 270 connections to the Quail Creek Subdivision. The system obtains water from two groundwater sources.

Facilities Description

Quail Creek MUD owns and operates two well sites, located at the intersections of Chaparral and Duck Streets, and Duck and Grouse streets, respectively on Aloe Field (West Highway 59) near the City of Victoria. The wells have a combined rated capacity of 1,140 gpm. In addition to the well site, Quail Creek MUD operates 3 high service booster stations, with a total rated capacity of 1,250 gpm. A ground storage facility is located at the intersection of Chaparral and Duck streets. Total system ground storage capacity is 400,000 gallons. Pressure maintenance is provided through the use of pressure tanks with a capacity of 10,000 gallons.

A summary of the Quail Creek MUD water system is presented in Appendix A. According to TDH records, the average daily usage within the system is approximately 130,000 gallons. Maximum daily usage is reported to be 207,000 gallons. System pressures range from 40 psi to 60 psi.

System Evaluation

Based upon the results of the most recent sanitary survey conducted by TDH, dated October 15, 1990, the Quail Creek MUD water system meets or exceeds State requirements, for well capacity, ground and pressure storage.

3.0 POPULATION AND WATER DEMAND PROJECTIONS

3.1 POPULATION PROJECTIONS

The TWDB produces population projections for each county in the State of Texas for use in water supply and wastewater disposal planning projects. Under the terms of the Texas Water Development Board/City of Victoria and Victoria County Planning Grant Contract, the study is to utilize TWDB population estimates in their planning process unless compelling reasons for using alternative estimates are presented. In this study, TWDB future population estimation methodologies are employed. TWDB future population estimates are computed and presented within the context of political boundaries, i.e., counties, cities, and rural areas (including municipalities with populations less than 1,000). The CV/VC service area encompasses only Victoria County, therefore, ready-made population estimates for the CV/VC were available.

3.1.1 Projection Methodology

The 1990 census (PL94-171) indicates that the City of Victoria has experienced a moderate growth in the last decade, whereas the remainder of the County showed a slight decline in growth rate. Because there are some basic differences between municipal and non-municipal areas, the following methodology was used to predict future populations, at ten-year intervals, for the City of Victoria and Victoria County.

The TWDB uses a Cohort Component Method with a Net Migration Component to predict future populations. Simply put, the TWDB uses U.S. Census Bureau derived local rates of fertility and mortality to determine a rate for the naturally expanding population base. In addition, estimates of immigration into the area and emigration from the area are used to estimate a net migration. The TWDB then constructs two models from these data. One model is calibrated to the 1950-70 statistical period which exhibited a much slower rate of Texas population growth than was observed in the late 1970s and early 1980s. Future population estimates using this model represent a conservative or "Low Population Series." A second model is constructed using growth rates developed for the 1970-80 statistical period. Future population estimates using this model represent an optimistic or "High Population Series." For this study, a similar methodology was used to predict future populations for the City and County of Victoria.

Texas Water Development Board data are generally used in all TWDB funded regional water and wastewater planning studies unless there are obvious or compelling reasons for the substitution of other data. Although the 1990 Census does offer more recent data, it is widely believed that the Census underestimates the actual population for this region. Therefore, the TWDB data, with the exception of manufacturing and irrigation water demands, will be used for the purposes of this study. Manufacturing and irrigation water demands were adjusted to reflect alternative computation methodologies and additional information contained in the Regional Water Plan for the Guadalupe River Basin prepared by HDR Engineering, Inc., January 1991. The HDR study was funded by the TWDB and accepted in 1991. Therefore, these data represent an improvement in the TWDB estimates and will be used for the purposes of this study.

Low Series Population Estimates

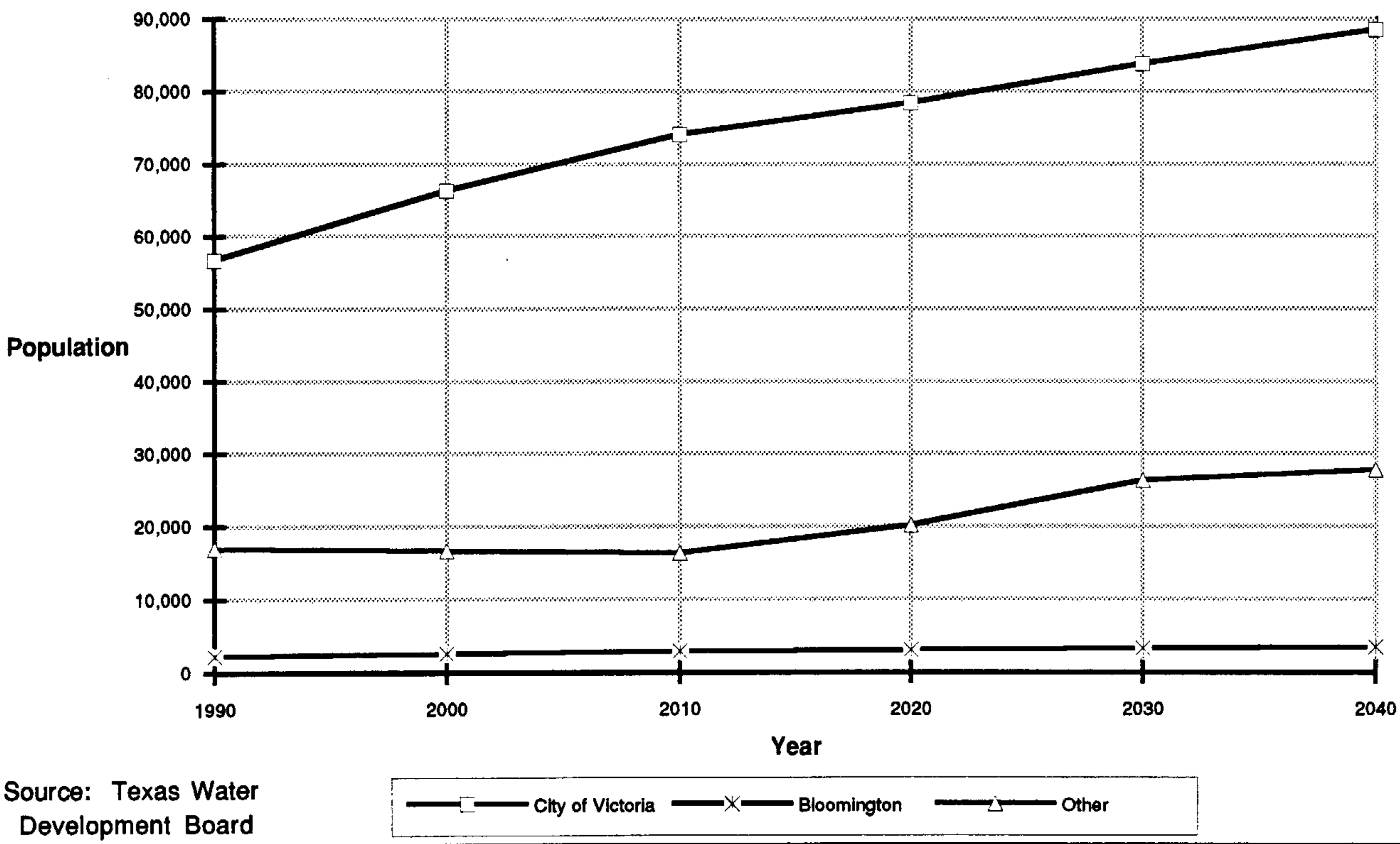
Low Series population estimates for the CV/VC area through the year 2040 are shown in Table 3-1 and Figure 3-1. Using the low series population estimates, the City of Victoria population is predicted to increase to more than 88,520 people (a 56% increase over the current population) over the next 50 years; the City of Bloomington population is predicted to increase to nearly 3,478 people; and the other combined county municipality populations are predicted to increase to more than 27,800 people. The

Table 3-1
Estimated Populations of City and County of Victoria Service Area
(1990-2040)

Year	City of Victoria		Bloomington		Other		Total Population of Victoria County	
	Low Series	High Series	Low Series	High Series	Low Series	High Series	Low Series	High Series
1990	56,772	57,733	2,249	2,288	16,985	17,271	76,006	77,292
2000	66,372	68,558	2,609	2,695	16,721	17,271	85,702	88,524
2010	74,095	77,880	2,912	3,061	16,432	17,271	93,439	98,212
2020	78,488	87,299	3,084	3,431	20,230	22,499	101,802	113,229
2030	83,829	96,356	3,294	3,787	26,359	30,296	113,482	130,439
2040	88,520	103,440	3,478	4,065	27,834	32,524	119,832	140,029

Source: Texas Water Development Board

Figure 3-1
Projected City and County of Victoria Future Populations
Low Series



Source: Texas Water Development Board

aggregate population of the CV/VC Service Area through the year 2040 is shown in Figure 3-2.

High Series Population Estimates

High Series population estimates for the CV/VC service area through the year 2040 are shown in Table 3-1 and Figure 3-3. Using the high series population estimates, the City of Victoria population is predicted to increase to more than 103,440; the City of Bloomington population is predicted to increase to nearly 4,065 people; and the other combined county municipality populations are predicted to increase to more than 32,500 people. The aggregate population of the CV/VC service area through 2040 is shown in Figure 3-4.

3.1.2 Population Projection Results

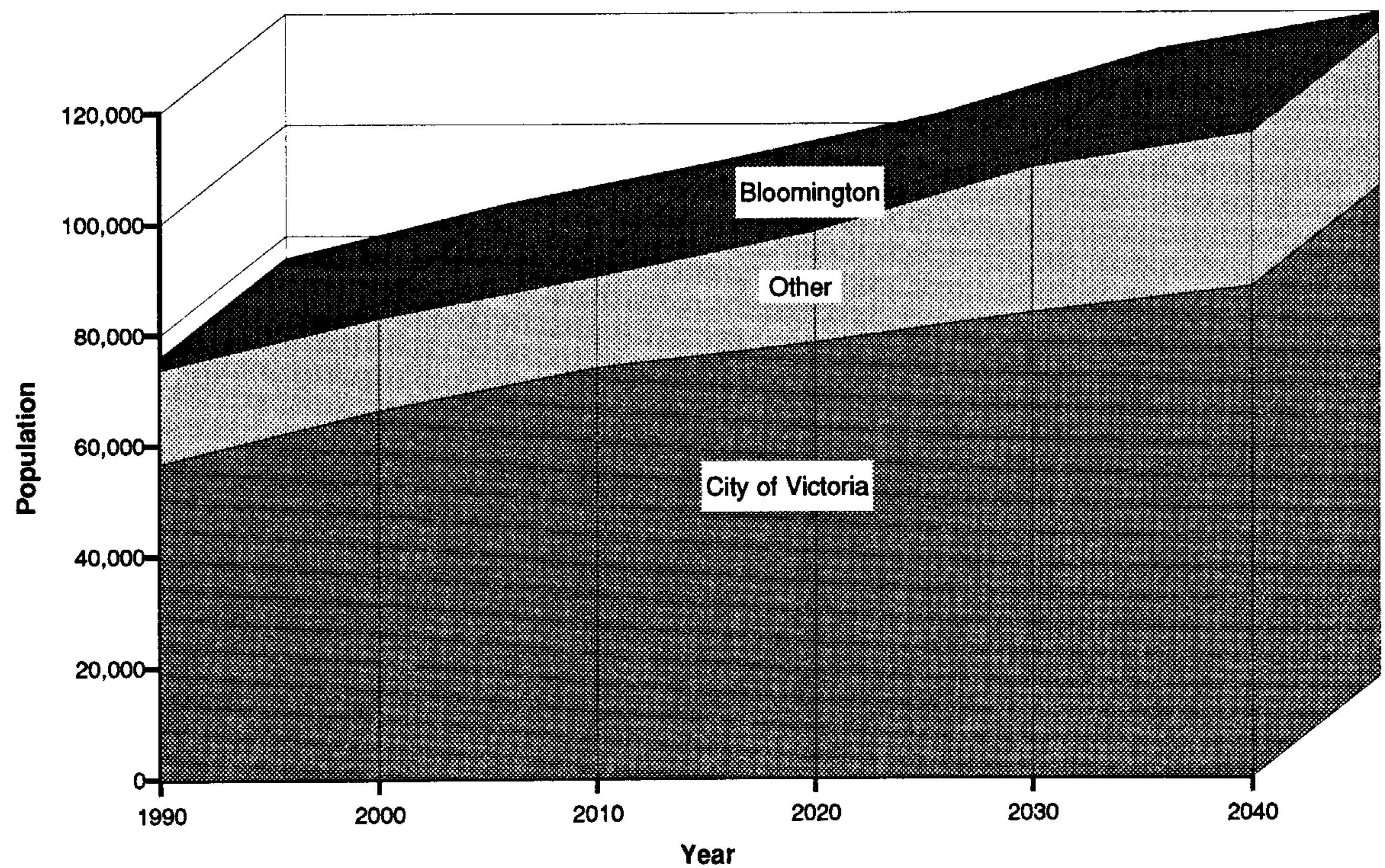
The CV/VC service area continues to demonstrate a moderate rate of future population growth started in the late 1970s and continuing into the 1980s. While other areas of Texas have shown a declining growth rate, this trend is not demonstrated in the historical water use data of the CV/VC area. Therefore, the High Series population estimates most adequately reflect the steady growth of the CV/VC Planning Area.

3.2 WATER DEMAND PROJECTIONS

3.2.1 Water Demand Projection Methodology

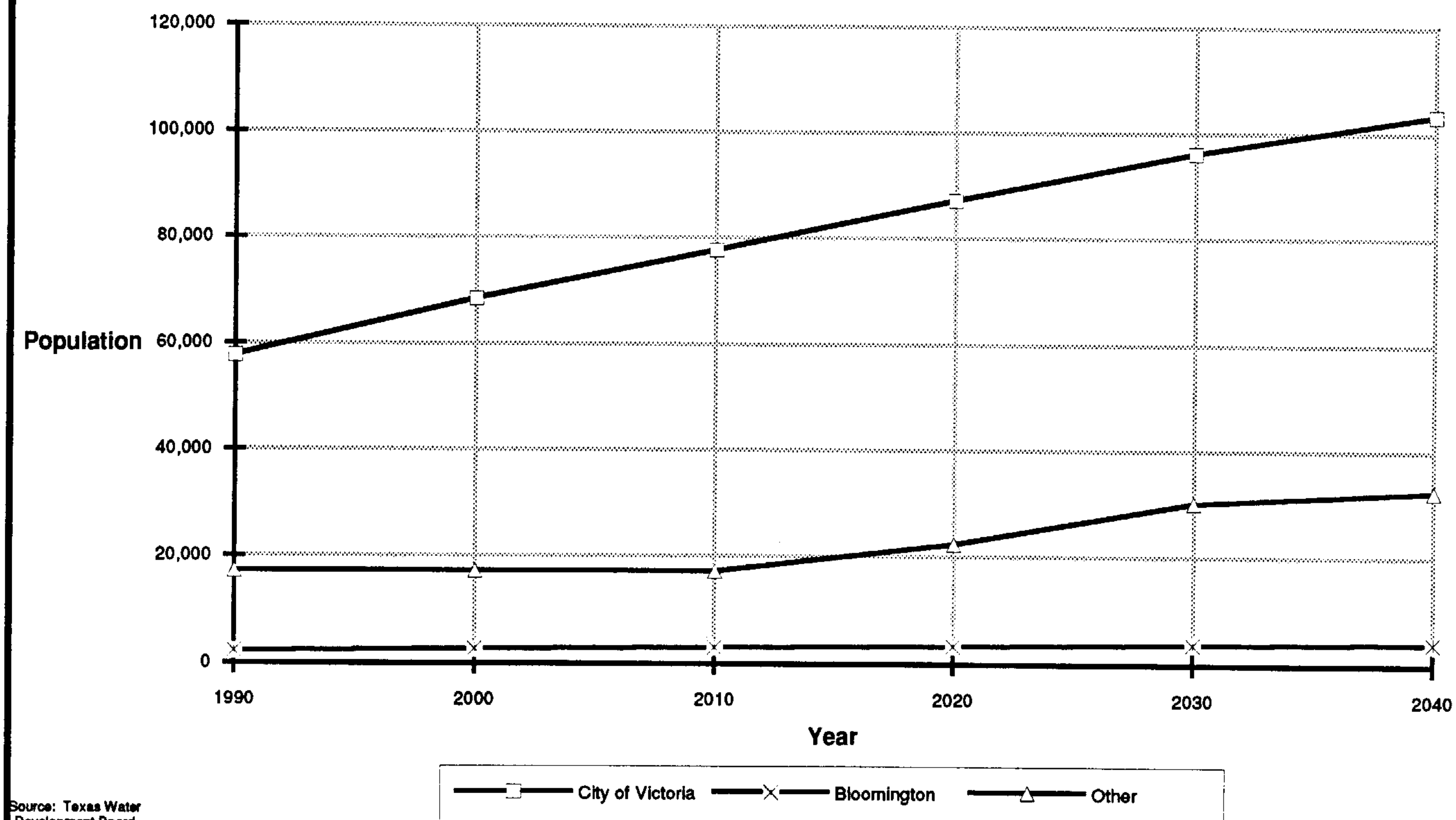
The TWDB applies historical per capita water use factors to its High and Low Series future population estimates to determine future water demands. In addition, the TWDB applies water conservation reduction factors to each historical use rate to obtain future

Figure 3-2
Aggregate Projected City and County of Victoria Future Populations
Low Series



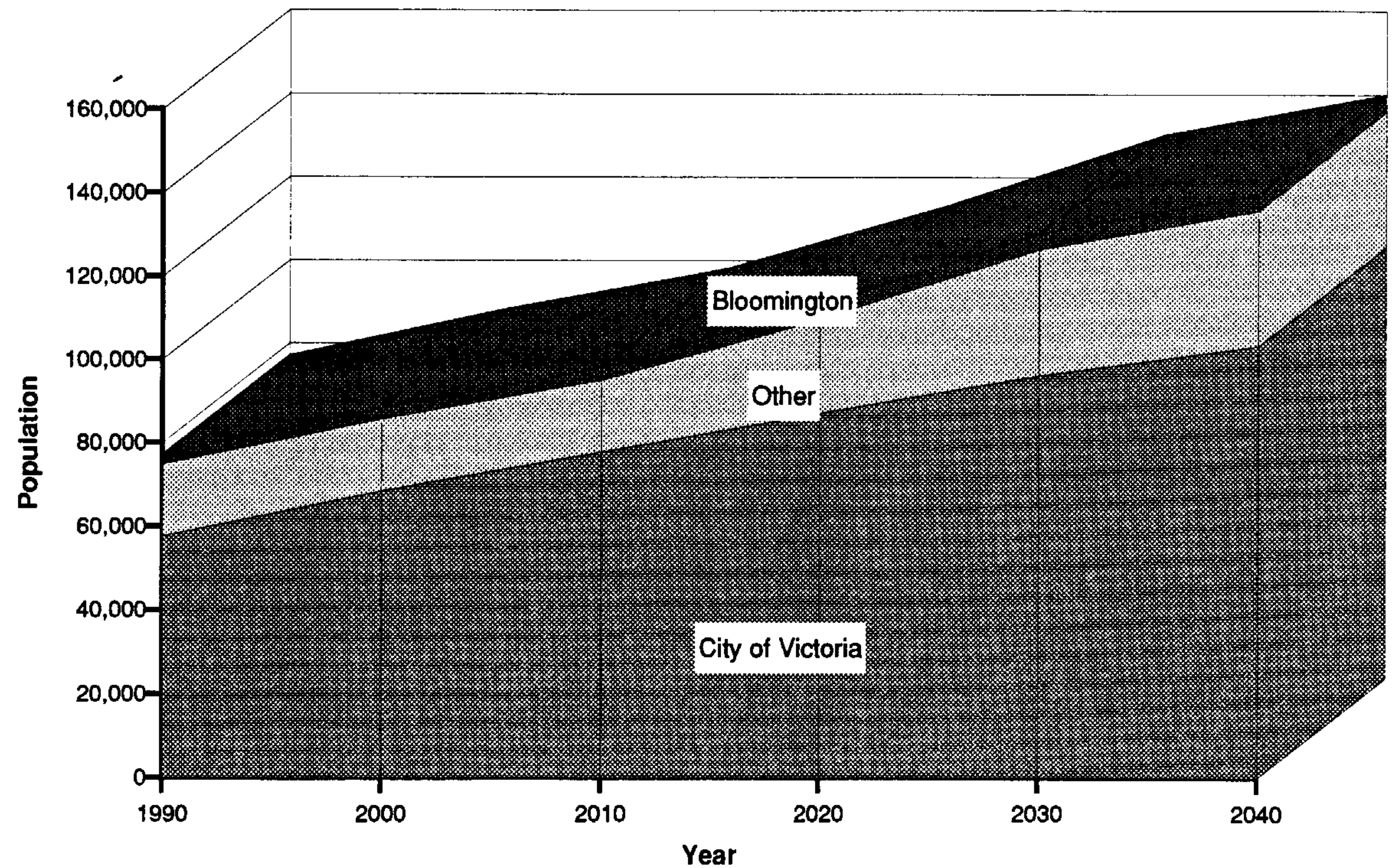
Source: Texas Water Development Board

Figure 3-3
Projected City and County of Victoria Future Populations
High Series



Source: Texas Water Development Board

Figure 3-4
Aggregate Projected City and County of Victoria Future Populations
High Series



Source: Texas Water Development Board

demands with and without implementation of water conservation measures. Thus, there are eight possible combinations of future water demand:

Low Population Series

Average Per Capita Use

(1) With Water Conservation
(2) Without Water Conservation

High Per Capita Use

(5) With Water Conservation
(6) Without Water Conservation

High Population Series

Average Per Capita Use

(3) With Water Conservation
(4) Without Water Conservation

High Per Capita Use

(7) With Water Conservation
(8) Without Water Conservation

Average and High Per Capita Water Use Rates are both predicated on the previous ten years of TWDB water use data specific to the county or city. The Average Per Capita Use Rate is simply the average water use rate exhibited over the last decade while the High Per Capita Use Rate is the highest single annual use rate recorded during the last decade.

Savings in water use resulting from implementation of rigorous water conservation programs are also computed by the TWDB. Conservation savings are computed differently for urban and rural settings; however, both are non-linear functions which assume an increasing rate of savings until some ultimate reduction limit is achieved. From that point, annual water conservation savings are assumed constant. For rural areas, the TWDB water conservation savings begin at 2% for the first year and increases to a maximum of 15% in 2020. Thence, conservation savings remain constant at 15%.

3.2.2 Water Demand Projection Results

The future water demand projections are broken down into the following groups: City of Victoria; City of Bloomington; other municipalities; and other non-municipalities (which includes manufacturing, steam electric, irrigation, mining and livestock). Each of these groups are illustrated in Tables 3-2 through 3-5, and Figures 3-5 through 3-12.

These numbers will be valuable in the future treatment capacity and distribution infrastructure design phase of this study. Aggregate CV/VC future water demand projections are shown in Table 3-6 and Figures 3-13 through 3-20 and are summarized in Figures 3-21 and 3-22. Depending on the population series, per capita use rate and water conservation scenario chosen, the total projected CV/VC 2040 water demand ranges from 143,262 to 166,948 acre-feet.

3.3 SELECTION OF FUTURE DEVELOPMENT PLANNING SCENARIOS

Planning for future water supply acquisition and future treatment plant and distribution infrastructure designs require different uses of the same information. If in planning for the acquisition of firm future water supplies, future demands are over or underestimated, adjustment can usually be made to either liquidate excess capacity or obtain additional supplies from alternative sources. However, if future water treatment or distribution capacities are underestimated the results can be costly. Additional capacity, at some future date, may be considerably more expensive than the initial cost of oversizing distribution system lines. Maintaining excess or unused treatment and distribution capacity can be equally expensive. Therefore the following future municipal water demand estimates will be used in the remainder of this study:

Table 3-2
Estimated Future Demands for the City of Victoria and the City of Bloomington
(1990-2040)

Year	Demand (AF)							
	City of Victoria Projected Future Demands							
	Low Population Series				High Population Series			
	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation
1990	9,221	8,990	10,493	10,231	9,377	9,143	10,670	10,404
2000	10,781	9,971	12,268	11,347	11,136	10,300	12,672	11,721
2010	12,035	10,530	13,694	11,983	12,649	11,068	14,394	12,595
2020	12,748	10,836	14,506	12,331	14,179	12,052	16,135	13,714
2030	13,616	11,573	15,493	13,169	15,651	13,303	17,809	15,138
2040	14,378	12,221	16,361	13,907	16,801	14,281	19,118	16,251

Year	Demand (AF)							
	City of Bloomington Projected Future Demands							
	Low Population Series				High Population Series			
	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation
1990	277	270	335	327	282	275	341	333
2000	321	297	389	360	332	307	402	372
2010	359	314	434	380	377	330	456	399
2020	380	323	460	391	423	359	512	435
2030	406	345	491	417	467	397	565	480
2040	429	364	519	441	501	426	606	515

Source: Texas Water Development Board

Table 3-3
Estimated Future Demands for Other Municipal and Non-Municipal Sources (Manufacturing)
(1990-2040)

Year	Demand (AF)							
	Other Municipal Projected Future Demands a/							
	Low Population Series				High Population Series			
	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation
1990	2,269	2,211	2,536	2,473	2,306	2,247	2,580	2,515
2000	2,232	2,067	2,498	2,311	2,306	2,133	2,580	2,386
2010	2,195	1,920	2,454	2,147	2,306	2,019	2,580	2,258
2020	2,701	2,296	3,020	2,569	3,003	2,552	3,359	2,855
2030	3,517	2,990	3,934	3,344	4,043	3,436	4,520	3,843
2040	3,715	3,157	4,154	3,532	4,339	3,689	4,853	4,125

Year	Demand (AF)							
	Other Non-Municipal Projected Future Demands (Manufacturing)							
	Low Population Series				High Population Series			
	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation
1990	27,045	27,045	27,045	27,045	27,036	27,036	27,036	27,036
2000	39,325	39,325	39,325	39,325	52,372	52,372	52,372	52,372
2010	52,381	52,381	52,381	52,381	52,487	52,487	52,487	52,487
2020	60,781	60,781	60,781	60,781	65,587	65,587	65,587	65,587
2030	68,814	68,814	68,814	68,814	76,930	76,930	76,930	76,930
2040	77,906	77,906	77,906	77,906	90,147	90,147	90,147	90,147

a/ Includes all municipal areas with the exception of the City of Victoria and the City of Bloomington.

Source: Texas Water Development Board

Table 3-4
Estimated Future Demands for Other Non-Municipal Sources (Steam Electric & Irrigation)
(1990-2040)

Year	Demand (AF)							
	Other Non-Municipal Projected Future Demands (Steam Electric)							
	Low Population Series				High Population Series			
	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation
1990	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
2000	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
2010	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
2020	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
2030	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000
2040	26,000	26,000	26,000	26,000	26,000	26,000	26,000	26,000

Year	Demand (AF)							
	Other Non-Municipal Projected Future Demands (Irrigation)							
	Low Population Series				High Population Series			
	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation
1990	23,357	23,357	23,357	23,357	26,019	26,019	26,019	26,019
2000	24,291	24,291	24,291	24,291	24,794	24,794	24,794	24,794
2010	20,879	20,879	20,879	20,879	23,489	23,489	23,489	23,489
2020	20,879	20,879	20,879	20,879	23,489	23,489	23,489	23,489
2030	19,574	19,574	19,574	19,574	22,184	22,184	22,184	22,184
2040	19,574	19,574	19,574	19,574	22,184	22,184	22,184	22,184

Source: Texas Water Development Board

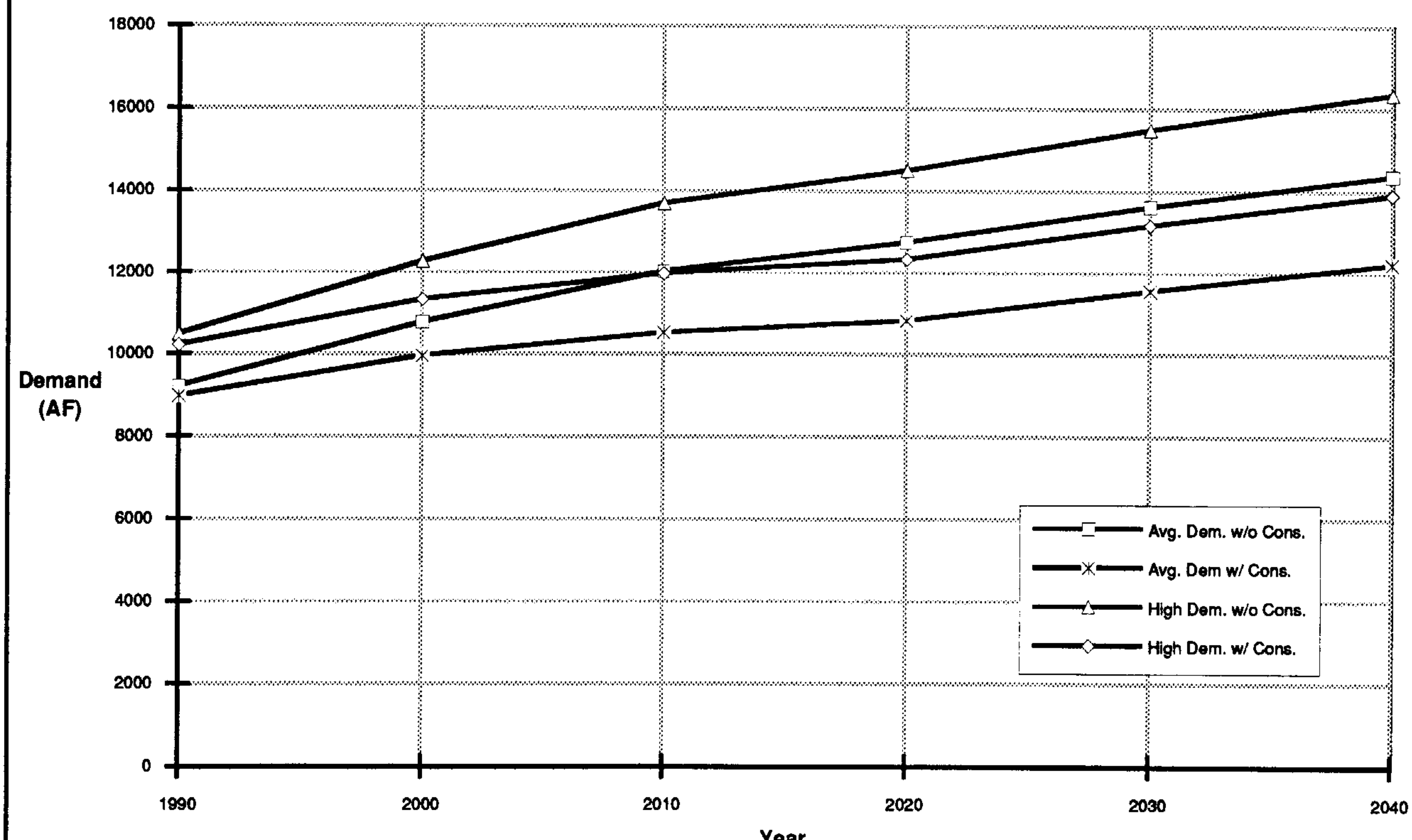
Table 3-5
Estimated Future Demands for Other Non-Municipal Sources (Mining & Livestock)
(1990-2040)

Year	Demand (AF)							
	Other Non-Municipal Projected Future Demands (Mining)							
	Low Population Series				High Population Series			
	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation
1990	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380
2000	1,538	1,538	1,538	1,538	1,538	1,538	1,538	1,538
2010	1,739	1,739	1,739	1,739	1,739	1,739	1,739	1,739
2020	1,940	1,940	1,940	1,940	1,940	1,940	1,940	1,940
2030	2,141	2,141	2,141	2,141	2,141	2,141	2,141	2,141
2040	2,417	2,417	2,417	2,417	2,417	2,417	2,417	2,417

Year	Demand (AF)							
	Other Non-Municipal Projected Future Demands (Livestock)							
	Low Population Series				High Population Series			
	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation	Avg. Demand Without Conservation	Avg. Demand With Conservation	High Demand Without Conservation	High Demand With Conservation
1990	1,400	1,400	1,400	1,400	1,400	1,400	1,400	1,400
2000	1,623	1,623	1,623	1,623	1,623	1,623	1,623	1,623
2010	1,623	1,623	1,623	1,623	1,623	1,623	1,623	1,623
2020	1,623	1,623	1,623	1,623	1,623	1,623	1,623	1,623
2030	1,623	1,623	1,623	1,623	1,623	1,623	1,623	1,623
2040	1,623	1,623	1,623	1,623	1,623	1,623	1,623	1,623

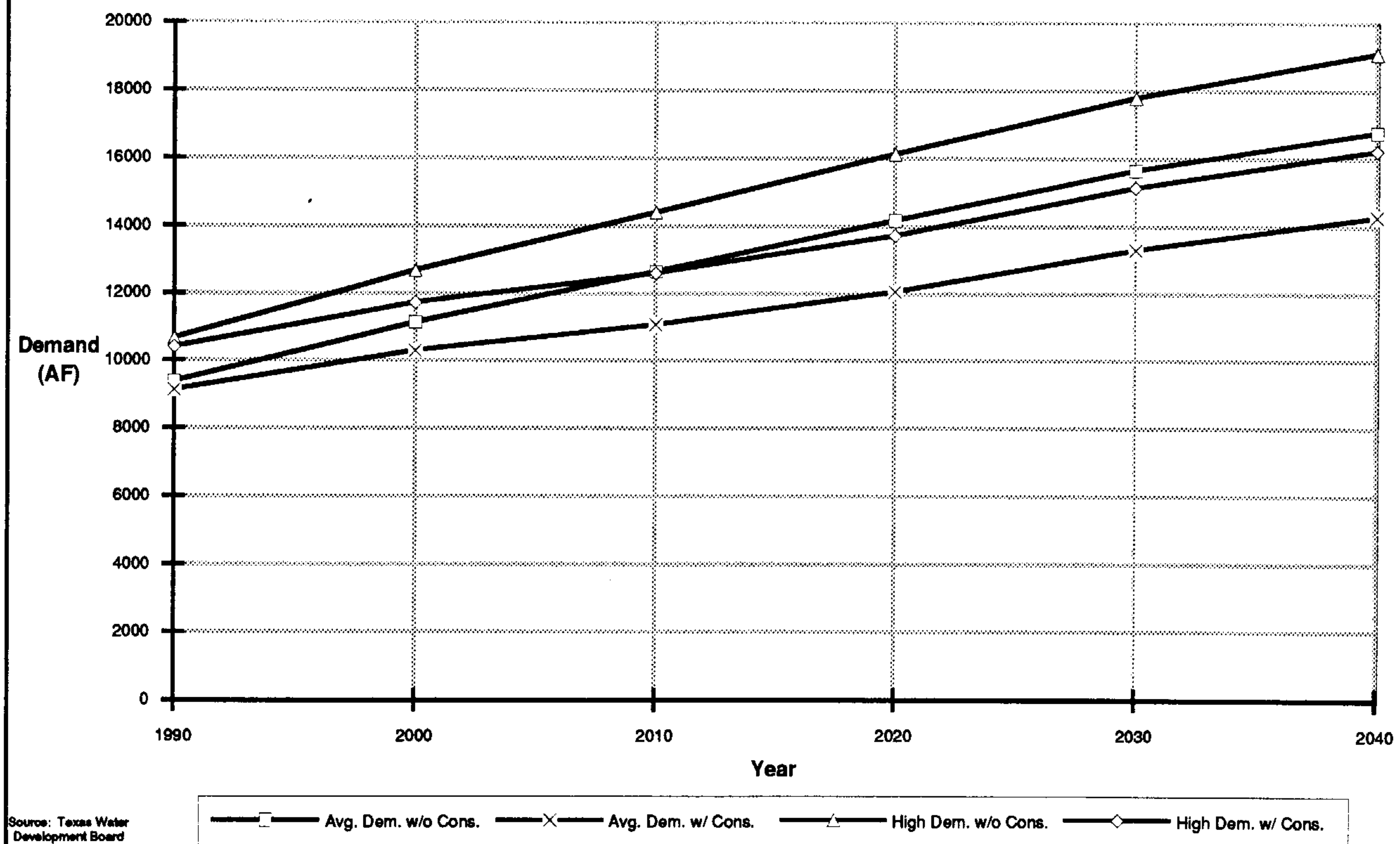
Source: Texas Water Development Board

Figure 3-5
City of Victoria Projected Future Demands
Low Population Series



Source: Texas Water Development Board

Figure 3-6
City of Victoria Projected Future Demands
High Population Series



Source: Texas Water Development Board

Figure 3-7
City of Bloomington Projected Future Demands
Low Population Series

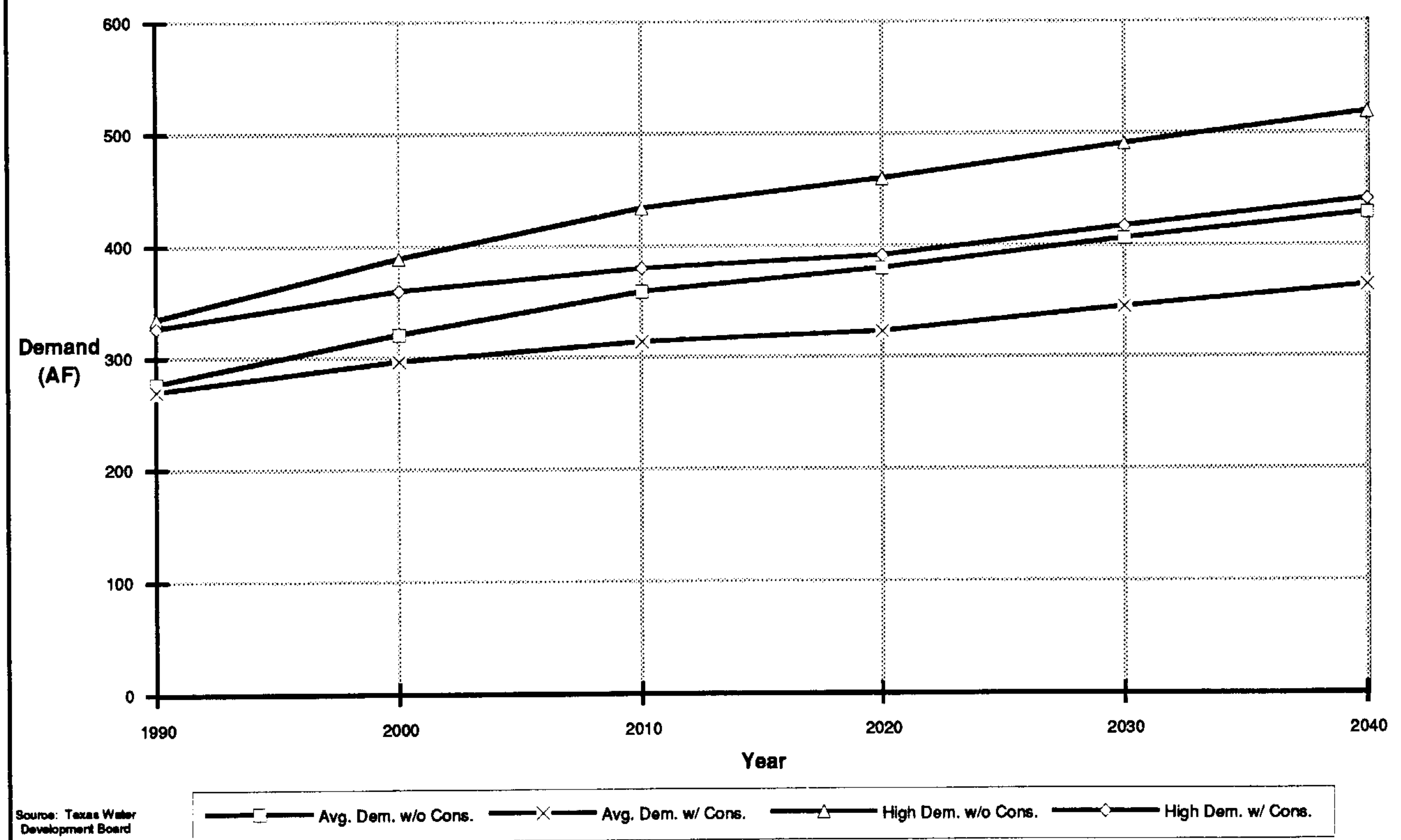
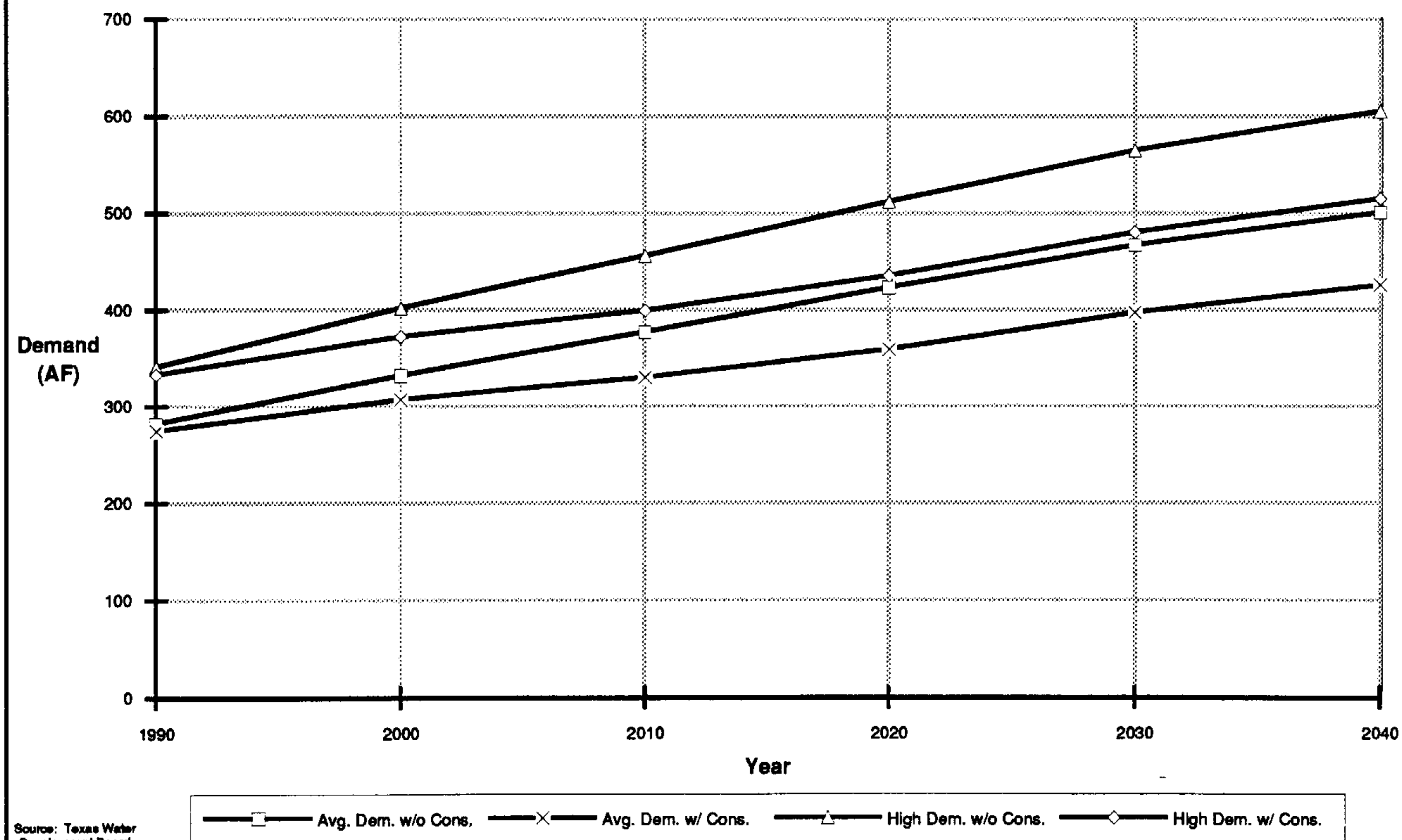
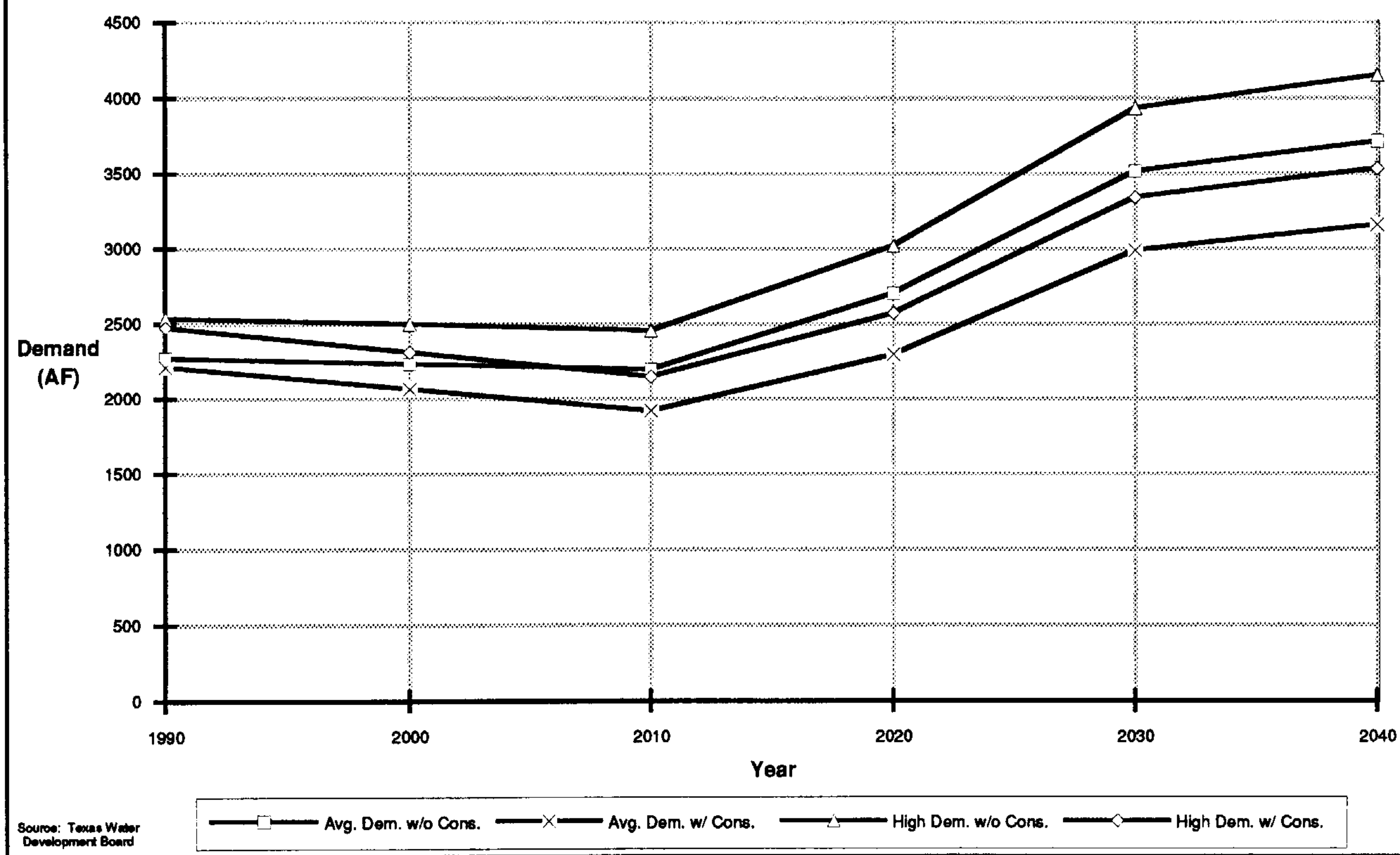


Figure 3-8
City of Bloomington Projected Future Demands
High Population Series



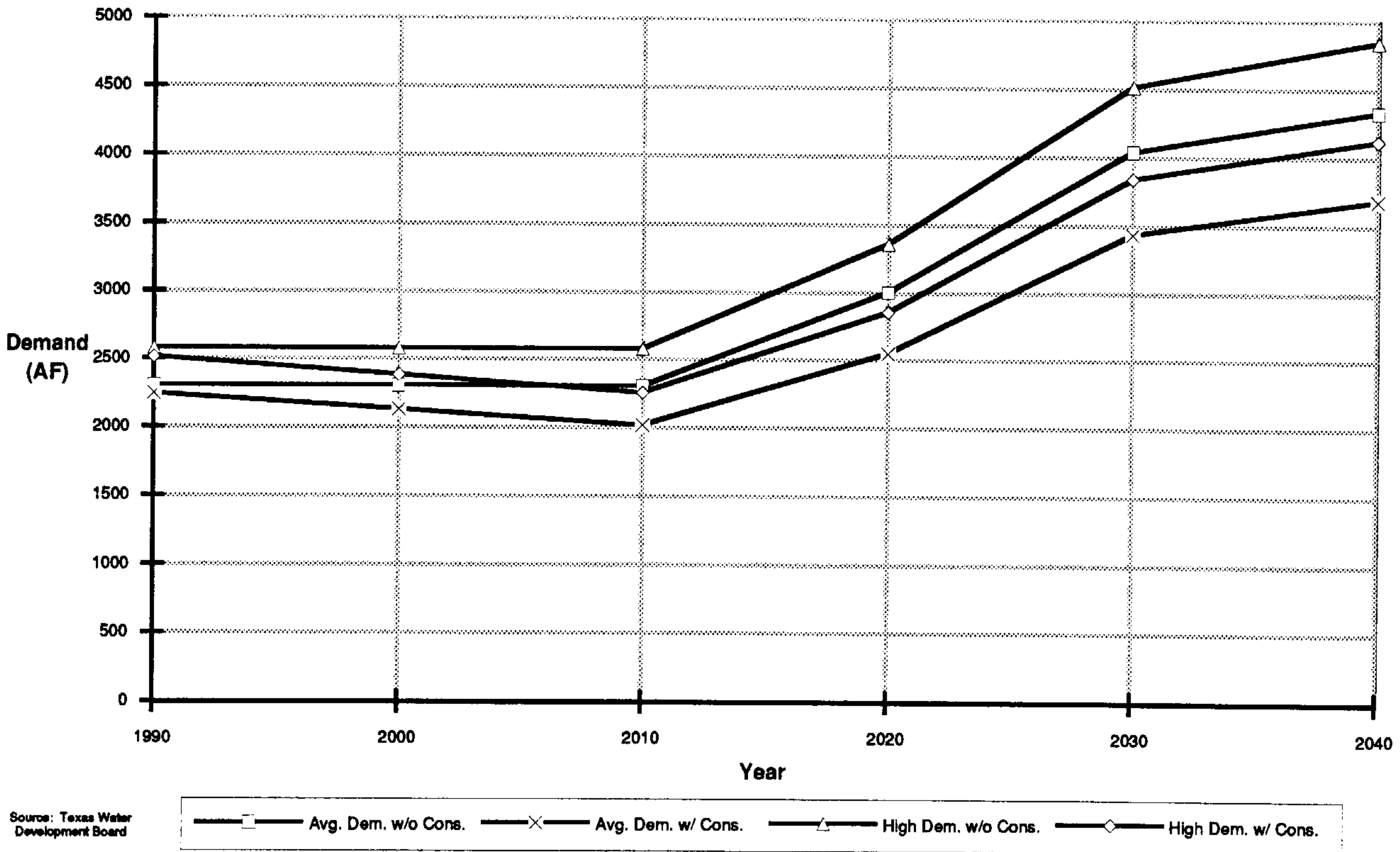
Source: Texas Water Development Board

Figure 3-9
Other Municipal Projected Future Demands
Low Population Series



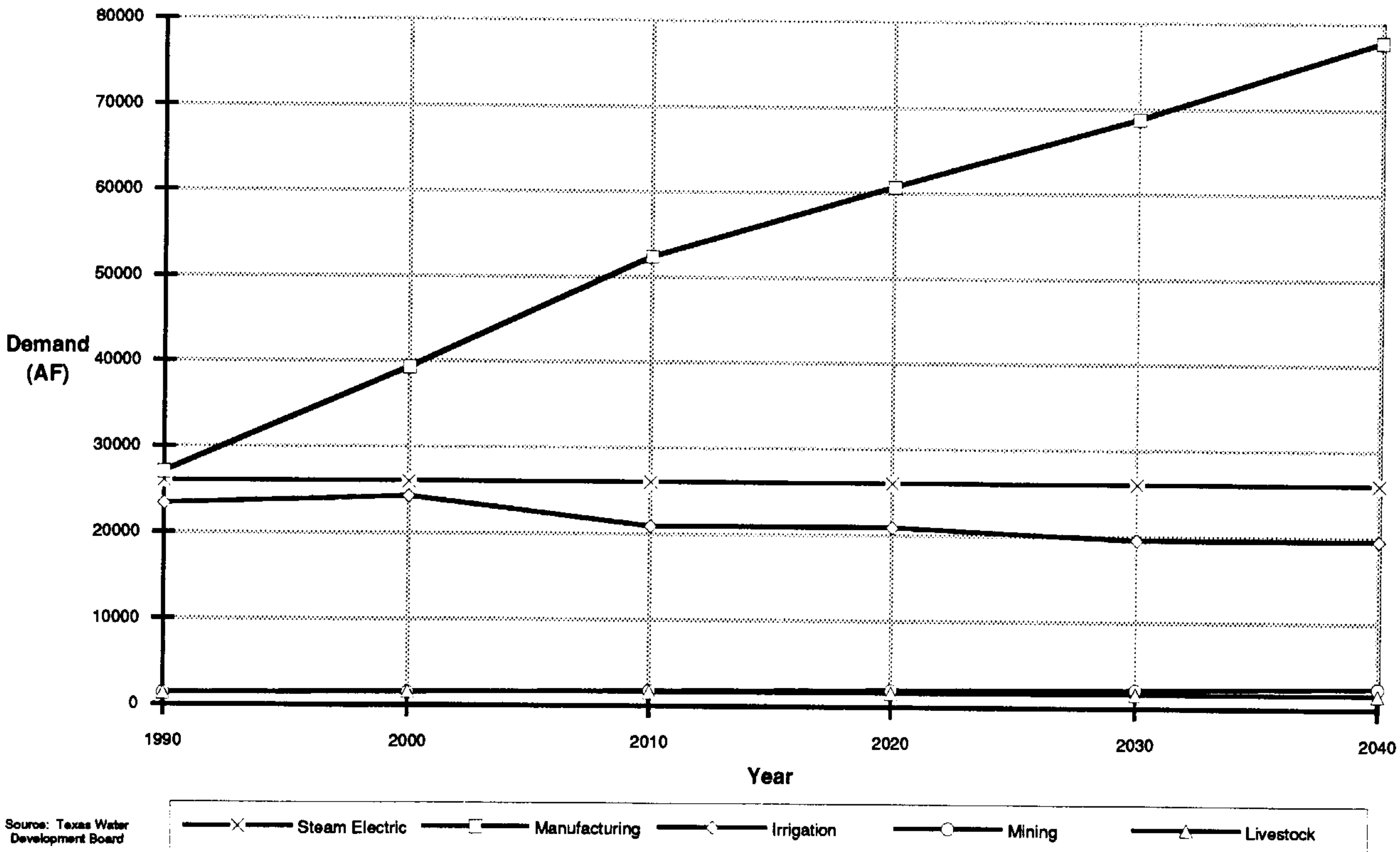
Source: Texas Water Development Board

Figure 3-10
Other Municipal Projected Future Demands
High Population Series



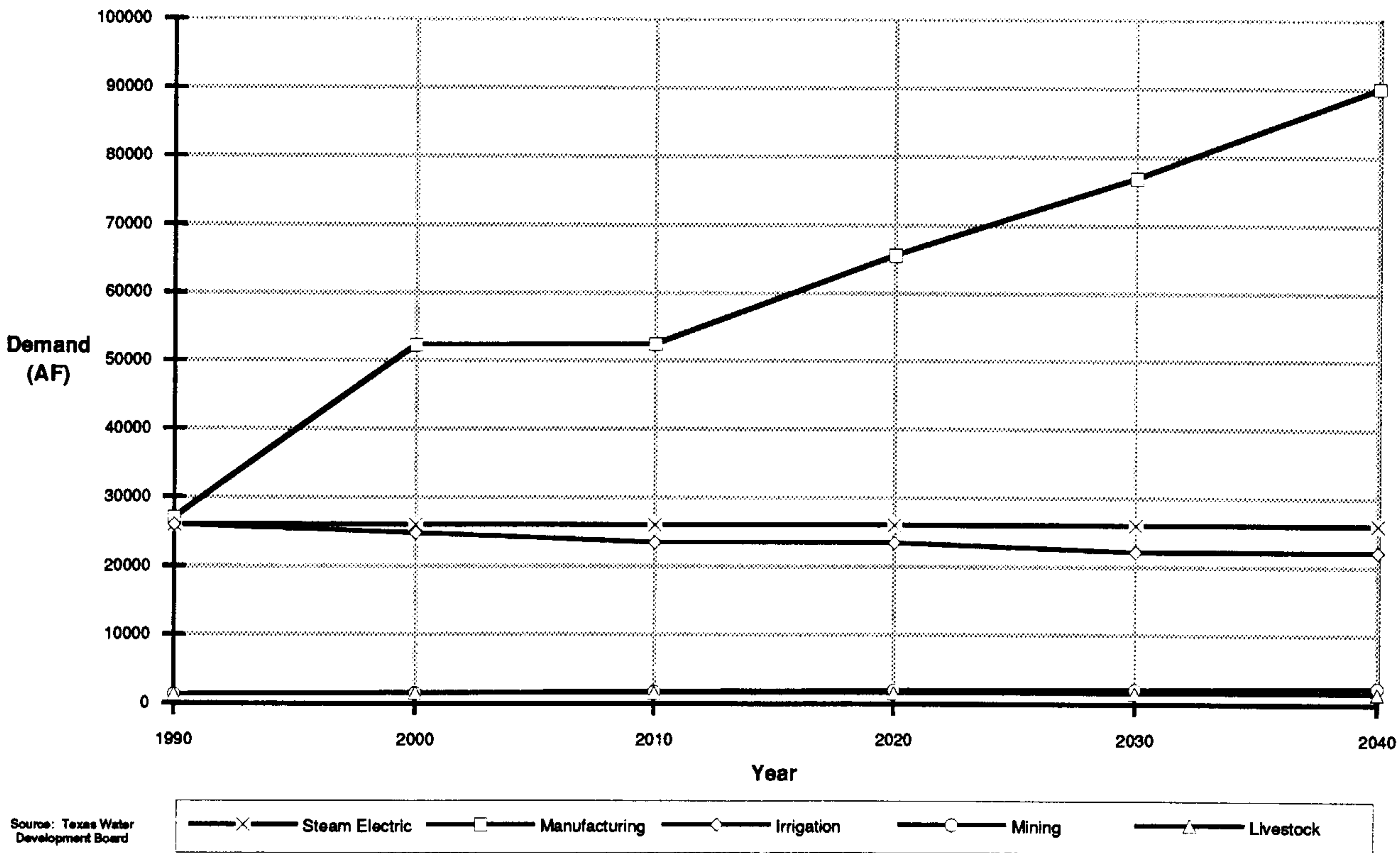
Source: Texas Water Development Board

Figure 3-11
Other Non-Municipal Projected Future Demands
(Average and High Per Capita Use - Low Population Series)



Source: Texas Water Development Board

Figure 3-12
Other Non-Municipal Projected Future Demands
(Average and High Per Capita Use - High Population Series)



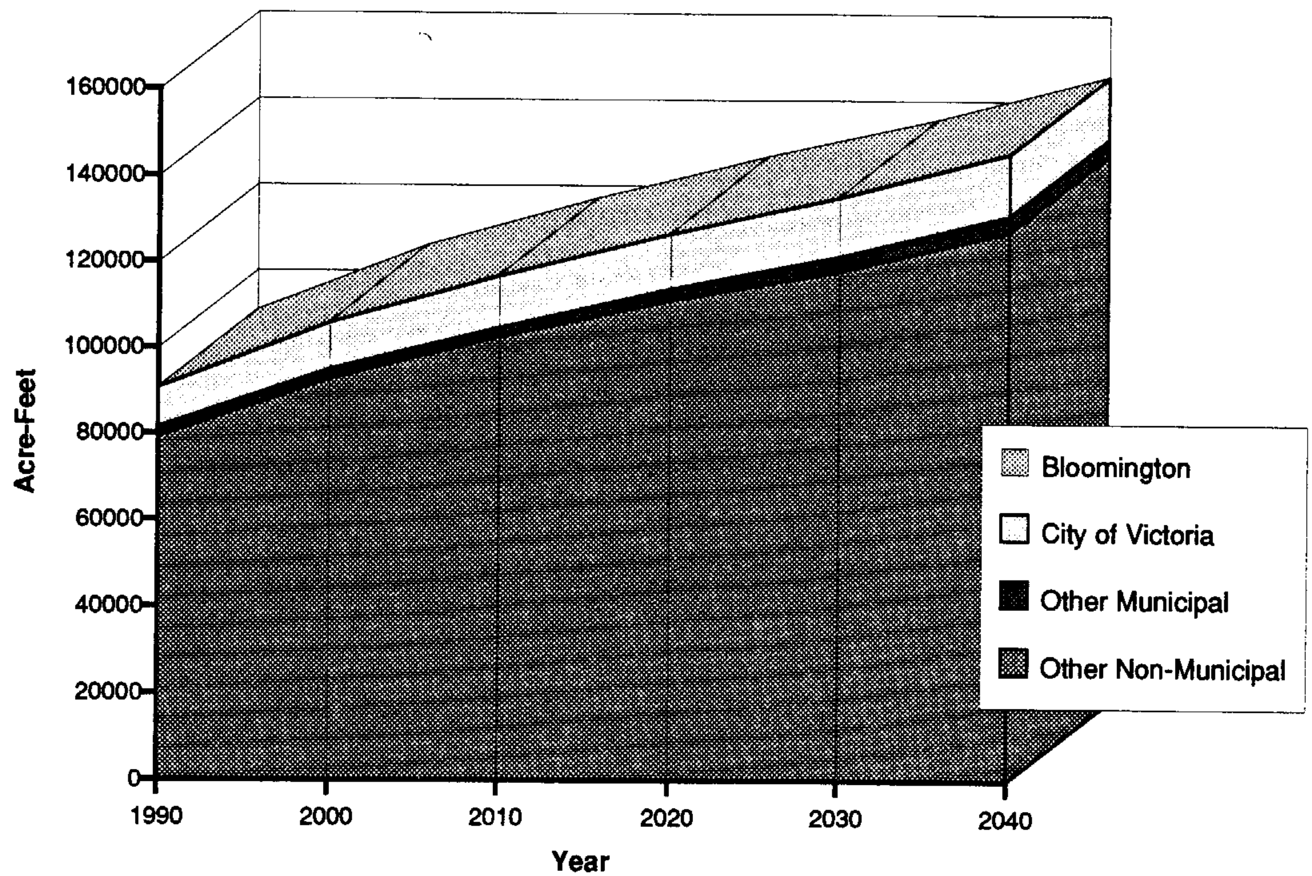
Source: Texas Water Development Board

Table 3-6
Estimated Future Demands for the Total County of Victoria
(1990-2040)

Year	Demand (AF)							
	Average Per Capita Water Use				High Per Capita Water Use			
	Low Population Series		High Population Series		Low Population Series		High Population Series	
	Without Conservation	With Conservation	Without Conservation	With Conservation	Without Conservation	With Conservation	Without Conservation	With Conservation
1990	90,949	90,653	93,800	93,500	92,546	92,213	95,426	95,087
2000	106,111	105,112	120,101	119,067	107,932	106,795	121,981	120,806
2010	117,211	115,386	120,670	118,755	119,204	117,132	122,768	120,590
2020	127,052	124,678	136,244	133,602	129,209	126,514	138,645	135,643
2030	135,691	133,060	149,039	146,014	138,070	135,082	151,772	148,339
2040	146,042	143,262	164,012	160,767	148,554	145,400	166,948	163,262

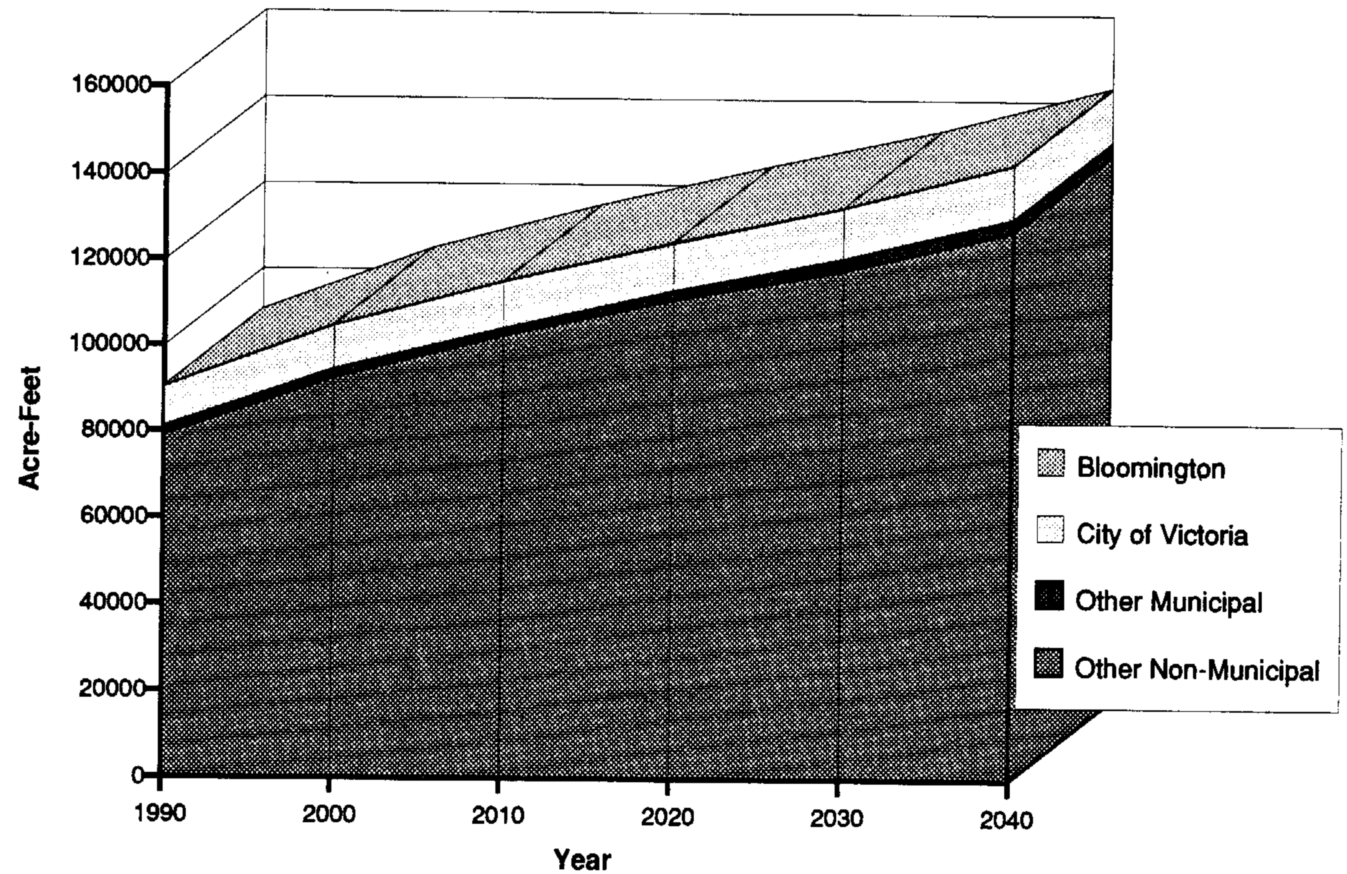
Source: Texas Water Development Board

Figure 3-13
Aggregate Projected City and County of Victoria Future Water Demand
Low Population Series - Average Per Capita Use
Without Conservation



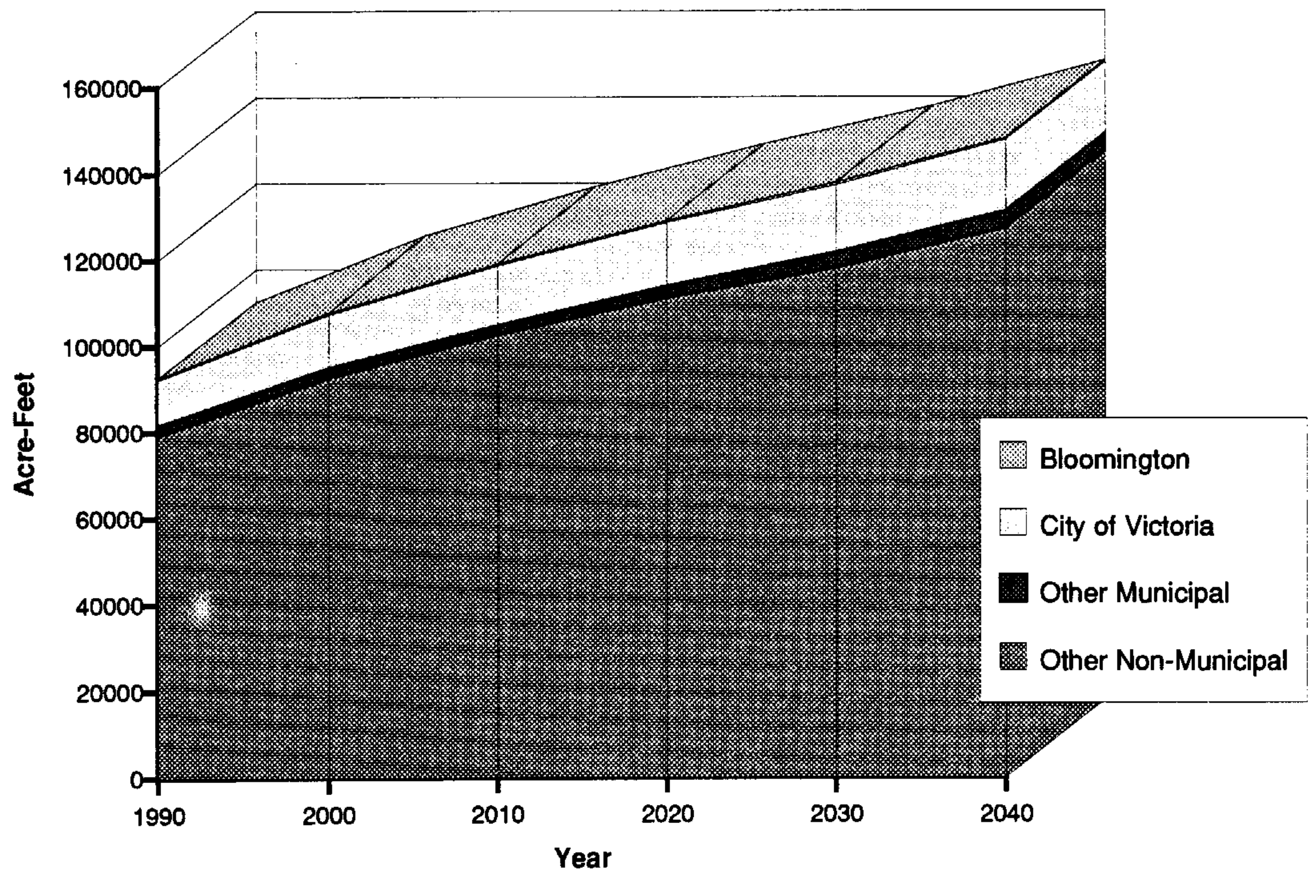
Source: Texas Water Development Baord

Figure 3-14
Aggregate Projected City and County of Victoria Future Water Demand
Low Population Series - Average Per Capita Use
With Conservation



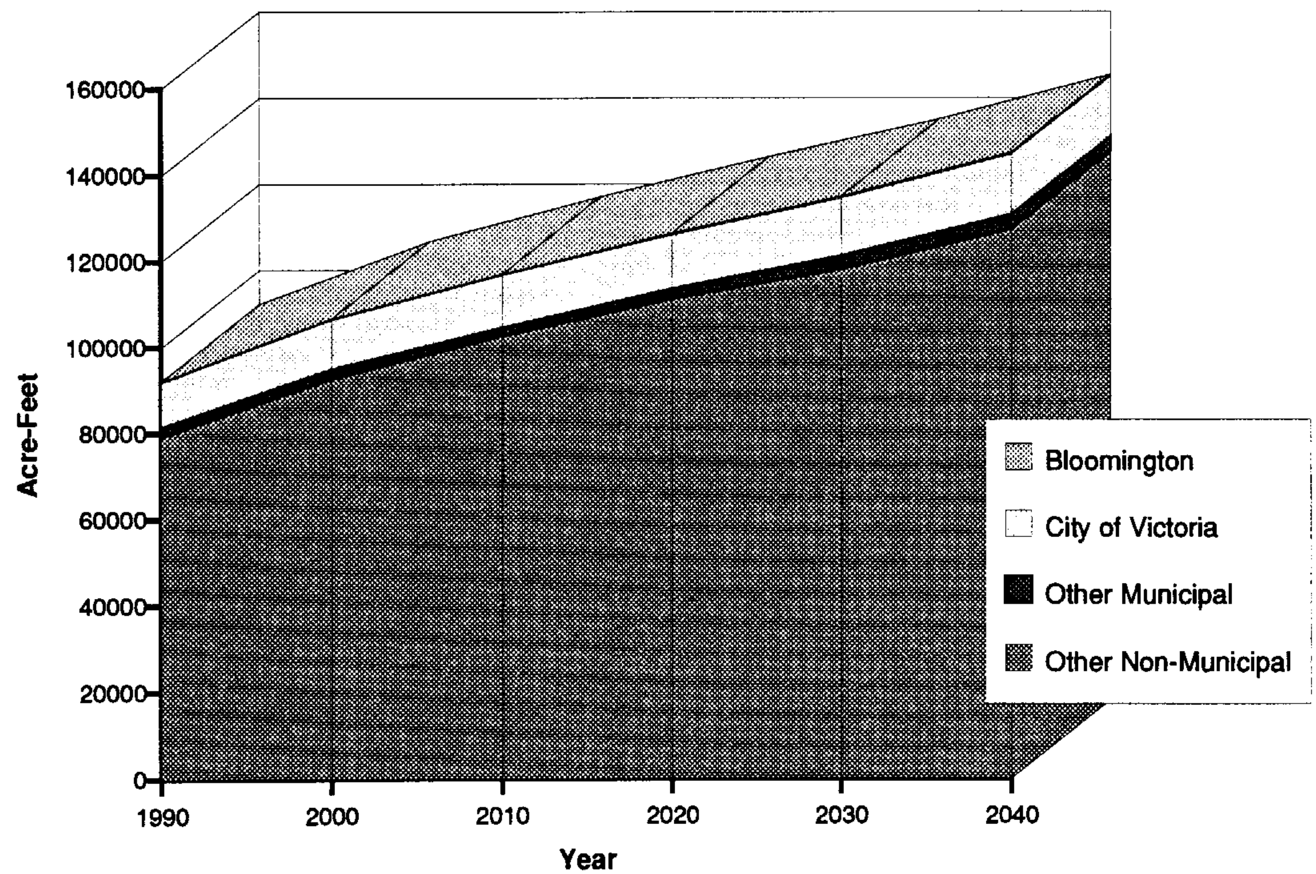
Source: Texas Water Development Board

Figure 3-15
Aggregate Projected City and County of Victoria Future Water Demand
Low Population Series - High Per Capita Use
Without Conservation



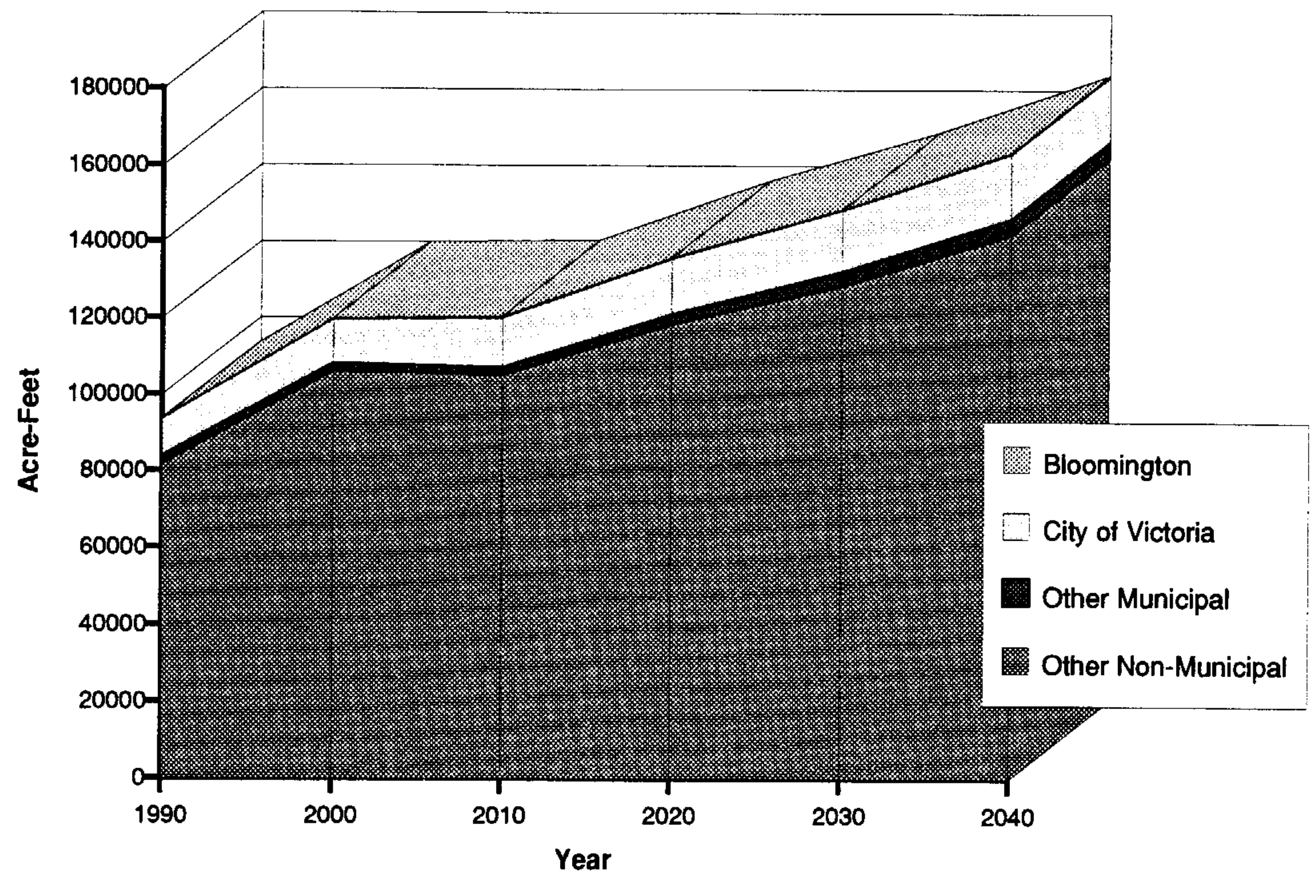
Source: Texas Water Development Board

Figure 3-16
Aggregate Projected City and County of Victoria Future Water Demand
Low Population Series - High Per Capita Use
With Conservation



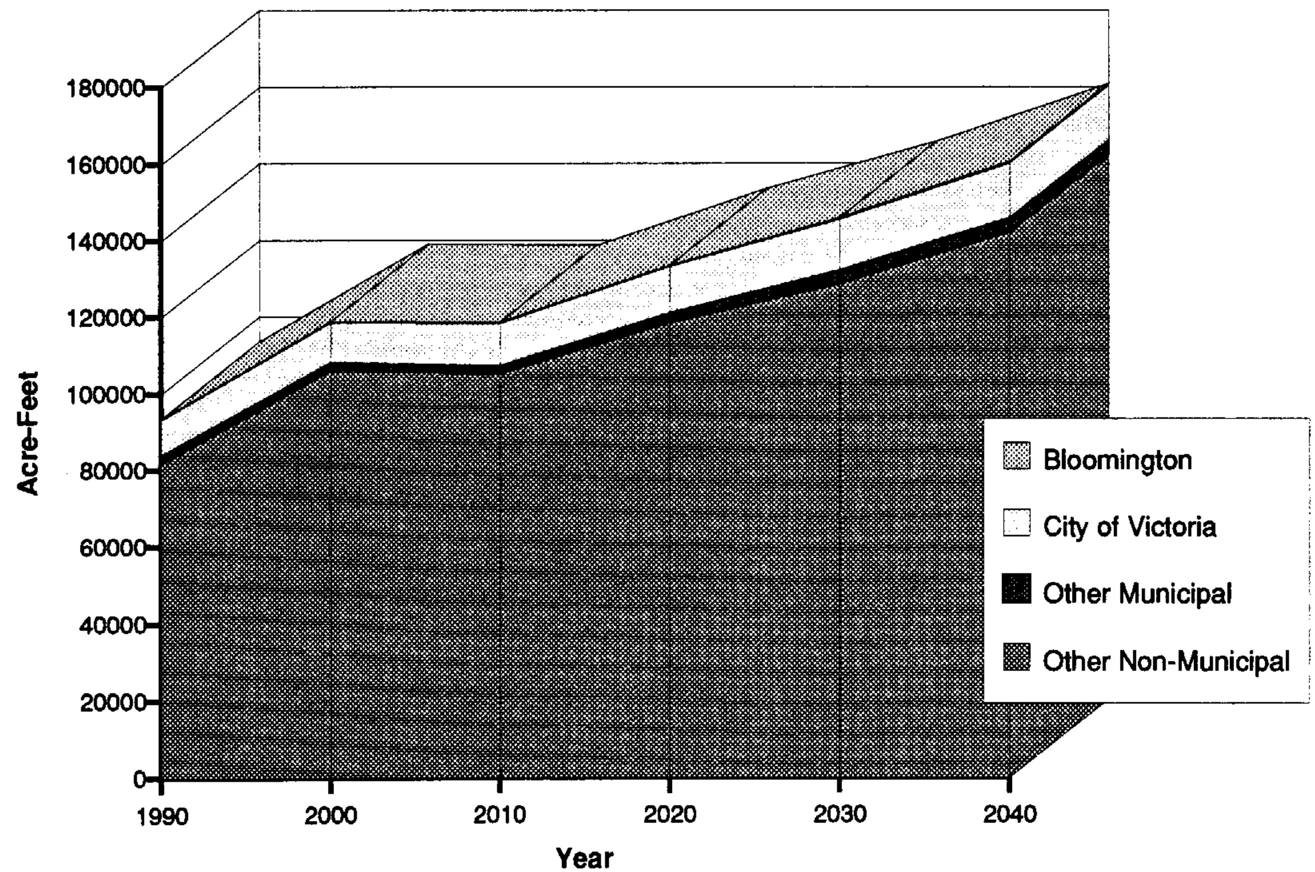
Source: Texas Water Development Board

Figure 3-17
Aggregate Projected City and County of Victoria Future Water Demand
High Population Series - Average Per Capita Use
Without Conservation



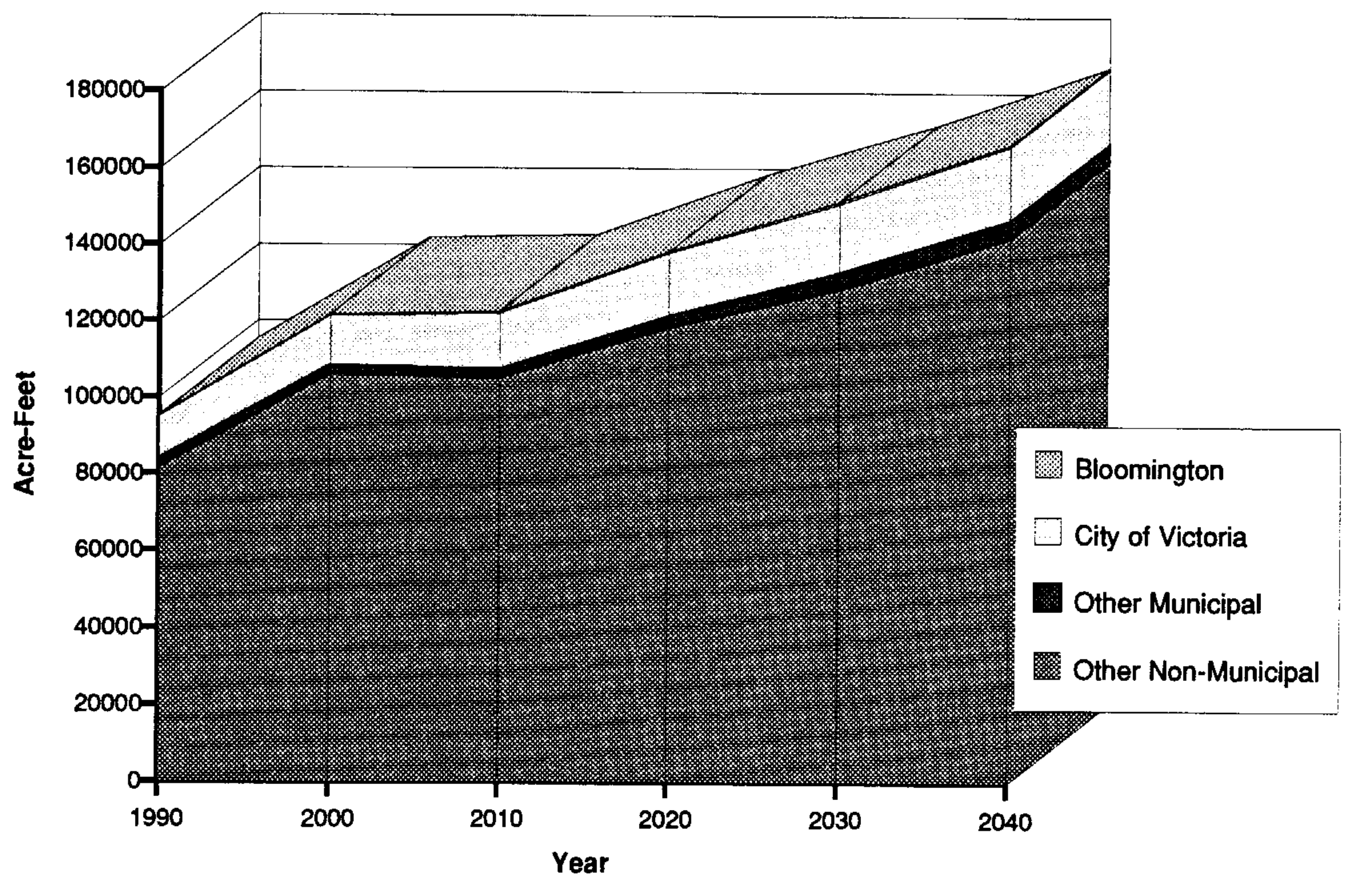
Source: Texas Water Development Board

Figure 3-18
Aggregate Projected City and County of Victoria Future Water Demand
High Population Series - Average Per Capita Use
With Conservation



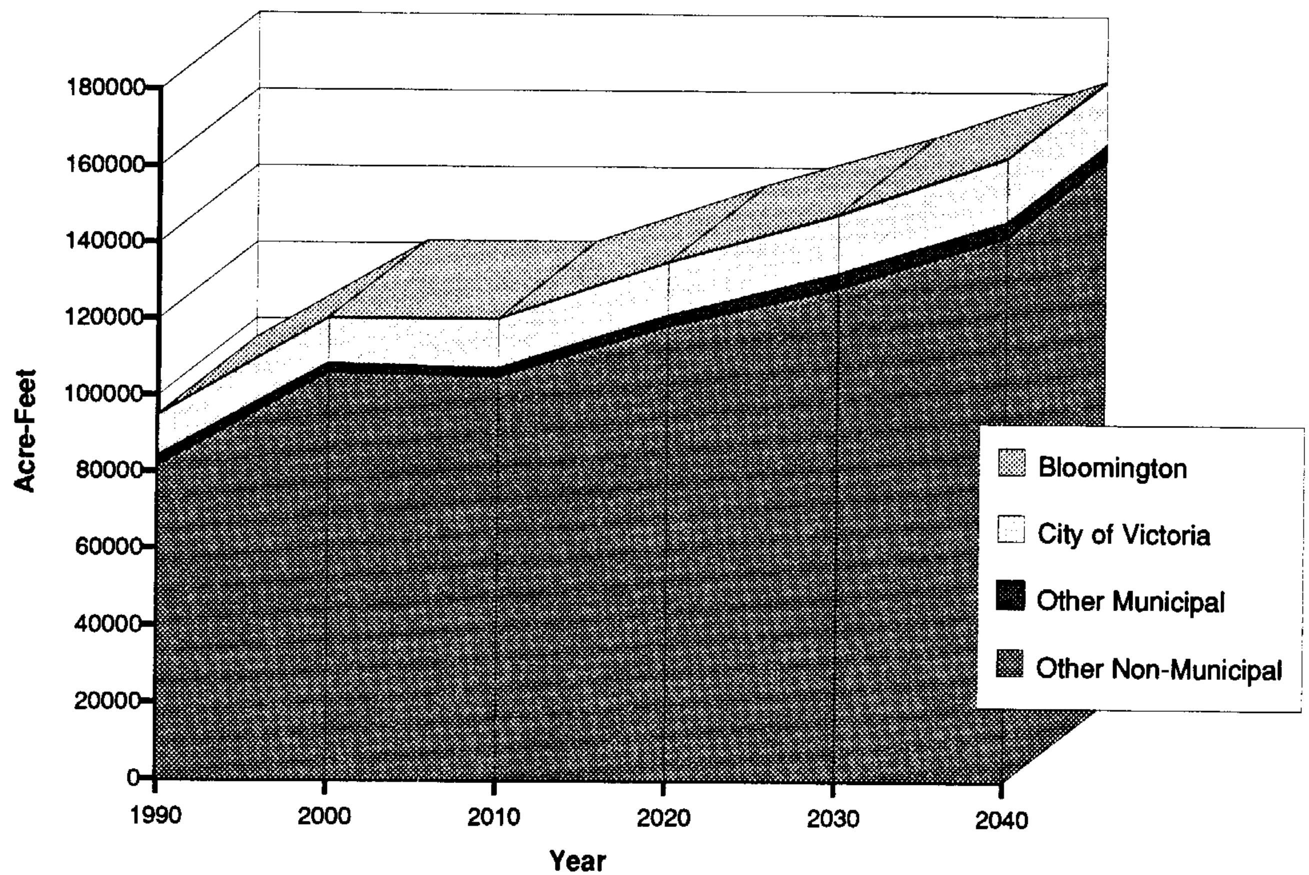
Source: Texas Water Development Board

Figure 3-19
Aggregate Projected City and County of Victoria Future Water Demand
High Population Series - High Per Capita Use
Without Conservation



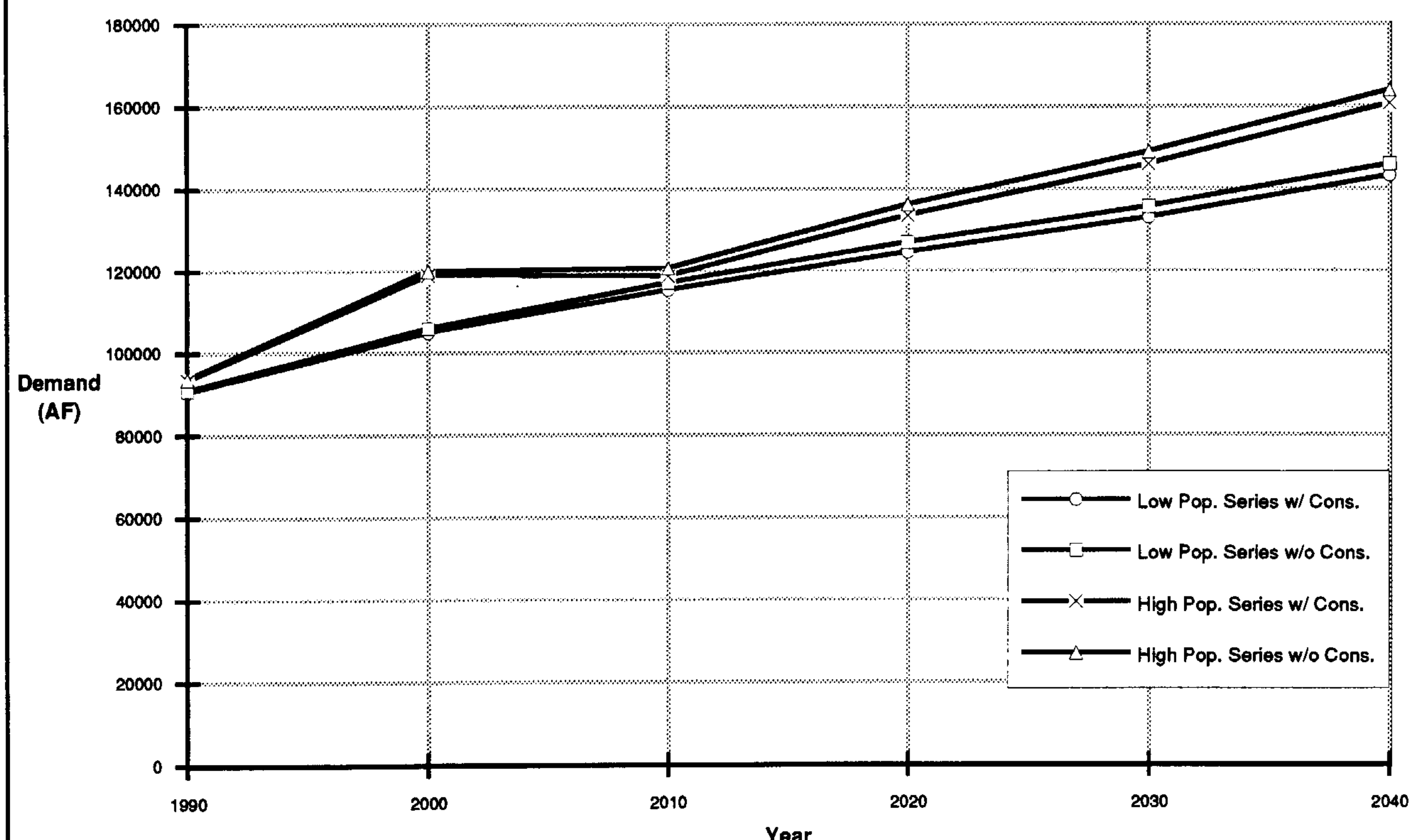
Source: Texas Water Development Board

Figure 3-20
Aggregate Projected City and County of Victoria Future Water Demand
High Population Series - High Per Capita Use
With Conservation



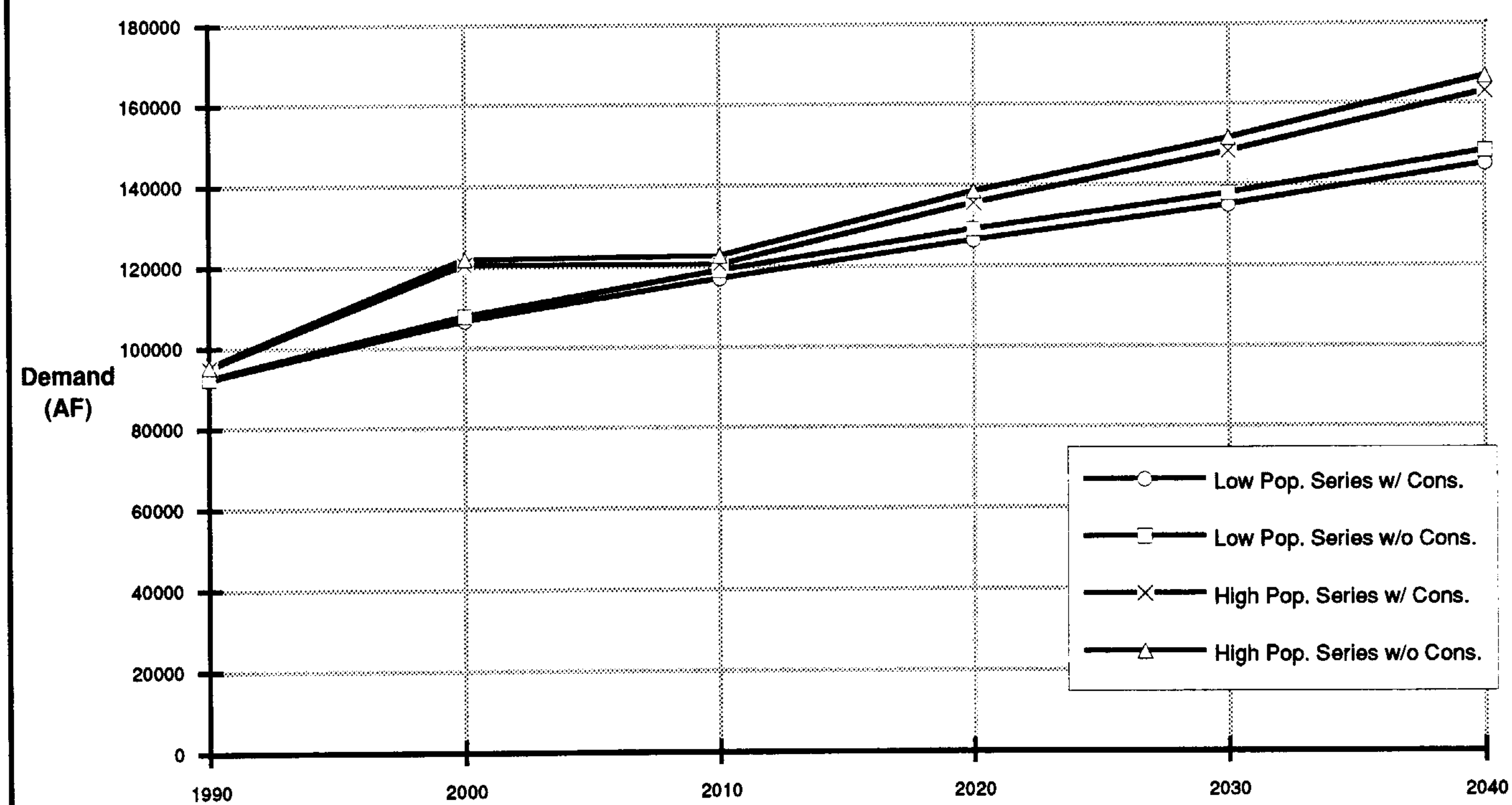
Source: Texas Water Development Board

Figure 3-21
Summary of Total Projected City and County of Victoria Demands
Average Per Capita Use



Source: Texas Water Development Board

Figure 3-22
Summary of Total Projected City and County of Victoria Demands
High Per Capita Use



Source: Texas Water Development Board

- High Population Series
- High Per Capita Use Rate
- With Water Conservation

To minimize the possible economic impacts of over or under-estimation of future populations and water demands, all water supply and infrastructure development scenarios examined will be phased.

4.0 WATER CONSERVATION AND DROUGHT CONTINGENCY PLAN

4.1 INTRODUCTION

A water conservation plan is required as part of an application for financial assistance from the Texas Water Development Board's (TWDB) Development Fund or the Water Loan Assistance Fund. Applicants for financial assistance are required to have a water conservation program in place before loan funds can be released. In accordance with the TWDB's Financial Assistance rules, this section outlines a water conservation program that will meet the regulatory requirements of the TWDB. The actual TWDB guidelines are listed in Table 4-1.

4.1.1 Planning Area

The geographical area included in the Regional Water Supply Plan includes all of Victoria County. The cities and communities within Victoria County are: Victoria, Bloomington, Placedo, Telferner, Mission Valley, Wood-Hi, Inez, Salem, Raisin, Guadalupe, Dacosta, Fordtran, Nursery and Crescent Valley. Table 4-2 lists the current Texas Department of Health record water purveyors in the County as well as population served, number of connections, persons per connection, average daily use, and average daily per capita use.

The study area is located within the Guadalupe River Basin, Lavaca-Guadalupe Coastal Basin, and Lavaca River Basin. The Lavaca River Basin stretches west to include the northeast portion of Victoria County and Lake Texana is located just to the east. The Guadalupe River flows through the center of the study area.

The Gulf Coast Aquifer is the sole source of fresh water supply for the entire planning area. Existing facilities within the study area include groundwater wells and treatment

Table 4-1

Texas Water Development Board Outline for Water Conservation Plans

Section 15.106(b), 15.607, 16.136(4), 17.125(b), 17.277(c), and 17.857(b) of the Texas Water Code and Sections 363.59 and 375.37 of Chapter 31 the Texas Administrative Code (TAC) require that applicants for financial assistance from the Texas Water Development Board (TWDB) submit a water conservation and drought contingency plan to the Board for approval, either with the application for financial assistance or after loan approval. In either case, the plan and resulting adopted program must be approved by TWDB before loan funds can be released.

All water conservation and drought contingency plans must address the water conservation measures identified in 31 TAC 363.52 and follow the TWDB's "Guidelines for Municipal Water Conservation and Drought Contingency Planning and Program Development" and the format outlined below. The two copies of the plan must be submitted to Mr. Craig Peterson, Executive Administrator, Texas Water Development Board, P.O. Box 13231, Capitol Station, Austin, Texas 78711-3231.

I. INTRODUCTION

√ A. Brief Description of the Planning Area Project

√ B. Utility Evaluation Data [TWDB Guidelines, pages 28-30]

√ C. Need for and Goals of the Program [31 TAC 363.59]

II. LONG-TERM WATER CONSERVATION PLAN

A. Plan Elements [Texas Water Code and TWDB Guidelines, pages 2-14]
[Each plan element needs to be addressed and cover the specific activities to be included or conducted. If an element is not applicable, a brief explanation of why it is inappropriate or inapplicable needs to be presented.

1. Education and Information

√ a. First-Year Program
√ b. Long-Term Program
√ c. Information to New Customers

√ 2. Water Conservation Plumbing Codes
√ 3. Water Conservation Retrofit Program
√ 4. Conservation-Oriented Water Rate Structure
√ 5. Universal Metering and Meter Repair and Replacement
√ 6. Water Conserving Landscaping
√ 7. Water Audits and Leak Detection
√ 8. Recycling and Reuse
√ 9. Means of Implementation and Enforcement

√ B. Annual Reporting [31 TAC 363.181 (b)]

√ C. Contracts with other Political Subdivisions [Texas Water Code]

Note: Check marks indicate completed sections located in Section 4.0 of this report.
Source: Texas Water Development Board

Table 4-1 (continued)

Texas Water Development Board Outline for Drought Contingency Plans

III. DROUGHT CONTINGENCY PLAN

A. Trigger Condition

√ 1. Mild Condition
√ 2. Moderate Condition
√ 3. Severe Condition
√ 4. Other

B. Drought Contingency Measures

√ 1. Mild Condition
√ 2. Moderate Condition
√ 3. Severe Condition
√ 4. Other

√ C. Information and Education

√ D. Initiation Procedures

√ E. Termination Notification Actions

√ F. Means of Implementation

IV. LEGAL AND REGULATORY COMPONENTS
[Draft documents need to be reviewed by the Board prior to local adoption. Final adopted resolutions and ordinances must be submitted to the Board before loan funds are released.]

A. Plan Adoption Resolution (Required)

B. Drought Contingency Ordinance/Regulation (Required)

C. Water Conservation Plumbing Code Ordinance/Regulation (Optional)

D. Plumbing Fixture Retrofit Ordinance/Regulation (Optional)

E. Conservation-Oriented Rate Ordinance/Regulation (Optional)

F. Water Conservation Landscape Ordinance/Regulation (Optional)

Note: Check marks indicate completed sections located in Section 4.0 of this report.
Source: Texas Water Development Board

Table 4-2
Water Supply System Populations and Water Uses a/

Water Supply System	Population Served	Number of Connections	Persons per Connection	Average Daily Use (mgd)	Average Daily per Capita Use (gcd)
City of Victoria	50,700	17,903	2.83	9.000	177.51
Victoria County WCID #1	1,800	625	2.88	0.206	114.44
Victoria County WCID #2	550	182	3.02	0.048	87.27
Quail Creek MUD	1,500	270	5.56	0.130	86.67
E.I. Dupont Company	1,400	25	56.00	0.034	24.00
Wagner Utility Company	465	143	3.25	0.044	94.62
Bloomington I.S.D. High School	400	6	66.67	0.010	24.00
Inez Elementary School	227	4	56.75	0.005	24.00
Mission Valley Elementary School	250	5	50.00	0.006	24.00
Coleto Water Company, Inc.	200	74	2.70	0.019	95.00
Devereux Foundation	122	12	10.17	0.015	120.00
Nursery Elementary School	120	3	40.00	0.003	24.00
Kincer's Inc.	100	1	100.00	0.002	18.00
Linden Hill Motel	69	23	3.00	N/A	N/A
Victoria Machine Works	60	2	30.00	0.001	24.00
Chubby's	50	1	50.00	0.001	18.00
Carnes Mobile Home Park	43	18	2.39	N/A	N/A
Coleto Creek Mobile Home Park	32	13	2.46	N/A	N/A
Arenosa Creek States	21	6	3.50	N/A	N/A
Spring Creek R.V. Park	18	9	2.00	N/A	N/A
River Ranch States b/	8	2	4.00	N/A	N/A
Lord's Land Trailer Park b/	30	7	4.29	N/A	N/A
Guadalupe Elementary School b/	143	1	143.00	N/A	N/A
Wood-Hi Elementary School b/	143	3	47.67	N/A	N/A
Total	58,451	19,338		10	
Average			3.02		162.93

a/ Source: Texas Department of Health Sanitary Survey System

b/ Declared inactive by TDH

facilities operated by the City of Victoria, and water wells and pumping facilities operated by the remaining purveyors located throughout Victoria County. In addition to production and treatment facilities, each purveyor operates and maintains independent water distribution systems to supply their customers. Continued growth projected for the service area will require expansion or development of new facilities to meet increased demands for water.

The overall objective of the study is to determine the availability and adequacy of surface and ground water supplies available to the City of Victoria and Victoria County (CV/VC) and to develop options for future supply acquisition and distribution infrastructure development. Given that additional treatment capacity will be needed, cost estimates will be determined for various alternative development scenarios. These include the phasing in of different sized treatment plants at a variety of locations. This section describes water conservation measures that could have an impact on projected water supply demands and phasing of projects (see Table 4-1).

4.1.2 Utility Evaluation Data

Texas Department of Health Sanitary Surveys were utilized to evaluate current levels of service within the planning study area. Sanitary surveys provide information regarding water treatment plant capacity, high service pumping capacity, storage capacity, and ability to meet minimum pressure requirements. Additionally, sanitary survey information may be used to establish historical average daily per capita water consumption for the utilities surveyed. However, not all water suppliers within Victoria County are reported by the TDH Sanitary Surveys or the TWDB well inventory.

Current Texas Department of Health Sanitary Surveys indicate that the County of Victoria encompasses an area of 894 square miles with 20 active water suppliers, serving a population of 58,127 persons through 19,325 connections. Table 4-2 contains a summary of the listed TDH water supply systems within the planning area. These sanitary surveys indicate that water supply systems obtain water from the Gulf Coast aquifer through a total of 47 water wells.

Sanitary surveys performed by personnel from the Texas Department of Health during 1990 found that all of the identified water supply systems meet or exceed State minimum requirements for total storage and high service pump capacity; four were found deficient in pressure storage capacity (Linden Hill Motel, Victoria Machine Works, Chubby's and Carnes Mobile Home Park), and one (Spring Creek R.V. Park) was found deficient in well pump capacity. Other utility information such as water uses, wastewater generation, water and wastewater rates, and other data is required by the TWDB Water Conservation Planning Outline (Table 4-3).

4.1.3 Need for and Goals of Program

The Texas Water Development Board has promulgated Financial Assistance Rules which require water conservation planning for any entity receiving financial assistance from the Board. The origin of these requirements is HB 2 and HJR 6, passed by the 65th Texas Legislature in 1985. The legislation is intended to encourage cost-effective regional water supply and wastewater treatment facility development. On November 5th, 1985 Texas voters approved an amendment to the Texas Constitution that provided for the implementation of HB 2. Previous to this study, the CV/VC have not developed a comprehensive plan for water conservation or drought contingency management of available supplies. This document provides specific guidelines for developing a water conservation and drought management program that will meet the regulatory requirements of the TWDB for the CV/VC planning area.

Since the early 1960s, per capita water use in the state has increased approximately four gallons per capita per day per decade. More importantly, per capita water use during

Table 4-3
UTILITY EVALUATION DATA

The following checklist provides a convenient method to insure that the most important items that are needed for the development of a conservation and drought contingency program are considered.

1. Utility Evaluation Data

A. Population of service area — 56,772 (Number)

B. Area of service area — 28.99 (Sq. mi.)

C. Number and type of equivalent 5/8" Meter connections in service area — 15,895 (Residential)

(3/4 " Only) — 1,289 (Commercial)

0 (Industrail)

D. Net rate of new connection additions per year (new connectins less disconnects) — 409 (Residential)

187 (Commercial)

9 (Industrail)

E. Water Use information:

1) Water production for the last year — 2,901,307,000 (gal./yr.)

2) Average water production for last 2 years — 3,062,947,500 (gal./yr.)

3) Average monthly water production for last 2 years — 127,622,810 (gal./mo.)

4) Estimated monthly water sales by user category (1000 gal.) Use latest typical year:

Month	Year	Residential	Commercial-Institutional	Industrial	Total
January	249,514	183,984	63,438	2,092	249,514
February	160,467	118,063	41,267	1,137	160,467
March	194,329	142,031	51,074	1,224	194,329
April	180,978	136,658	43,256	1,064	180,978
May	223,105	165,553	56,227	1,325	223,105
June	237,664	186,160	50,279	1,225	237,664
July	339,228	270,234	67,530	1,464	339,228
August	275,773	209,392	64,517	1,864	275,773
September	266,564	204,726	60,656	1,182	266,564
October	2,462,623	182,040	62,694	1,889	2,462,623
November	221,420	163,350	58,205	1,865	221,420
December	187,010	136,004	48,248	2,758	187,010
Total	2,782,675	2,098,195	665,391	19,089	2,782,675

5) Average daily water use (Res./Comm./Ind.) 7,948,786 (gpd)

6) Peak daily use (Res./Comm./Ind.) 17,698,000 (gpd)

7) Peak to average use ratio (average daily Summer sue divided by annual average daily use) 1.17

8) Unaccounted for water (% of water production) 6 (%)

F. Wastewater Information

1) Percent of your potable water customers sewered by your wastewater treatment system 86 (%)

2) Percent of potable water customers who have septic tanks or other privately operated sewage disposal systems 14 (%)

3) Percent of potable water customers sewered by another wastewater utility 0 (%)

4) Percent of total potable water sales to the three categories in F (1), F (2), F(3).

a) Percent of total sales to customers you serve 94 (%)

b) Percent of total sales to customers who are on septic tanks or private disposal systems 6 (%)

c) Percent of total sales to customers who are on other wastewater treatment systems 0 (%)

5) Average daily volume of wastewater treated 5,550,000 (gal.)

6) Peak daily wastewater volumes 9,863,000 (gal.)

7) Estimated percent of wastewater flows to your treatment plant that originate from the following categories:

Residential	40	(%)
Industrial and Manufacturing	40	(%)
Commercial/Institutional	15	(%)
Storm Water (I/I)	5	(%)
Other - Explain		(%)

G. Safe annual yield of water supply * 13,348,821 (gal.) X 1000 (* Developed by TWDB)

H. Peak daily design capacity of water system 24,000 (gal.) X 1000

I. Major high-volume customers: (List)

	Quantity (cal/yr):
Citizens Medical Center	54,524,000
Detar Hospital	38,448,000
Victoria College	15,090,000
Victoria Regional Airport	12,457,000

J. Population and water use or wastewater volume projections

Year	Population Potential	Daily Average MGD	Daily Maximum MGD
1990	57,733	9,359,785	18,397,000
1995	63,145	10,151,435	20,000,000
2000	68,558	10,943,090	22,000,000

K. Percent of water supply connection in system metered

100 (%) (Residential)

100 (%) (Commercial)

100 (%) (Industrial)

L. Water rate structure / Existing rate structure

Residential & Commercial	Residential & Commercial (Outside the City)	Industrial
	See Appendix B	

M. Average annual revenues from water and wastewater rates:

Water 3,802,000 (Dollars)

Wastewater 3,805,000 (Dollars)

N. Average annual revenue from non-rate derived sources:

865,700 (Dollars)

O. Average annual fixed costs of operation:

5,281,167 (Dollars)

P. Average annual variable costs of operation:

2,176,985 (Dollars)

Q. Average annual water or wastewater revenues for other purposes (if applicable):

0 (Dollars)

R. Applicable local regulations:

* See Appendix B for water and wastewater ordinances

S. Applicable State, Federal or other regulations as a Public Water Supply, the City of Victoria must abide by the rules of the following agencies:

1) Texas Water Commission
2) Texas Department of Health
3) Environmental Protection Agency

droughts is typically about one third greater than during periods of average precipitation. Thus, the goals of the program are to reduce overall water usage through water conservation practices and to provide for a reduction in water usage during times of shortage.

Water use in the residential and commercial sectors involves day-to-day activities of all citizens of the state, and includes drinking, bathing, cooking, toilet flushing, fire protection, lawn watering, swimming pools, laundry, dishwashing, car washing and sanitation. In addition, rural areas carry the additional demands of supporting small-scale private livestock production and the, often not-so-small, family garden. The objective of a conservation program is to reduce the quantity of water required for each of these activities through implementation of efficient water use practices. The drought contingency program provides procedures for both voluntary and mandatory actions placed in effect to temporarily reduce usage demand during a water shortage crisis. Drought contingency procedures include water conservation and prohibition of certain uses. Both are tools that CV/VC managers and officials will have available to them in order to operate effectively under a variety of demands.

The water conservation plan outlined below will have the overall objective of reducing water consumption in the CV/VC service area. It will have the added advantage of reducing the amount of wastewater needing treatment and disposal. Although the impetus for this study is regional planning for water supply needs, the study focuses on measures that specifically reduce the amount of water used and, ultimately, on the amount of wastewater produced. Such measures will have the effect of extending the time until additional water and wastewater treatment capacity must be provided.

Various cities throughout the country have adopted water conservation techniques and technologies depending upon the severity of their water supply situation. In particular, California has taken significant steps to reduce water consumption, and here in Texas, the

City of Austin has adopted an aggressive water conservation program. Drawing on the experiences of some of these cities, we can make some assumptions about the feasibility, cost, and effectiveness of specific measures. For the purpose of reducing the quantities of water required, two of the measures outlined below deserve particular attention: adopting vigorous plumbing codes for new construction; and, retrofitting.

According to Texas Water Development Board high population series figures, the population of the CV/VC Planning Area is expected to increase 81 percent over the period 1990 to 2040. Under drought conditions, when consumption is typically at its highest, and without implementation of water conservation measures, an 81 percent increase in the population would increase demand from approximately 95,000 ac-ft/yr to over 166,000 ac-ft/yr. With such high rates of growth, it is evident that the greatest savings in water usage can be realized by adopting stringent plumbing codes for new construction. Throughout the nation, utilities are finding that revised plumbing codes which reduce new water usage by 25-30 percent can have a significant impact on reducing the high cost of renovating and constructing water and wastewater treatment facilities. However, because water use in rural areas is less weighted toward domestic functions, lesser reductions, on the order of 10-15 percent, can be expected.

Existing plumbing facilities can also be retrofitted in order to reduce water consumption. Although this may involve an initial capital outlay, all of the measures are cost-effective in the long-term, and various methods have been devised to recover the costs. For instance, a plan for San Antonio assumes that a two percent increase in water and wastewater rates for 5 years would raise enough money to cover a $100 rebate for each customer retrofitting a toilet to flush on 1.5 gallons (resulting in an overall savings on the customer's water and wastewater bill). An aggressive retrofit program can result in water savings of 15-25 percent per residence. With market penetration typically running at 20-50 percent, this would result in an overall water consumption savings of around 5 percent. In its water conservation program, the City of Austin estimates a 6.7 percent savings within 5 years. This program consists of substituting low-flow shower heads, installing toilet dams, and checking for leaks. The benefit/cost ratio is estimated at more than ten, with an average savings to the customer of $52/year from reductions in water, wastewater, and electricity.

In Figure 4-1, drought condition water demands through the year 2040 for the entire CV/VC service area are shown without implementation of water conservation measures. Also shown are the flows that would result from the adoption of the two measures outlined above. Overall savings by 2040 are approximately two percent or 3,500 ac-ft/yr. The assumptions made are:

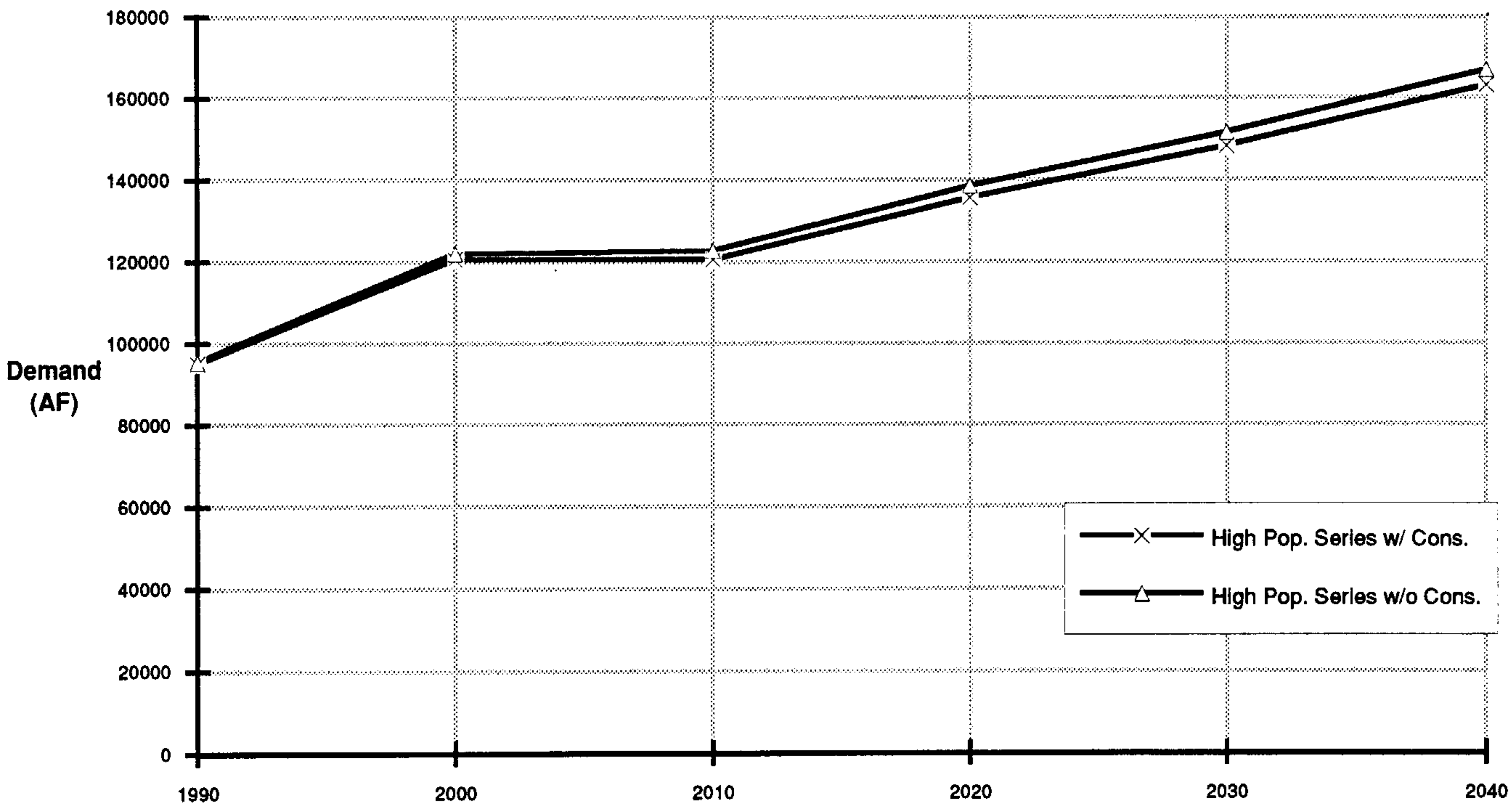
- Adoption of a code that would reduce water consumption in all new construction from the current average of 163 gpcd;

- This code would be phased in during the 1990s and early 2000s (a net water savings of 2% by 1995; 5% by 2000; 7½% by 2005; 10% by 2010 12½% by 2015 and 15% by 2020);

- Existing uses could be reduced by 5 percent through retrofitting and other conservation measures.

These savings in water demand can be related directly to savings in water supply procurement, treatment and distribution costs, as well as, wastewater disposal costs. By reducing average daily demand and peak 2-hour demands by as much as three percent, water treatment and distribution system requirements will be commensurably reduced by three percent. New water treatment facilities cost roughly $1,000,000/per million gallons of capacity. Therefore, a water savings of 3,500 ac-ft/yr (3.13 MGD) will result in an unamortized savings of at least $3,100,000, plus, reduced raw water and operation and maintenance. Operation and maintenance costs for the water system infrastructure will

Figure 4-1
Total Projected City and County of Victoria Demand
High Per Capita Use



Source: Texas Water Development Board

be reduced because of lower chemical requirements, reduced pumping requirements, and appropriate pump station and line sizing. Design of urban water treatment and distribution systems are influenced more by fire protection requirements than average daily per capita water usage. Rural fire protection demands are less stringent; the Fire Protection Bureau requires a basic flow rate of 500 gpm. Thus, the impacts of water conservation are not diminished by fire protection requirements.

The drought contingency program (to be filed under a separate cover) includes those measures that can cause the CV/VC to significantly reduce water use on a temporary basis. These measures involve voluntary reductions, restrictions, and/or elimination of certain types of water use and water rationing. Because the onset of an emergency condition is often rapid, it is important that the CV/VC be prepared in advance. Further, the citizen or customer must know that certain measures not used in the water conservation program may be necessary if a drought or other emergency condition occurs.

4.2 LONG-TERM WATER CONSERVATION

4.2.1 Plan Elements

Nine principal water conservation methods are delineated as part of the proposed water conservation plan.

Education and Information

The CV/VC will promote water conservation by informing water users about ways to save water inside of homes and other buildings, in landscaping and lawn maintenance, and in recreational uses. Information will be distributed to water users as follows:

- The initial year will include the distribution of educational materials outlined in the Maintenance Program section.

- Distribution of a fact sheet explaining the newly-adopted Water Conservation Program and the elements of the Drought Contingency Plan. The initial fact sheet will be included with the first distribution of educational material.

- In addition to activities scheduled in the Maintenance Program, an outline of the program and its benefits will be distributed either through the mail or as a door-to-door hand-out.

Maintenance Program:

- Distribution of educational materials will be made semi-annually, timed to correspond with peak summer demand periods. Such material will incorporate information available from the American Water Works Association (AWWA), Texas Water Development Board (TWDB) and other similar associations in order to expand the scope of this project. A wide range of materials may be obtained from:

  Texas Water Development Board
  P.O. Box 13231, Capitol Station
  Austin, Texas 78711-3231

- New customers will be provided with a similar package of information as that developed for the initial year, namely, educational material, a fact sheet explaining both the Water Conservation Program and the elements of the Drought Contingency Plan, and a copy of "Water Saving Methods That Can Be Practiced by the Individual Water User."

Plumbing Codes

The CV/VC study area generally adheres to and enforces the 1982 Southern Building Code's Standard Plumbing Code. These Codes have been in effect for several years and are expected to be upgraded to the 1991 Southern Building Code's Standard Plumbing Code by the end of 1991. The most significant components under consideration are:

- Showers shall be equipped with approved flow control devices to limit total flow to a maximum of 2.75 gallons per minute (gpm) at 80 psi of pressure;
- Sink faucets shall deliver water at a rate not to exceed 2.2 gpm at 60 psi of pressure;
- Toilets shall use a maximum of 1.6 gallons per flush; and
- Urinals shall use a maximum of 1.0 gallons per flush.

Retrofit Program

The CV/VC will make available, through its education and information programs, pertinent information for the purchase and installation of plumbing fixtures, lawn watering equipment and appliances. The advertising program will inform existing users of the advantages of installing water saving devices.

Table 4-4

Expected Savings to the CV/VC Service Area Through Implementation of a Water Use Retrofit Program

Action	Cost Per House [a]	Savings Per House [b/]	Penetration [c/]	Total Savings [d/]	Total Cost [e/]	Cost Per gpd [f/]
Distribution of Water Savings Kits [g/]	$1.00	18.4 gpd	50%	429,419 gpd	$23,338	$0.054
Vouchers for Shower Heads and Toilet Dams [h/]	$8.00	38.2 gpd	20%	356,605 gpd	$74,682	$0.210
Installation of Shower Heads and Toilet Dams [i/]	$20.00	33.9 gpd	50%	791,158 gpd	$466,760	$0.59
Refund for Replacing Toilets [j/]	$400.00	45.7 gpd	10%	213,309 gpd	$1,867,040	$4.376

a/ Assumes two bathrooms per single-family residence.

b/ Based on 160 gpcd and 3.0 persons per residence.

c/ Percentage of residences participating fully in the program.

d/ Based on 2040 projections of 46,676 residences in CV/VC Service Area.

e/ Total Program implementation cost.

f/ Cost per gpd saved.

g/ Assumes free distribution to all services area residences @ two kits per residence.

h/ Assumes participant retrieval of kits @ two kits per residence.

i/ Assumes installation by CV/VC personnel or private contractors.

j/ Assumes $200 per toilet.

The CV/VC will contact local plumbing and hardware stores and encourage them to stock water conserving fixtures, including retrofit devices.In addition, the CV/VC will embark upon an aggressive retrofit program. Several alternatives are summarized in Table 4-4. Market penetration is based on the experience of other cities offering such programs. Savings are calculated based on TWDB's high series population projections for the year 2040 (140,029 persons) and an assumed household size of 3.0 persons per household (46,676 residences).

The least-cost alternative is to deliver two packages/house containing two flow restrictors, a plastic restrictor for a shower head, a toilet bag and two dye tablets. Based on past experience, the toilet bags are the most acceptable to customers and could be expected to realize savings of 4.8 gpcd in participating households. A more acceptable and more permanent option is to provide customers with low-flow shower heads and toilet dams. Because of the greater costs associated with providing these items, vouchers would be included in the water bill to be exchanged at convenient locations for each water supply system. It is assumed that most of the equipment claimed through this mechanism would be installed. Another more fool-proof system, used extensively in the City of Austin, involves the installation of low-flow shower heads and toilet dams at no charge to the customer. In Austin, market penetration has exceeded 50 percent and in participating households has resulted in water savings of around 15 percent. A fourth option is to provide rebates of $100 to customers who replace their toilets with those that flush 1.5 gallons (see Table 4-4).

Water Rate Structure

The structure of rates is as important as the rate itself in sending appropriate signals to consumers. There are approximately 20 different types of rate structures used throughout the nation, some of which can be used in combination. Some rate structures encourage conservation; others discourage it.

Water systems which do not use water meters generally utilize fixed charge. This rate structure establishes rates which are the same for all users categories or are based on building types, sizes, values, frontages, or other measure. Rates may be collected as a separate bill, or may be merely included in property taxes. Fixed charges do not promote water conservation or economic efficiency, and they result in small users subsidizing large users. Only six (6) water supply corporations (City of Victoria, Victoria County WCID #1, Victoria County WCID #2, Quail Creek MUD Wagner Utility Co. and Coleto Water Co.) utilize customer metering.

Another typical rate structure is the declining block rate. With this structure, unit charges decrease as usage increases. Justification of declining block rates is based on economies of scale — as water use increases, it may cost less per unit to provide the water. However, perceived economies of scale may be fallacious for large users if their water demand results in a need for expanded supply or facilities. Declining block rates enhance revenue stability since the more variable components of demand are located in the tail blocks. The declining block structure, however, often results in prices which exceed cost of service in the initial blocks and which are less than the cost of service in the tail blocks. Declining block rates encourage wasteful water use and result in small users subsidizing large users.

A uniform commodity rate structure charges the same unit rate for all units consumed. Water bills go up and down proportionately with water use. The rate design provides some incentive to conserve average water use and is simple and equitable. This is the rate structure currently used by water supply systems.

There are two major forms of peak load pricing: seasonal pricing and peak demand pricing. Peak load pricing is used to reduce summer or peak demand. This structure is useful if there is a high peak or summer seasonal demand and if capacity investment or resource adequacy is determined by the peak demand. Peak load pricing helps to reduce the most "elastic" demands, such as watering outdoor plants. Peak load pricing helps to reduce demand during critical water supply periods.

Seasonal rates are set higher during the summer. They serve as an annual reminder to customers that rates will increase every year before the water-short season. They also make it less likely that a customer will become accustomed to a permanently higher rate.

Peak demand pricing, sometimes called excess use pricing, is the charging of a significantly higher price for all water used above an average use. The average use may be an average for an entire user sector, or may be based on an individual user's average winter use.

Peak demand pricing may be structured differently for different user sectors in order to maintain equity.

Peak load pricing depends on frequent meter reading and prompt billing. Customers may not perceive the indirect message to conserve in their outdoor use if their summer water bill arrives in December. New remote meter reading technologies can be particularly useful if using peak load pricing.

Inverted block rates are designed so that as consumption increases, unit prices increase. This structure usually reduces average as well as peak demand, with residential use reductions of up to 10 percent. This structure sends consumers price signals to decrease incremental demands. It is particularly useful for utilities that expect a system expansion to drive up unit costs. There is a potential problem with cross-sectional equity, however, especially if large water users do not influence demand peaks. There are also concerns about large users potentially subsidizing small users. A utility contemplating inverted block rates might wish to set different block structures or different minimum fees for different water-using sectors.

Mixed or combined rate structures are frequently used. The most common mixed rate structure combines a flat or minimum charge with some sort of block rate structure. This type of rate structure is justified on grounds that a portion of the cost of service is fixed; once the capital structures are in place, the supplier has a fixed expense regardless of water consumption. The block rate portion would be set to cover the more variable cost components. Incentive to conserve with this mix of rate structures depends on how much of typical water demand is reflected in the variable portion of the water bill and what type of variable structure is used. When all or most of consumption lies within the minimum charge block, the rate essentially becomes a flat rate, with no incentive to conserve.

Another common mixed rate structure combines some form of peak demand rate with the regular rate structure. This can be done as a seasonal rate or as an excess consumption surcharge.

Other rate structures may apply to specific conditions:

- Lifeline pricing is sometimes used to maintain low rates for low-income residents or very low-volume water users to maintain affordable water for those least able to pay higher costs.

- Scarcity pricing is a form of an increasing block rate which adds the price for a depleting supply to the existing price. This may be effective if increased demand endangers a sole source of water supply or requires potential construction of an expensive additional supply.

- Sliding scale pricing is a modified form of increasing block rates in which, rather than charging higher rates for discrete blocks of use, the unit price for all water consumed increases with consumption.

- In developing areas, a spatial pricing system might be used to recoup the cost of expanding the system to serve a remote location or the higher expense of serving higher elevations.

- Hook-up fees or added service charges are other ways to recoup the cost of additional services.

As supply expansion becomes more and more expensive, interest is growing about an economic concept known as "marginal cost pricing." The marginal price equals either the reduction in the total water bill resulting from saving one unit of water, or the increase in the total bill resulting from the last unit of water consumed. The marginal cost of supply equals the cost of providing the last unit of water. Average water rates are determined by the total costs of supplying all system users. Generally, the marginal water rate will not equal the marginal cost of supply.

To the supplier, the least expensive available water supply is the first used, and the actual cost of providing the last unit of supply may exceed the average cost. Because the actual cost of supplying the last unit is likely to be greater than the rate charged for that unit, economic signals lead to over-consumption. To the consumer, however, the most valuable units consumed are the first ones, and the last units consumed are the least valuable. Therefore, if the prices for the last units increase with the cost of supply, consumption will decrease.

Use of marginal cost pricing is particularly useful for water systems near demand capacity. The cost of expanding the system or the supply to meet additional demand should be reflected in the price as capacity is approached. Where expansion is actually needed, marginal cost pricing would result in a smaller capacity expansion than if average pricing is used.

For a system with excess capacity, the marginal cost of supply may actually be lower than the average cost due to economies of scale. The use of marginal cost pricing, then, will vary depending on how close system demand is to capacity. The varied nature of marginal cost pricing may make it impractical as an exact pricing method. However, the actual cost of various units of supply should be considered as a part of rate-setting decisions, especially where demand approaches capacity.

Prices should be set to reflect the actual cost of service, including all costs associated with property, hardware, operations, maintenance and personnel. These costs should include depreciation of capital assets and needed planning expenses. Prices should not be hidden in property taxes, as this eliminates direct incentive for conservation.

There is little consensus regarding what pricing structures are most effective in encouraging conservation, however the following are known about consumer behavior. If a new pricing structure results in an unchanged total bill, there will be no response by the users. When prices do go up, response is delayed until bills are received. The initial response to higher rates may exceed the long term response if the perceived price impact is greater than the ultimate reality. If prices are too low in the first place, a price increase may have little impact on demand.

Equity among water use segments is an issue to consider when weighing pricing alternatives. Careful analysis should be made of the allocation of the total cost of supplying water to a community. Public participation in rate changing decisions is necessary to achieve political acceptability of the resulting rate.

A final point about rate hikes and revenues: Higher rates will result in increased net revenues, because elasticities are generally between zero and -1, and percent water use reductions will be less than percent price increases.

CV/VC members are currently studying the myriad of conservation encouraging rate structure and will select a system that will most effectively serve the particular needs of their regional system.

Universal Metering

All water users, including utility and public facilities in the City of Victoria are currently metered. All new construction, including multi-family dwellings, is separately metered. The program of universal metering will continue, and is made part of the Water Conservation Plan.

The CV/VC suppliers, through their billing system, currently monitors water consumption and inspects meters that vary from previously established norms. In addition, the CV/VC will establish the following meter maintenance and replacement programs:

Meter Type	Test and Replacement Period
Master meter	Biannual
Larger than 1 inch	Every 3 years
1-inch and less	Every 7 years

The City currently meters 94 percent of its water pumped. Through a successful meter maintenance program, coupled with computerized billing and leak detection programs, the CV/VC will be able to maintain water delivery rates, from production to consumer, in the 85 percentile range.

Water Conservation Landscaping

In order to reduce the demands placed on the water system by landscape, livestock and garden watering, the CV/VC, through its information and education program, will encourage customers and local landscaping companies to utilize water saving practices during installation of landscaping, gardens and stock watering facilities for residential and commercial institutions. The following methods will be promoted by the education and information program:

- Encourage subdivisions to require drought-resistant grasses and plants that require less water.

- Initiate a program to encourage the adoption of xeriscaping.

- Encourage landscape architects to use drought-resistant plants and grasses; and efficient irrigation systems.

- Encourage licensed irrigation contractors to use drip irrigation systems, when possible, and to design all irrigation systems with conservation features such as sprinklers that emit large drops rather than a fine mist and a sprinkler layout that accommodates prevailing wind patterns.

- Encourage commercial establishments to use drip irrigation for landscape watering, when practical, and to install only ornamental fountains that use minimal quantities of water, including recycling features.

- Encourage local nurseries to offer adapted, drought-resistant plants and grasses and efficient watering devices.

Leak Detection and Repair

The CV/VC water supply systems will utilize modern leak detection techniques, including listening devices, in locating and reducing leaks. Through their billing program, CV/VC will identify excessive usage and take steps to determine whether it is a result of leakage. Once located, all leaks will be immediately repaired. A continuous leak detection and repair program is vital to profitability. The CV/VC is confident that the program will more than pay for itself.

Recycle and Reuse

The GBRA currently operates a conventional wastewater treatment facility for the City of Victoria. GBRA uses groundwater from an on-site well for washdown at this facility. The CV/VC will encourage all wastewater plants to use treated effluent as washdown water. Many other CV/VC customers utilize some sort of on-site wastewater treatment and disposal method. The CV/VC will make available to its customers, information about on-site reuse of non-sewage wastewater.

There are currently no water treatment plants in Victoria County, but future water treatment plant designs will include an evaluation of returning filter backwash to the head of the plant.

4.2.2 Implementation/Enforcement

The staff of the different water entities will administer the Water Conservation Program. They will oversee the execution and implementation of all elements of the program and supervise the keeping of adequate records for program verification.The plan will be enforced through the adoption of the Water Conservation Plan by the CV/VC member in the following manner:

- Water service taps will not be provided to customers unless they have met the plan requirements; and

- The building inspector will not certify new construction that fails to meet plan requirements.

The CV/VC will adopt the final approved plan through resolution or ordinance, and commit to maintain and enforce the program for the duration of the CV/VC's financial obligation to the State of Texas.

Contracts with Other Political Subdivisions

The CV/VC will, as part of a contract for sale of water to any other political subdivision, require that entity to adopt applicable provisions of the CV/VC's water conservation and drought contingency plan or already have a plan in effect. These provisions will be through contractual agreement prior to the sale of water to the political subdivision.

The staff of the different water entities will administer the Water Conservation Program. They will oversee the execution and implementation of all elements of the program and supervise the keeping of adequate records for program verification.

The plan will be enforced through the adoption of the Water Conservation Plan by the CV/VC member in the following manner:

- Water service taps will not be provided to customers unless they have met the plan requirements;

- The proposed block rate structure should encourage retrofitting of old plumbing fixtures that use large quantities of water; and

- The building inspector will not certify new construction that fails to meet plan requirements.

The CV/VC will adopt the final approved plan and commit to maintain the program for the duration of the CV/VC's financial obligation to the State of Texas.

Contracts with Other Political Subdivisions

The CV/VC will, as part of a contract for sale of water to any other political subdivision, require that entity to adopt applicable provisions of the CV/VC's water conservation and drought contingency plan or already have a plan in effect. These provisions will be through contractual agreement prior to the sale of water to the political subdivision.

4.3 DROUGHT CONTINGENCY PLAN

4.3.1 Introduction

Drought and other uncontrollable circumstances can disturb the normal availability of a community or utility water supply. Victoria County is fortunate to have access to surface water and groundwater. The CV/VC will be able to conjunctively use ground and surface water. Selective wells will be maintained and will be used to augment or replace surface supplies during drought periods.

A triggering criteria during a drought period has been established predicated on the flow of water from the Guadalupe River. Section 4.3.2 outlines a three-step curtailment plan which will be enacted depending on the river flow and the water level of the aquifers.

4.3.2 Trigger Conditions

Mild Drought - When the flow of the Guadalupe River falls below 478 cfs (#08176500) at Victoria.

Moderate Drought - When the flow of the Guadalupe River falls below 466 cfs.

Severe Drought - When water cannot be pumped from the Guadalupe River.

4.3.3 Drought Contingency Plan

Mild Drought Measures:

- Inform public by giving notice of mild drought to customers.
- Voluntary curtailment of water use will be encouraged.
- City of Victoria staff will contact all major users and request their cooperation in curtailing water use.

Moderate Drought Contingency Measures:

- Inform public by giving notice of moderate drought to customers; the notice will be posted as well as notifying the news media of the moderate drought.
- The City of Victoria will request cooperation in the curtailment of water use.

Severe Drought Contingency Measures:

- Public will be informed as mentioned above.

- There will be mandatory water curtailment issued to all CV/VC water users as described below.

- All utilities will be requested to implement mandatory water curtailment.

4.3.4 Severe Conditions Curtailment Program

- Continue all relevant actions defined in the preceding phase.

- Request that outdoor watering be reduced by implementing an odd/even house address outdoor watering schedule. If drought conditions persist and the odd/even outdoor watering schedule results in continued well level declines, then ban all outdoor water use.

- Develop and provide suggested limits on water use by both commercial and residential users.

4.3.5 Information/Education

As a component of the Information/Education section in the Water Conservation Plan, the purpose and effect of the Drought Contingency Plan will be communicated to the public through articles in the local newspapers, radio and television media.

When trigger conditions appear to be approaching, the public will be notified through publication of articles in the local newspapers, radio and television media.

When trigger conditions have passed, the local newspapers, radio and television media will publish notification that the drought contingency measures are abated for that condition and, if applicable, will outline measures necessary for the reduction condition.

Throughout the period of a trigger condition, regular articles will appear to explain and educate the public on the purpose, cause and methods of conservation for that condition. Also, information will be provided daily to the local media to relate how much water was used the previous day.

4.3.6 Implementation/Enforcement

It will be the responsibility of the City of Victoria to monitor the status of the water levels in designated monitor wells and the flow in the main stem and tributaries of the Guadalupe River. When a trigger condition is reached, the City of Victoria will notify each entity to begin implementation of the Drought Contingency Plan.

The City of Victoria will continue to monitor the water emergency until it is determined that a trigger condition no longer exists and then advise all entities of the change in condition.

4.3.7 Update of Trigger Conditions

Annually, the City of Victoria will examine the production requirement and ability to maintain these requirements to determine the trigger condition's need to be re-established.

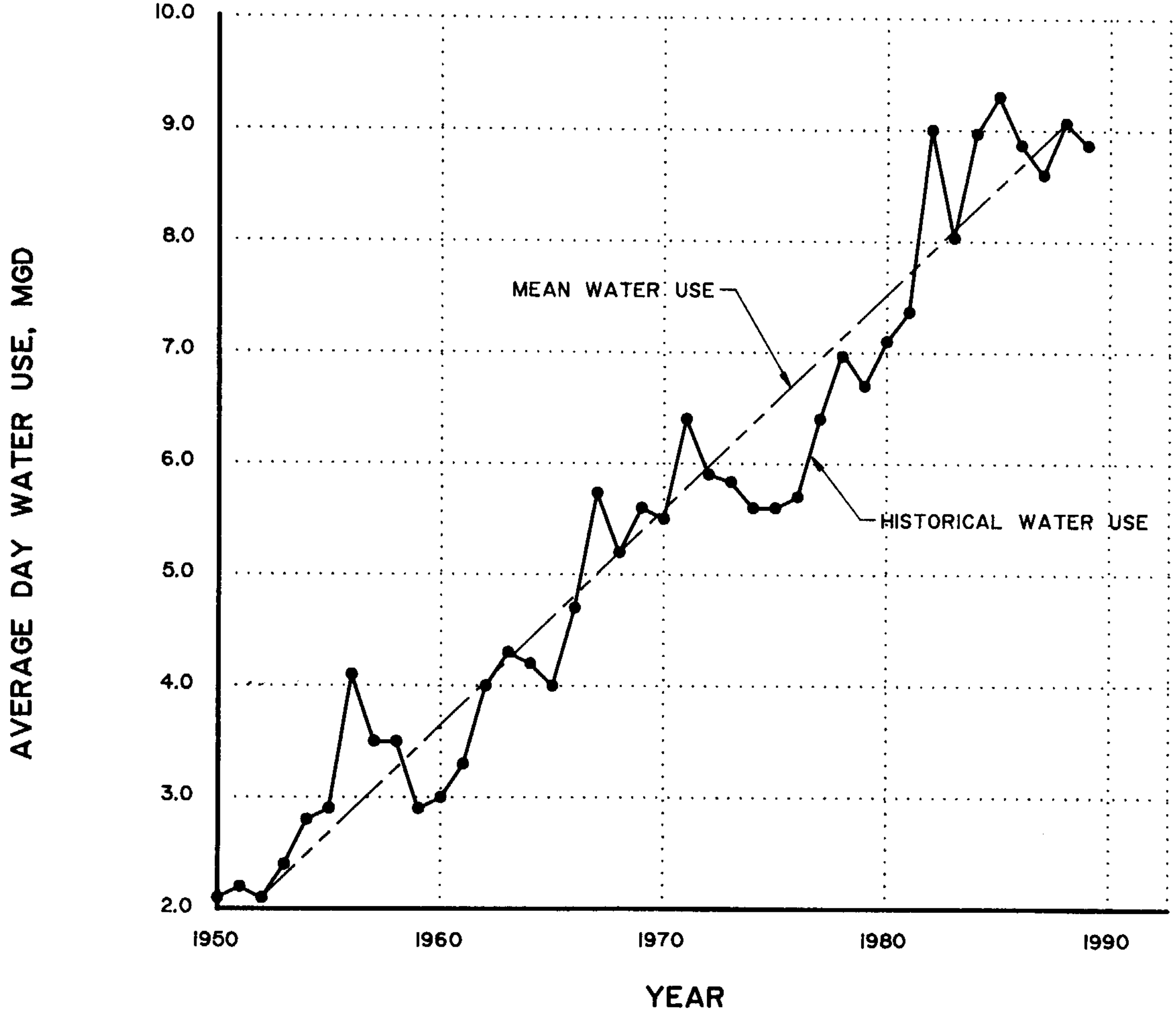
5.0 GROUNDWATER EVALUATION

5.1 INTRODUCTION

The City of Victoria and the majority of Victoria County derive their water supply from groundwater sources. Notable exceptions are steam electric facilities and manufacturing facilities that have water rights permits or water use contracts for water in the Guadalupe River. The amount of groundwater used in the county has grown consistently over the past 40 years spurred on by the growth in the City of Victoria. The City of Victoria water use has grown steadily from an average day use of 2 MGD (2,240 acre-feet/year) in 1950 to at or near 9 MGD (10,082 acre-feet/year) in 1990. See Figure 5-1 for a time plot of the City of Victoria's water use.

Placing the growing City and County water demands on the aquifer systems that underlie the County has resulted in lower potentiometric surfaces in the areas of greatest demand. Since the City of Victoria is the largest groundwater user in the County, the area of greatest groundwater decline is in the area of the City's well fields. A review of water level data for wells in the vicinity of the City of Victoria shows water level declines in the City of up to 60 feet in the 40 years from 1950 to 1990. Data for a well south of the City, near the Du Pont manufacturing facility, show water level decreases of 40 feet in the same period. Finally, data for a well north of the City of Victoria near the DeWitt County line has shown no loss in water level due to the increase in pumping.

The County's water demands are predicted to grow from 85 MGD (95,087 acre-feet/year) in 1990 to 146 MGD (163,262 acre-feet/year) in 2040. As the City and County water demands continue to increase over the next 50 years, the growing demand will continue to lower the potentiometric surfaces in the aquifers. As the water levels fall in the aquifer, several concerns arise. First, will there be enough water available to meet the



CITY OF VICTORIA
HISTORICAL WATER USE

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FIGURE 5-1

increase in the County's water demand? Second, groundwater may no longer be the most economical water supply source due to the increased number of wells and the increased pumping heads needed to produce water from the wells. Third, the potential for land surface subsidence will increase. Finally, the chance of groundwater pollution increases from saltwater intrusion, dewatering overlying formations, lower quality water in lower formations migrating upward and pollution from leaking underground storage tanks.

To be able to address these concerns requires that the response of the aquifers to increased pumping be estimated. There are various means of analyzing the ability of an aquifer to supply water. Some are qualitative and others quantitative. Since the widespread use of computers, the ability to predict an aquifer's response with mathematical models has become common. These models, when properly applied, can simulate an aquifer's response to a given demand and can be used to predict the potentiometric decline in the aquifer given future demands. To properly prepare these mathematical models, extensive data on the geology and hydrogeology of the aquifer are required.

In the following sections, the ability of the aquifer system to meet the existing and future water demands of the county are evaluated. First, the geology of the aquifer system is discussed as well as the hydrogeology and hydrologic conditions that allow water to be recharged to and drawn from the aquifers. The existing and future water demands are discussed. The historical water levels of the aquifer system are evaluated and a conceptual and digital model for predicting the ability of the aquifer system to meet future demands are developed. Also, the existing water quality aspects of the aquifer and the impact lower groundwater levels will have on future water quality are addressed. Finally, the subsidence due to lowering the groundwater levels is predicted.

5.2 REGIONAL SETTING

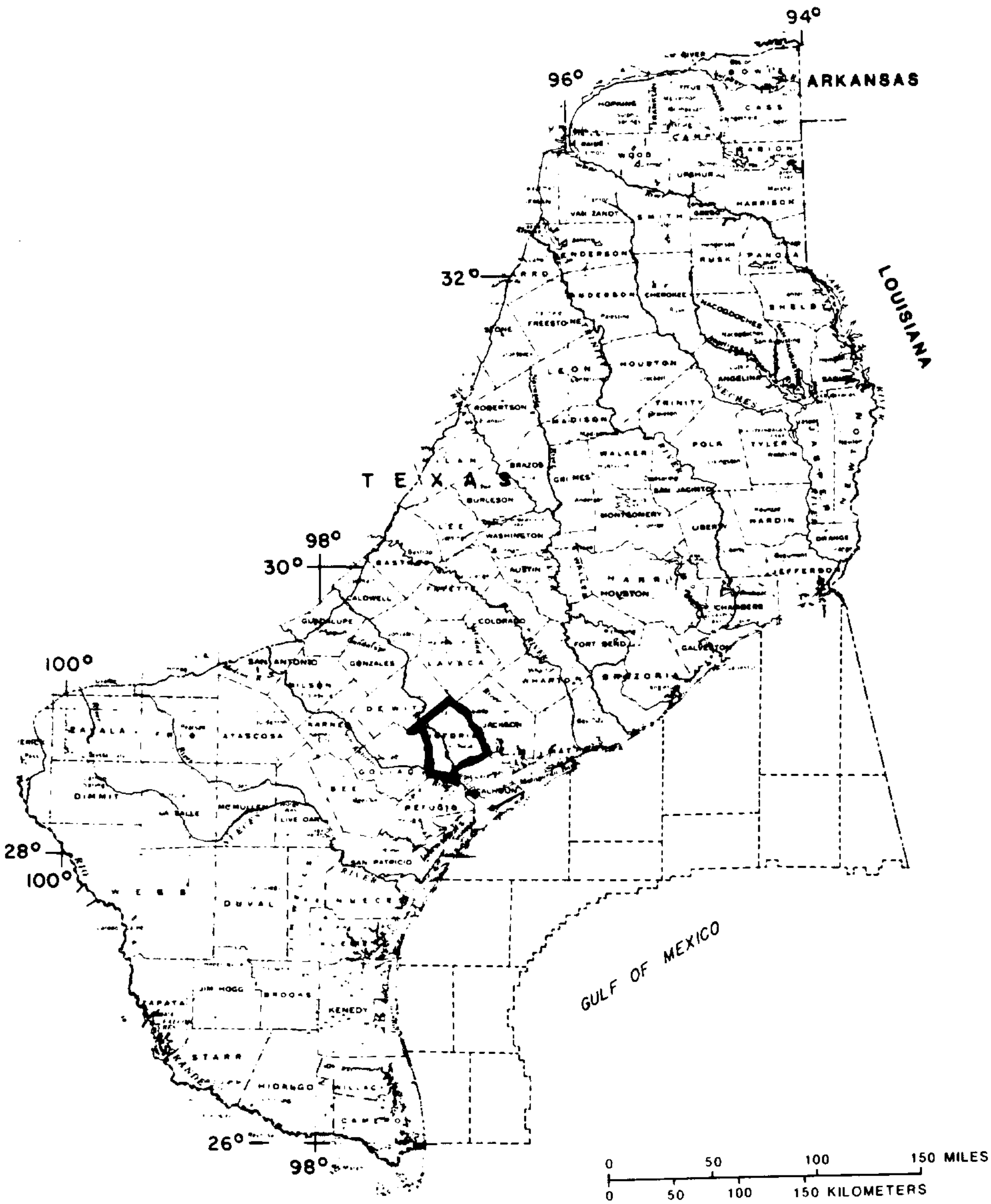
5.2.1 Physiography

Victoria County is located in the southeastern part of Texas and is surrounded by six other Texas counties which include DeWitt and Lavaca counties to the north, Jackson and Calhoun counties to the southeast, and Goliad and Refugio counties to the west and southwest. A small part of the southeastern corner of the county extends to Lavaca Bay at the Gulf of Mexico (see Figure 5-2). The County has an area of about 894 square miles, or 572,160 acres, of which 2,330 acres (0.4 percent) are surface waters. Elevations range from above 200 feet, National Geodetic Vertical Datum of 1929 (ft, NGVD, formerly called mean sea level) in the northern parts of the study area to zero feet, NGVD, at the southeastern corner of the county.

Most of the county is nearly level to gently sloping plain that is dissected by a few well-defined streams and rivers. The northwestern part of the county is mainly gently sloping and is dissected by many well-defined drainageways (Miller, 1982). Land use in Victoria county consists mainly of cattle ranching and farming. In 1967, about 68 percent of the County was rangeland, 21 percent was cropland, 4 percent was pasture and hayland, and 4 percent was urban and built-up areas and water areas. The rest was idle land (Miller, 1982).

5.2.2 Climate

The climate of Victoria County is classified as humid subtropical. Winters are mild, characterized by polar canadian air masses that move southward across the state and out over the Gulf of Mexico producing cool, cloudy, and rainy weather. Precipitation is most often in the form of slow, gentle rains. Spring weather is variable, though moderate overall. March is relatively dry, but thunderstorms or other weather disturbances may



LOCATION OF VICTORIA AND SURROUNDING COUNTIES (SOURCE: RYDER, 1988)

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FIGURE 5-2

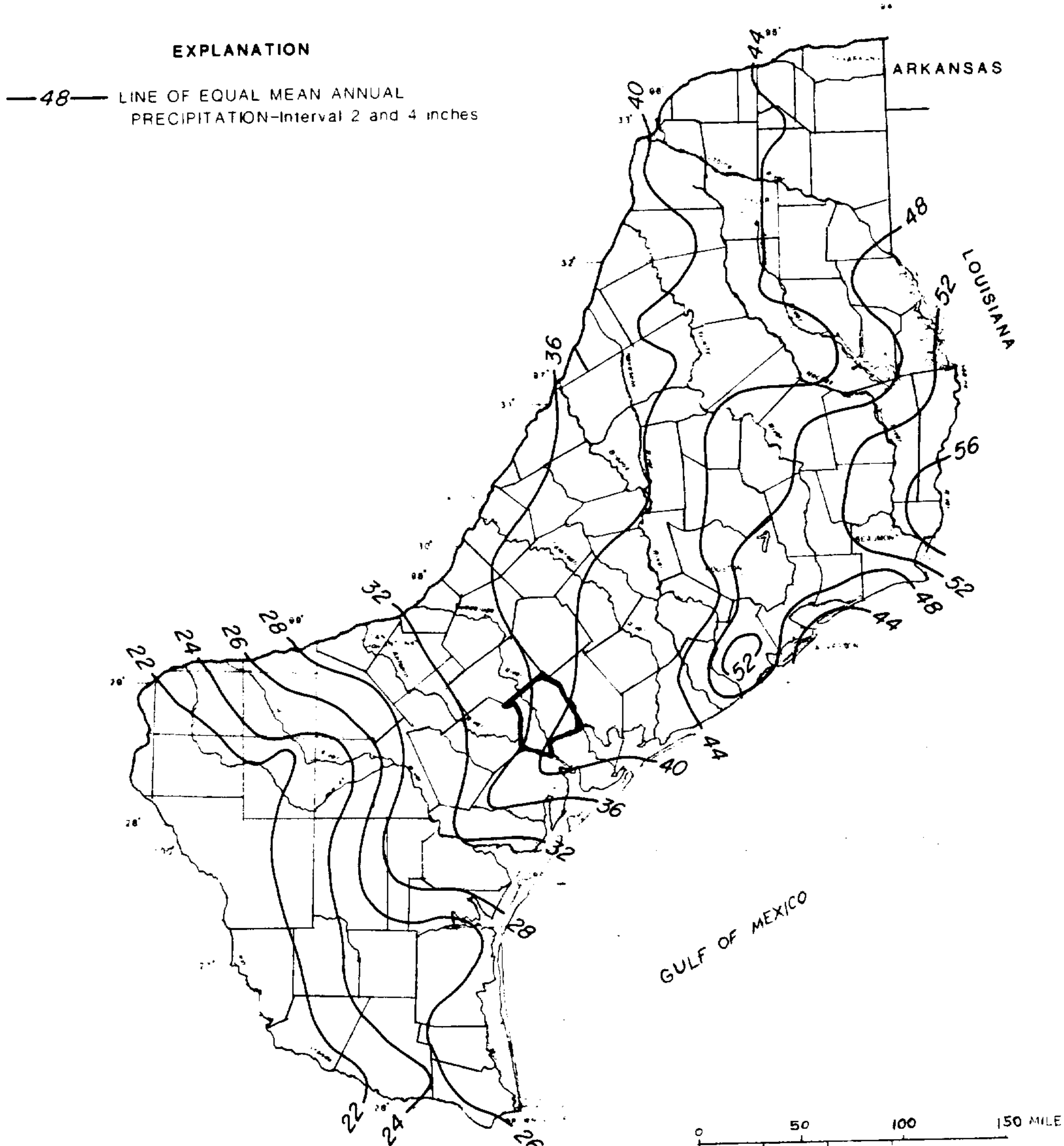
quickly dump excessive amounts of precipitation on the area resulting in large amounts of runoff. Fall is a moderate season with rainfall increasing, but frequently there are periods of mild, dry sunny weather. Heavy rains may occur early in fall in association with disturbances which move westward from the Gulf of Mexico. Tropical storms are a threat to the area in summer and fall, but severe storms are rare. In winter, the average temperature is 55°F and the average daily minimum temperature is 44°F. The lowest temperature on record is 16°F. In summer the average temperature is 83°F and the average daily maximum temperature is 92°F. The highest recorded temperature is 107°F.

Precipitation

The average annual precipitation is 38 inches (see Figure 5-3). Of this, 25 inches, or 65 percent, usually falls in April through September, which includes the growing season for most crops. In 2 years out of 10, the rainfall in April through September has been less than 20 inches. The heaviest one-day rainfall during the period of record was 8.3 inches at the City of Victoria. Thunderstorms occur about 50 days each year, and most occur in summer.

Average seasonal snowfall is less than one inch. The greatest snow depth at any one time during the period of record was one inch.

Prevailing winds are from the south-southeast, with average windspeed as high as 12 miles per hour during the spring season. The average relative humidity in mid-afternoon is approximately 60 percent. Humidity is higher at night and the average at dawn is about 90 percent.



MEAN ANNUAL PRECIPITATION IN THE TEXAS GULF COSTAL AREA. BASED ON NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION RECORDS FOR THE PERIOD 1951-80. (MODIFIED FROM TEXAS DEPARTMENT OF WATER RESOURCES, 1984, FIG. 5)

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FIGURE 5-3

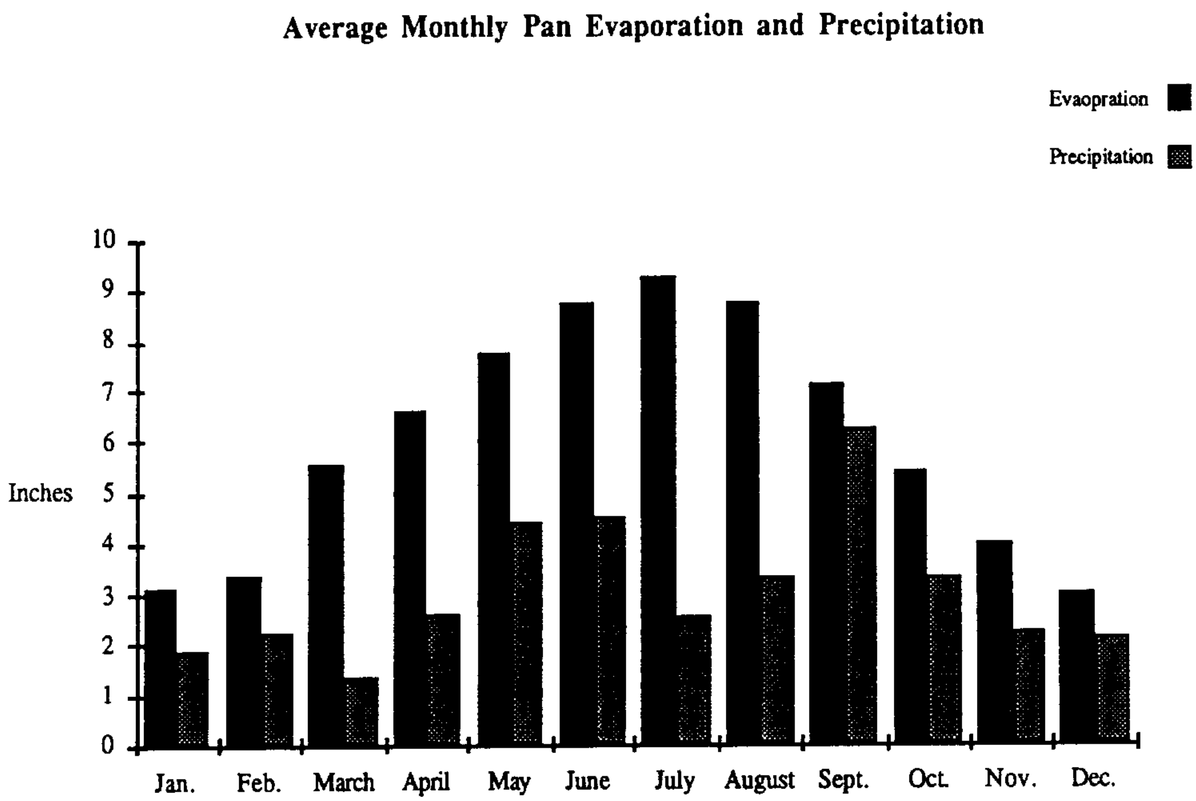
Evapotranspiration

Evapotranspiration is the term used to describe the processes whereby water is returned to the atmosphere as vapor through direct evaporation and through transpiration by plants. The annual potential evapotranspiration loss in Victoria County for the period 1970 to 1990 ranges from 53.3 to 68.3 inches/year with 61.6 inches/year as the mean.

Figure 5-4 contains average monthly evaporation recorded as pan evaporation and the average monthly precipitation for the Victoria County area. This plot is significant because it shows that the area is subject to more evaporation than rainfall. Potential evapotranspiration is the term used to define the amount of water that can be evaporated or transpired from the land surface if sufficient water were available in the soil to meet the demand. Actual evapotranspiration is always considerably less than potential evapotranspiration (Freeze and Cherry, 1979).

5.2.3 Regional Surface Water Features

The major surface water features in the Victoria County area are the San Antonio River, Guadalupe River, Lavaca River, Lavaca Bay, San Antonio Bay, and the Coleto Creek Reservoir. The rivers generally flow to the south and southeast. The San Antonio and the Guadalupe flow together to form the southern corner of Victoria County. The Lavaca River lies to the east of Victoria County and flows south parallel to the eastern border. San Antonio and Lavaca Bays lie to the southeast and are the estuaries for those respective rivers. Numerous creeks and intermittent streams flow into the rivers in the area, and artesian wells are present in the southern portion of the county. A significant amount of data concerning these surface water features has been collected by the United States Geological Survey. The following is a brief description of each of the major river basins in or near Victoria County.



AVERAGE MONTHLY EVAPORATION AND
AVERAGE MONTHLY PRECIPITATION

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FIGURE 5-4

Lavaca River Basin

The Lavaca River basin is located on the coastal prairie lying north of the San Antonio-Matagorda Bay area. The City of Yoakum is the largest population center in the basin. The drainage area of the basin is 2,309 square miles. Headwaters of the Lavaca River originate in southern Fayette County and flow into Lavaca Bay. About 60 percent of the basin is drained by the Navidad River and its tributaries. The Navidad River headwaters also originate in Fayette County and flow to the headwater of Lake Texana.

For water quality monitoring purposes, the Lavaca River has been divided into five segmented waters totaling 188 stream miles. There is one major reservoir in the basin covering 10,995 surface acres. The Commission routinely monitors six sites throughout the basin.

The water quality of the basin is good. The Lavaca River above tidal influences experience frequent elevated fecal coliform bacteria levels. According to a bacteriological study, it was determined that non-confined livestock is the main source.

Guadalupe River Basin

Headwaters of the Guadalupe River form in southwestern Kerr County. The river flows southeasterly to Guadalupe Bay, part of the San Antonio Bay System. The Blanco and San Marcos Rivers are major tributaries to the Guadalupe River. Total basin drainage area is 6,070 square miles. The Guadalupe River Basin has been divided into 17 segmented waters for monitoring purposes. Four new segmented waters have been added to this basin. One reservoir covering 8,230 surface acres and 749 stream miles are routinely monitored.

Flow in the Guadalupe River is very variable over a 20 year time series (see Figures 5-5, 5-6, 5-7 and 5-8). Although the flow in the river gets low at times, it has not ceased over the 20 year span of record. The minimum flow for this period of record was approximately 125 cfs and the maximum flow was over 179,000 cfs at the City of Victoria.

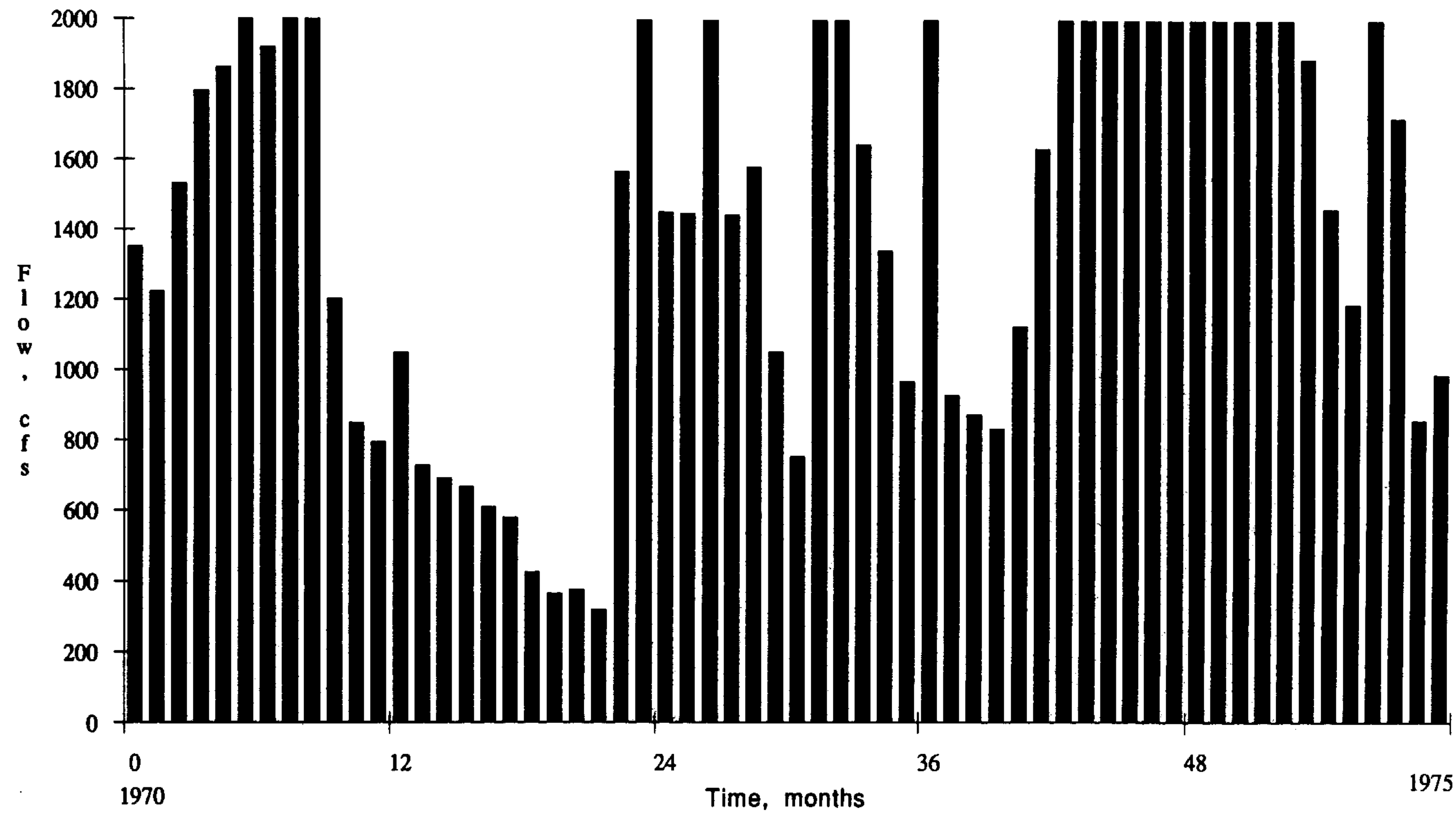
The Guadalupe River Basin is characterized by generally high quality throughout. Abundant growths of lush aquatic vegetation occur in the San Marcos and Comal Rivers due to natural nitrate nitrogen levels originating primarily from spring sources.

Due to the excellent water quality and abundant spring flow from the Edwards Aquifer the entire Guadalupe River and its tributaries are used extensively for contact recreation and play a major role in the basin's economy.

The Coleto Creek Reservoir forms part of the western border of Victoria County. Construction on the reservoir was completed in 1980 and the primary use is for cooling water supply for the Central Power and Light (CP&L) electric power generating facility in Goliad County. The reservoir is fed by Coleto Creek as well as a pipe line from the Guadalupe River. Consequently, the reservoir maintains a fairly constant water level throughout the year.

San Antonio River Basin

The San Antonio River begins at Brackenridge Park in the City of San Antonio and flows southeast to its confluence with the Guadalupe River near the Gulf Coast. San Antonio, the third largest city in the state is the largest metropolitan area in the basin. Total basin drainage area is 4,180 square miles. Major tributaries to the San Antonio River include the Medina River, Leon Creek, Cibolo Creek, and Salado Creek.



GUADALUPE RIVER AT VICTORIA, TEXAS 1970-1975

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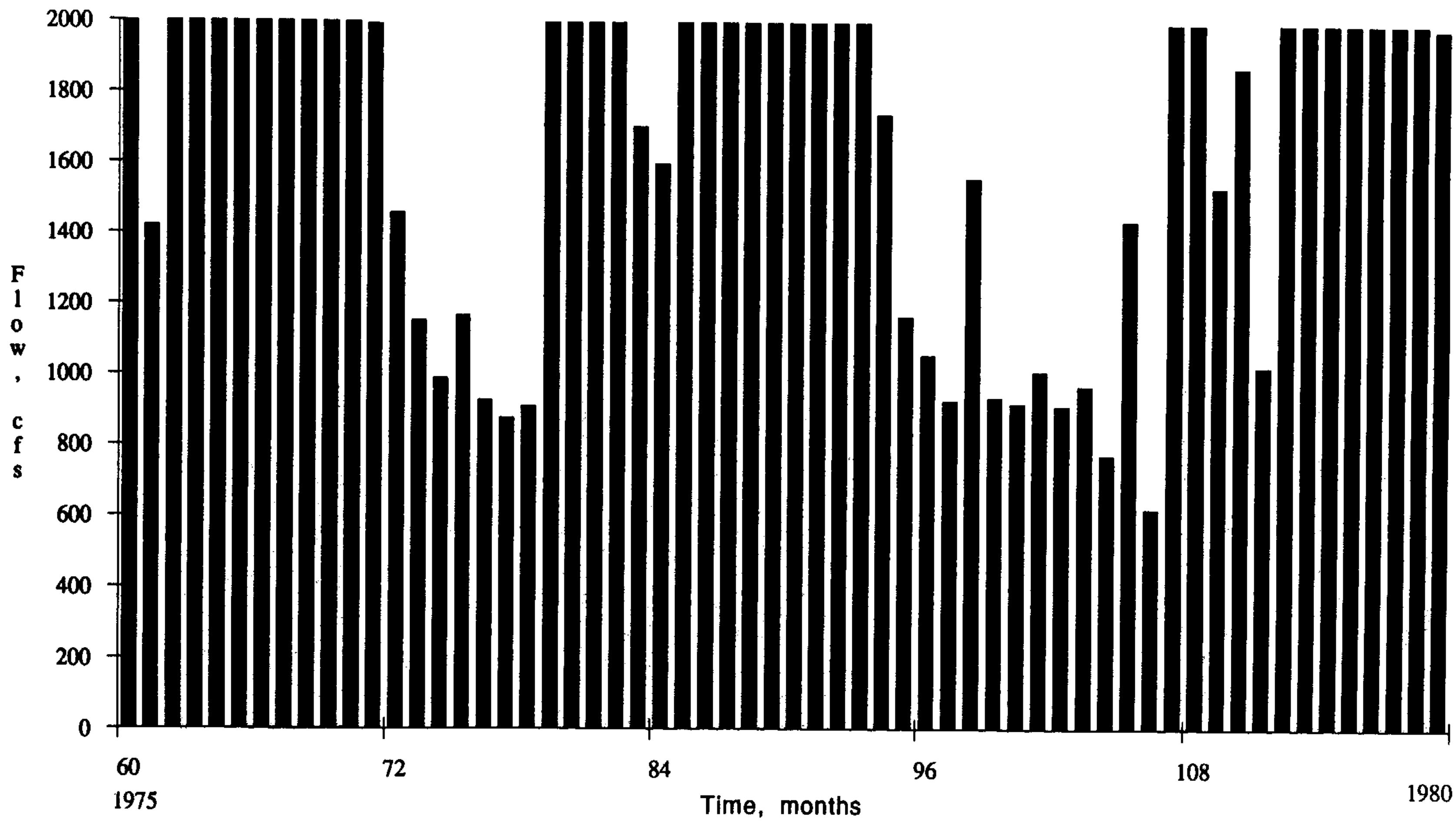
FIGURE 5-5



GUADALUPE RIVER AT VICTORIA, TEXAS 1975-1980

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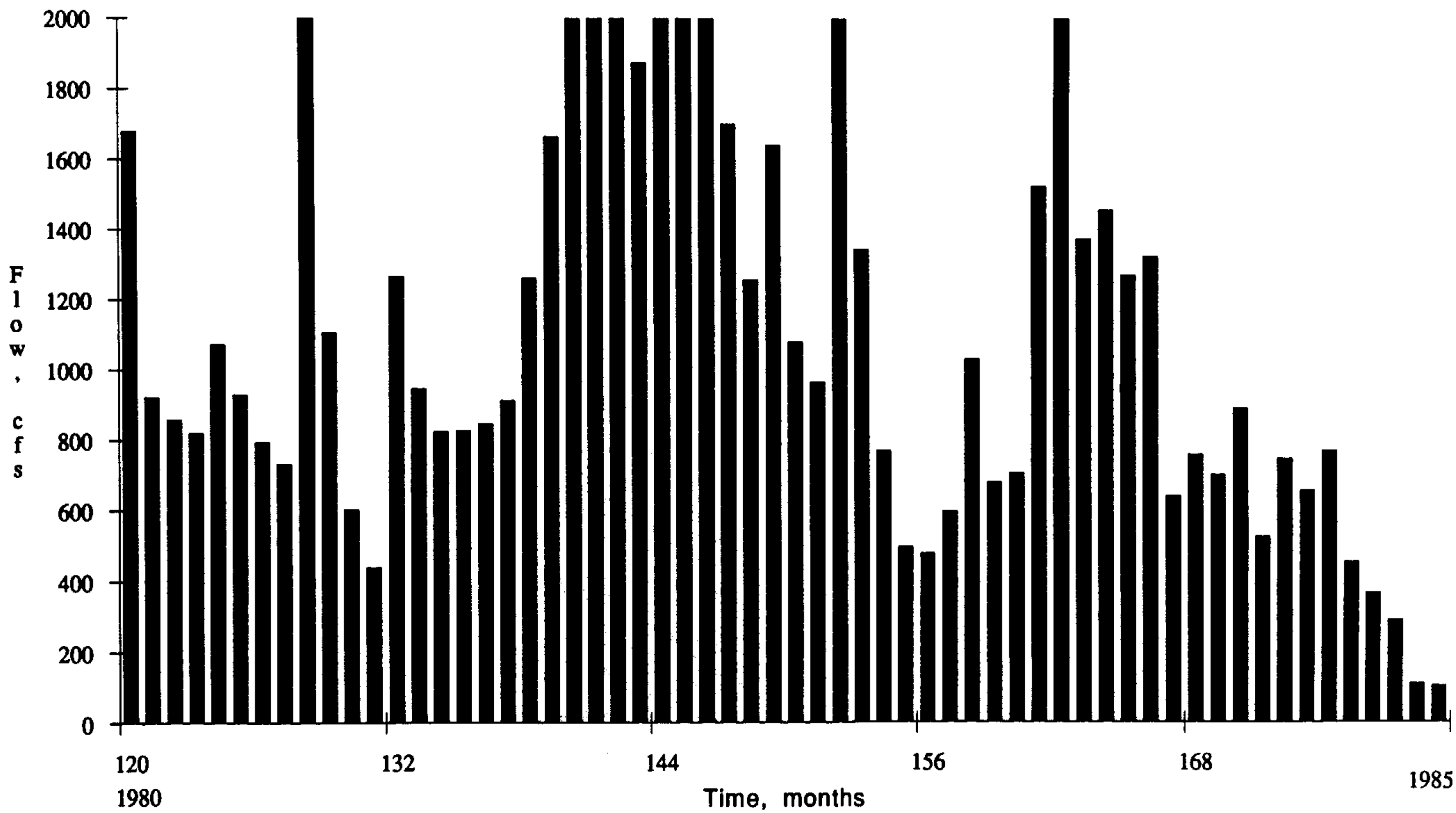
FIGURE 5-6



GUADALUPE RIVER AT VICTORIA, TEXAS 1980-1985

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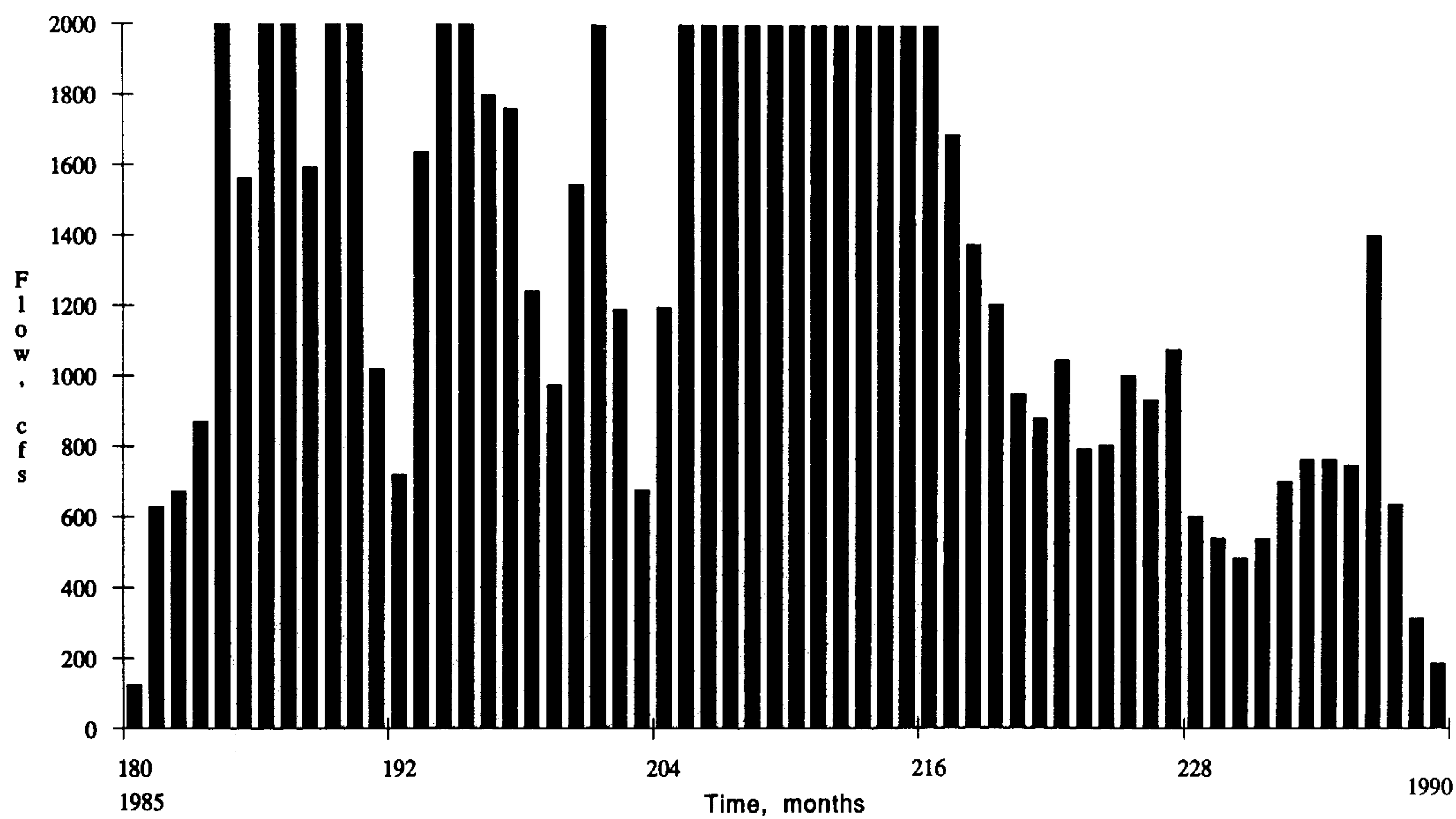
FIGURE 5-7



GUADALUPE RIVER AT VICTORIA, TEXAS 1985-1990

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FIGURE 5-8

For water quality monitoring purposes, the San Antonio River basin has been divided into 13 segmented waters. Two reservoirs covering 5,987 surface acres and 611 stream miles are routinely monitored.

Historically, the water quality of the upper reaches of the San Antonio River was relatively poor, particularly during periods of low flow. Construction of three City of San Antonio waste treatment facilities has been completed to achieve advanced waste treatment levels. The Dos Rios treatment facility is complete and the Rilling Road facility has been terminated. Permit limitations for Leon Creek and Salado Creek have been upgraded to reflect advanced waste treatment. Since the completion of the additional treatment, the dissolved oxygen level in the San Antonio River has increased above the stream criteria, and aquatic life has returned. Due to the increase in dissolved oxygen levels, the non-fishable status has been lifted for Segments 1901 and 1911.

Water quality is stressed in the lower portions of Leon Creek and the Medina River and can be attributed to the City of San Antonio Leon Creek Wastewater treatment facility. Poor water quality conditions also exist in mid-Cibolo Creek due to municipal point source discharge.

5.3 GEOLOGIC AND HYDROGEOLOGIC SETTING

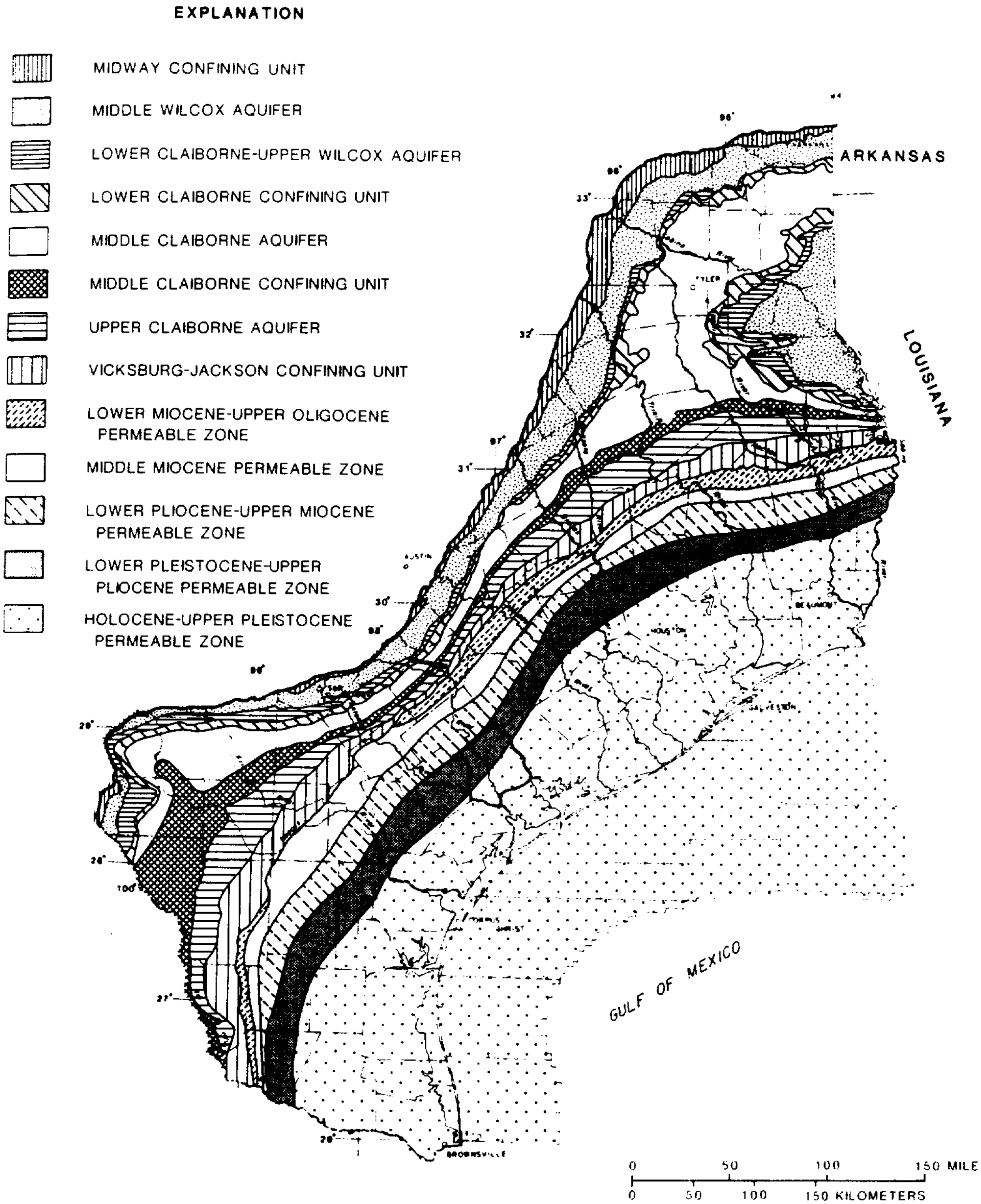
5.3.1 Introduction

The geologic and hydrogeologic units in the study area form a complex aquifer system. These units are part of a larger geologic setting known to underlie the Gulf Coastal Plain of Texas. Geologically, Tertiary and Quaternary deposits of clay, silt, sand, and gravel as much as 12,000 feet thick underlie the coastal plain (Ryder and Ardis, 1991). The geologic strata that underlie the Gulf Coastal Plain have outcrops that parallel the gulf coast. These clastic sediments then dip and thicken as they approach the Gulf of Mexico (see Figure 5-9).

The hydrogeologic units of the southeast Texas area have been grouped into two major aquifer systems. The Texas coastal uplands aquifer system and the Texas coastal lowlands system (Ryder, 1988). The two systems in Texas are separated by the poorly permeable Vicksburg-Jackson confining unit and are underlain by the practically impermeable Midway confining unit (see Tables 5-1 and 5-2). For the purposes of this study, only the Texas coastal lowlands system will be discussed because it is the major source of water for the Victoria County area. The definitions of the hydrogeologic units and the names assigned to them may or may not conform to conventional definitions and names as found in the published literature. The hydrogeologic units are named for the group or series designation of the sediments that comprise the units.

5.3.2 Coastal Lowlands Aquifer System

The coastal lowlands aquifer system is contained within five different geologic units. These units are the Oligocene (?), Miocene, Pliocene, Pleistocene, and Holocene series. Many investigators disagree as to the position of the top of Oligocene deposits (Baker, 1979). It is possible that all of the coastal lowlands units are Miocene or younger. The units are, from oldest to youngest, the: lower Miocene-upper Oligocene permeable zone; lower Miocene-upper Oligocene confining unit; middle Miocene permeable zone; middle Miocene confining unit; lower Pliocene-upper Miocene permeable zone; lower Pleistocene-upper Pliocene permeable zone; Holocene-upper Pleistocene permeable zone. Table 5-2 shows the definitions and names of hydrogeologic units that may be found in recent published reports; the example shown is from Baker (1979).



GENERALIZED OUTCROPS OF AQUIFERS, PERMEABLE ZONES, AND CONFINING UNITS. (SOURCE: RYDER, 1988)

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FIGURE 5-9

TEXAS COASTAL UPLANDS

SYSTEM	SERIES	Group	STRATIGRAPHIC UNITS	HYDROGEOLOGIC UNITS
TERTIARY	OLIGOCENE		Frio Clay; Vicksburg Group [1]	Vicksburg-Jackson confining unit
TERTIARY	EOCENE	Jackson Group	Whitsett Formation Manning Clay Wellborn Sandstone Caddell Formation	Vicksburg-Jackson confining unit
TERTIARY	EOCENE	Claiborne Group	Yegua Formation	Upper Claiborne aquifer
TERTIARY	EOCENE	Claiborne Group	Cook Mountain Fm.	Middle Claiborne confining unit
TERTIARY	EOCENE	Claiborne Group	Sparta Sand Weches Formation Queen City Sand	Middle Claiborne aquifer
TERTIARY	EOCENE	Claiborne Group	Reklaw Formation	Lower Claiborne confining unit
TERTIARY	EOCENE	Claiborne Group	Carrizo Sand	Lower Claiborne-upper Wilcox aquifer
TERTIARY	EOCENE	Wilcox Group	Undifferentiated	Lower Claiborne-upper Wilcox aquifer
TERTIARY	EOCENE	Wilcox Group	Undifferentiated	Middle Wilcox aquifer
TERTIARY	PALOCENE	Midway Group	Wills Point Formation Kincaid Formation	Midway confining unit

STRATIGRAPHIC AND HYDROGEOLOGIC UNITS FOR THE COASTAL UPLANDS AQUIFER SYSTEM. (SOURCE: RYDER, 1988)

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TABLE 5-1

TEXAS COASTAL LOWLANDS

Modified from Baker (1979)

SYSTEM	SERIES	STRATIGRAPHIC UNITS	HYDROGEOLOGIC UNITS	HYDROGEOLOGIC UNITS IN THIS REPORT
QUATERNARY	HOLOCENE	Alluvium	CHICOT AQUIFER	Holocene-upper Pleistocene permeable zone
QUATERNARY	PLEISTOCENE	Beaumont Clay Montgomery Formation Bentley Formation Willis Sand	CHICOT AQUIFER	Holocene-upper Pleistocene permeable zone Lower Pleistocene-upper Pliocene permeable zone
TERTIARY	PLIOCENE	Goliad Sand	EVANGELINE AQUIFER	Lower Pleistocene-upper Pliocene permeable zone Lower Pliocene-upper Miocene permeable zone
TERTIARY	MIOCENE	Fleming Formation	EVANGELINE AQUIFER BURKEVILLE CONFINING SYSTEM	Lower Pliocene-upper Miocene permeable zone Middle Miocene confining unit 1/
TERTIARY	MIOCENE	Oakville Sandstone	BURKEVILLE CONFINING SYSTEM Jasper aquifer	Middle Miocene confining unit 1/ Middle Miocene permeable zone
TERTIARY	MIOCENE	Catahoula Sandstone or Tuff 2/ Anahuac Formation 1/	CATAHOULA CONFINING SYSTEM (RESTRICTED) Jasper aquifer	Middle Miocene permeable zone Lower Miocene-upper Oligocene confining unit 1/
TERTIARY	-?- OLIGOCENE	Catahoula Sandstone or Tuff 2/ "Frio" Formation 1/	CATAHOULA CONFINING SYSTEM (RESTRICTED) Jasper aquifer	Lower Miocene-upper Oligocene permeable zone

1/ Present only in the subsurface

2/ Catahoula Tuff west of Lavaca County

STRATIGRAPHIC AND HYDROGEOLOGIC UNITS FOR THE COASTAL LOWLANDS AQUIFER SYSTEM. (SOURCE: RYDER, 1988)

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TABLE 5-2

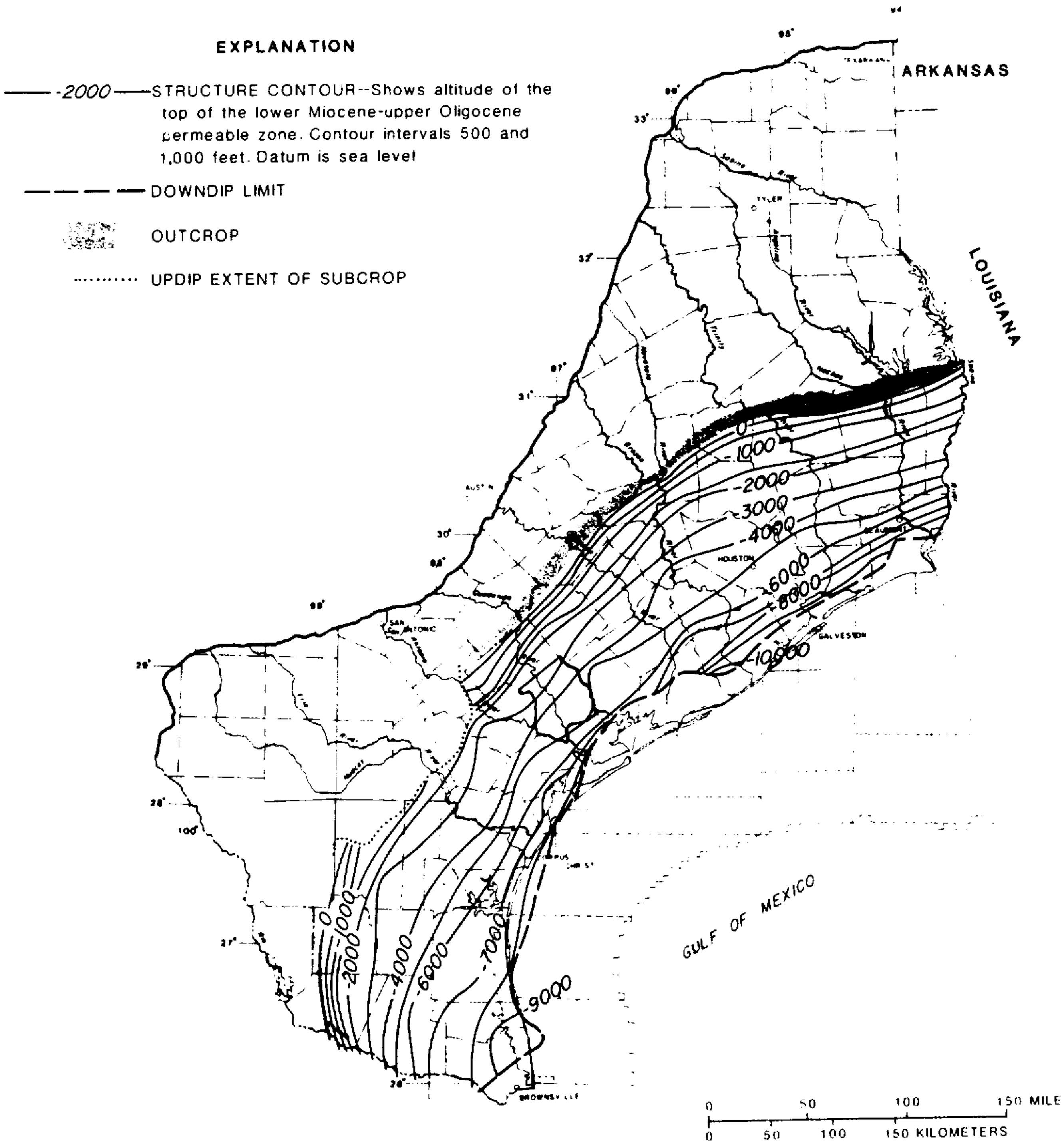
Lower Miocene-Upper Oligocene Permeable Zone

The lowermost permeable zone in the coastal lowlands aquifer system is the lower Miocene-upper Oligocene permeable zone. It is underlain by the nearly impermeable Vicksburg-Jackson confining unit. The zone consists of sand or tuff with interbedded clays in the lower part of the Catahoula Sandstone or Tuff of Oligocene (?) and Miocene age, and of sands in its subsurface equivalent, the "Frio" Formation (see Table 5-2).

The unit is exposed across most of the area: however, it is present only in the subsurface in a large part of the west-central area (see Figure 5-10). Outcrop width ranges from about two miles at the Rio Grande to about thirteen miles at the Sabine River (see Figure 5-10). The altitude of the top of the unit ranges from less than 500 feet above sea level in the outcrop areas to more than 10,000 feet below sea level in Brazoria County (see Figure 5-10). Thickness of the unit ranges from zero feet in the outcrop areas to more than 4,000 feet in the southwest (see Figure 5-11).

Lower Miocene-Upper Oligocene Confining Unit

The lower Miocene-upper Oligocene confining unit consists of massive clays with some interbedded thin sands belonging generally to the Anahuac Formation of Oligocene (?) and Miocene age (Ellisor, 1944) (see Table 5-2). The unit is not exposed in the study area; it exists only in the subsurface (see Figures 5-12 and 5-13). All of the permeable zones in the coastal lowlands system are in contact in the updip areas, without intervening confining units (Ryder, 1988). The confining unit in the west pinches out in its downdip direction and then continues again farther downdip (see Figures 5-12 and 5-13). The top of the unit ranges in altitude of less than 500 feet, NGVD, in the west to more than 10,000 feet, below NGVD, offshore in the extreme southwest. Thickness of the unit ranges from zero feet in the updip areas to more than 3,000 feet in the east and in Calhoun County to the south of the study area (Ryder, 1988).



ALTITUDE OF THE TOP OF THE LOWER MIOCENE-UPPER OLIGOCENE PERMEABLE ZONE. (SOURCE: RYDER, 1988)

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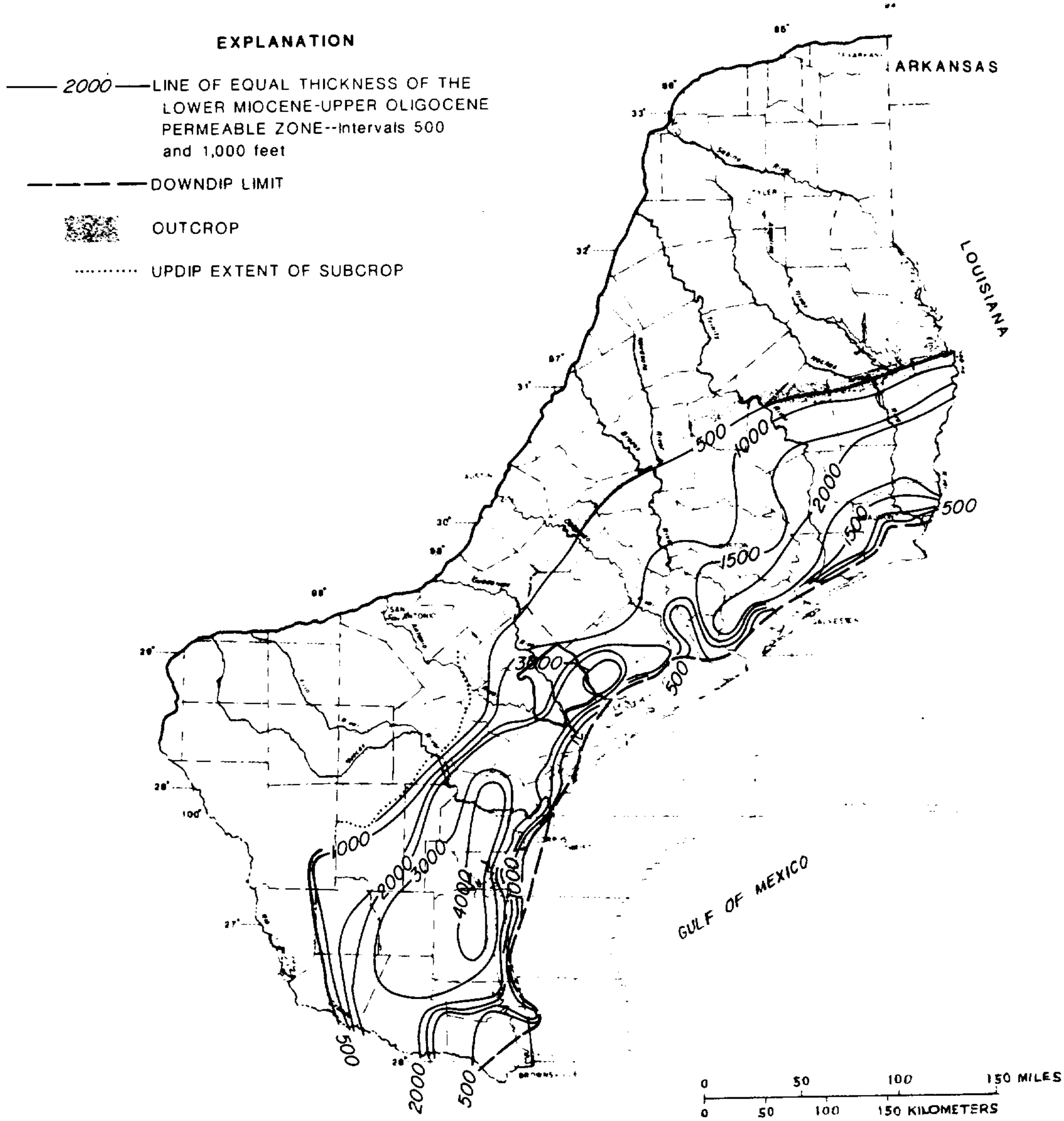
FIGURE 5-10



THICKNESS OF THE LOWER MIOCENE-UPPER OLIGOCENE PERMEABLE ZONE. (SOURCE: RYDER, 1988)

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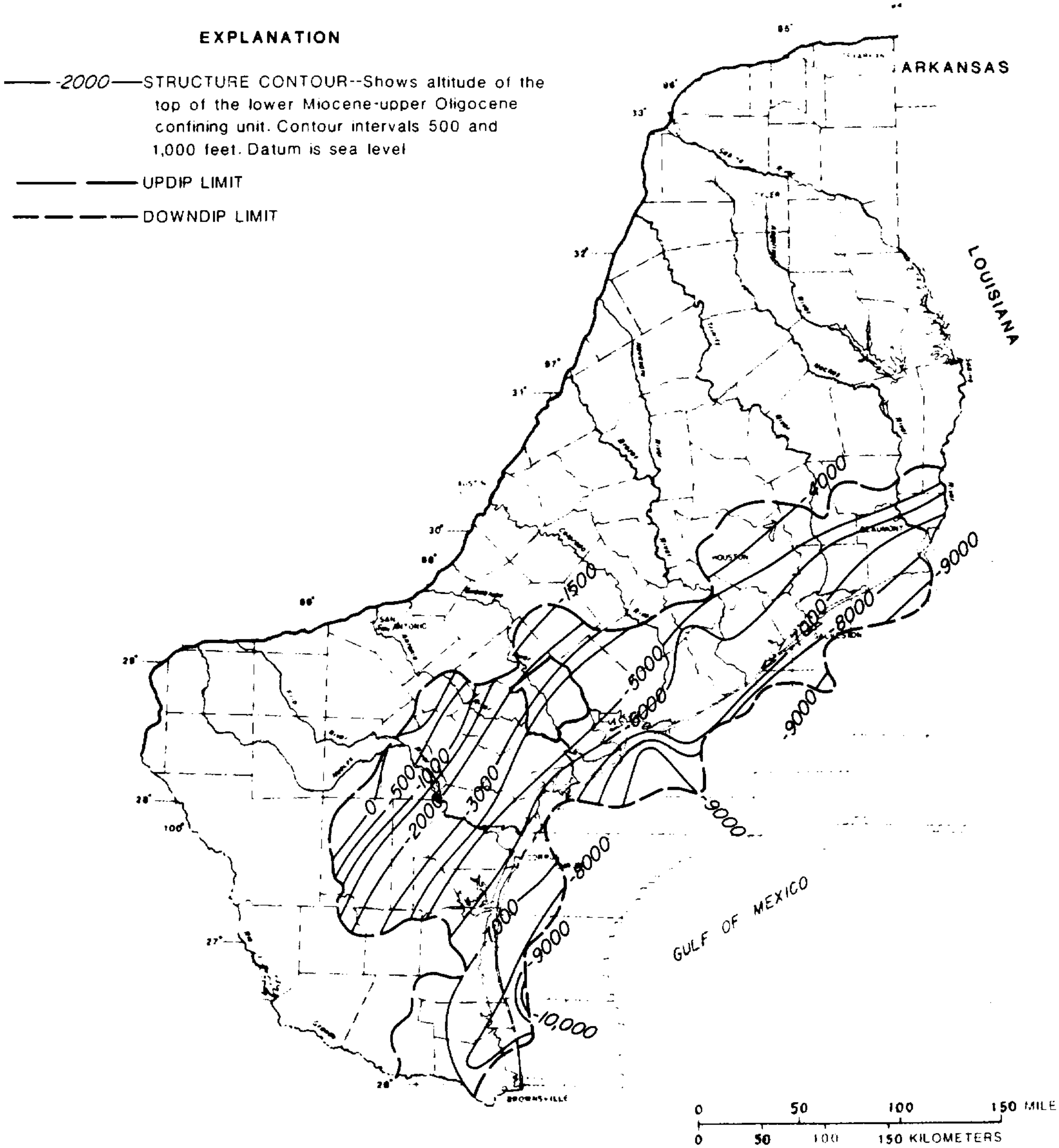
FIGURE 5-11



ALTITUDE OF THE TOP OF THE LOWER MIOCENE-UPPER OLIGOCENE CONFINING UNIT. (SOURCE: RYDER, 1988)

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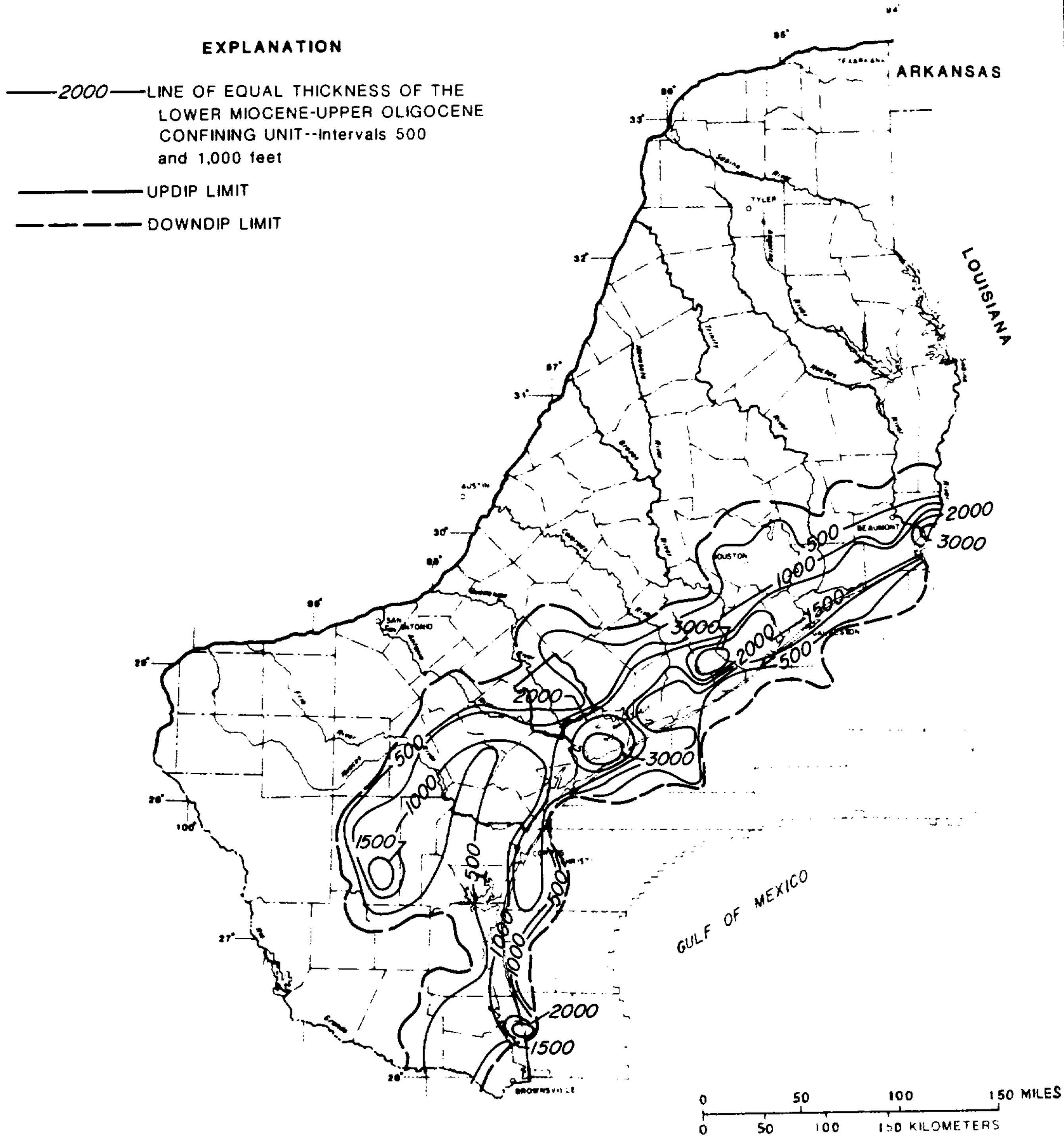
FIGURE 5-12



THICKNESS OF THE LOWER MIOCENE-
UPPER OLIGOCENE CONFINING UNIT.
(SOURCE: RYDER, 1988)

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FIGURE 5-13

Middle Miocene Permeable Zone

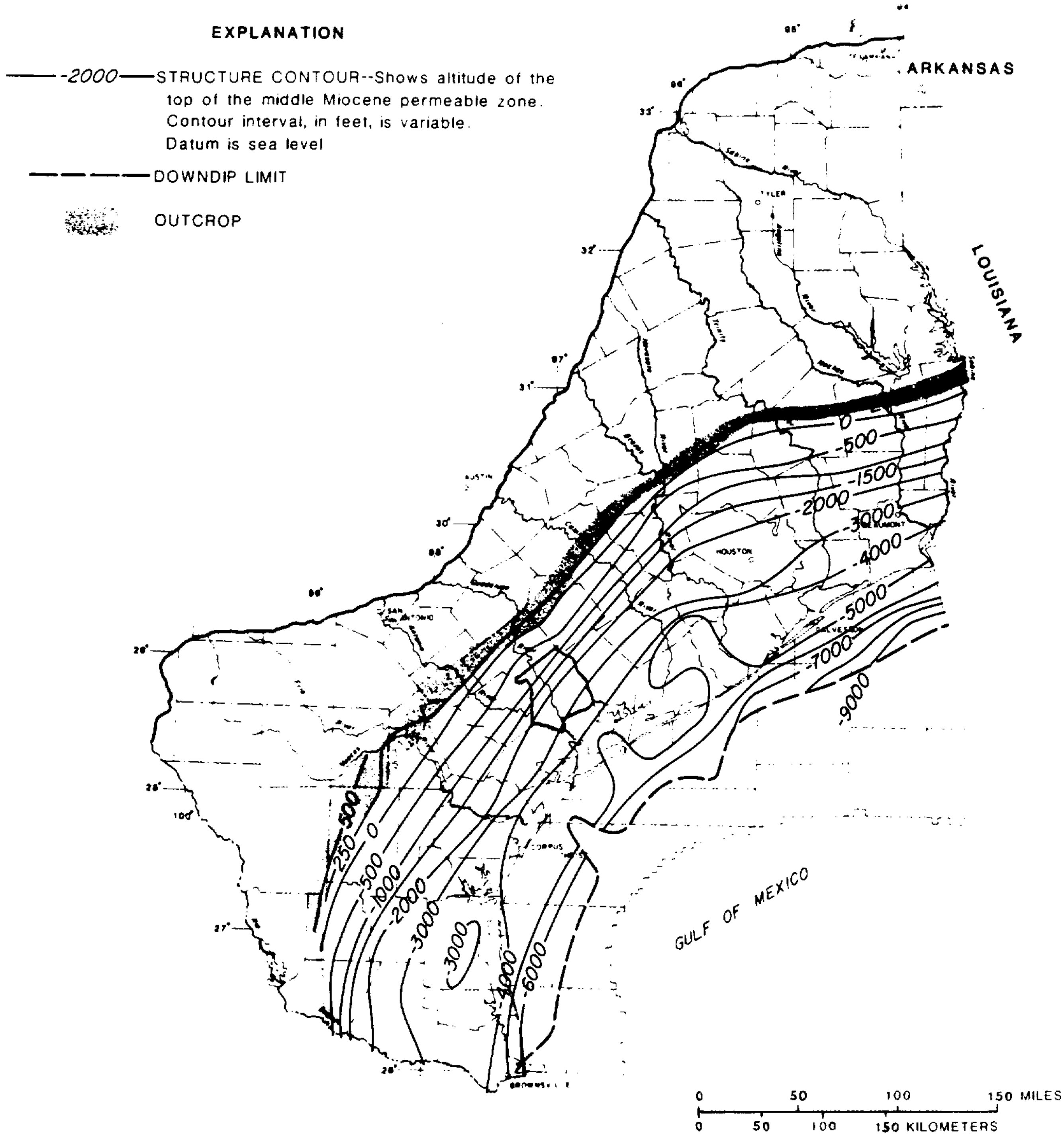
The middle Miocene permeable zone consists of sands in the upper part of the Catahoula Sandstone or Tuff, and of sands in the lower parts of the Oakville Sandstone and Fleming Formation (see Table 5-2). The unit is exposed continuously along its outcrop zone, with widths ranging from about three miles in the Rio Grande valley to about 20 miles in McMullen County in the west-central area (see Figure 5-9). The top of the unit ranges in altitude of about 500 feet, NGVD, in the southwest outcrop to more than 9,000 feet, below NGVD, in the east (see Figure 5-14). Thickness of the unit ranges from zero feet in the outcrop area to more than 5,000 feet near Matagorda Bay in the central area (see Figure 5-15) (Ryder, 1988).

Middle Miocene Confining Unit

The middle Miocene confining unit consists of clayey sediments in the upper part of the Oakville Sandstone and in the middle part of the Fleming Formation (see Table 5-2). The unit is not exposed at the surface, but exists only in the subsurface (Ryder, 1988). The top of the unit ranges in altitude from 250 feet, below NGVD, to more than 7,500 feet, below NGVD, in the southeast (see Figure 5-16). Thickness of the unit ranges from about 500 feet in the updip areas to more than 1,500 feet in several places downdip (see Figure 5-17) (Ryder, 1988).

Lower Pliocene-Upper Miocene Permeable Zone

The lower Pliocene-upper Miocene permeable zone consists mainly of sands in the lower part of the Goliad Sand of Pliocene age, and of sand and interbedded clays in the upper part of the Fleming Formation of Miocene age (see Table 5-2). The unit is underlain by a confining unit only in downdip areas; in updip areas it directly overlies the Middle Miocene permeable zone (Ryder, 1988). The unit crops out across the area, with widths



ALTITUDE OF THE TOP OF THE MIDDLE MIOCENE PERMEABLE ZONE.
(SOURCE: RYDER, 1988)

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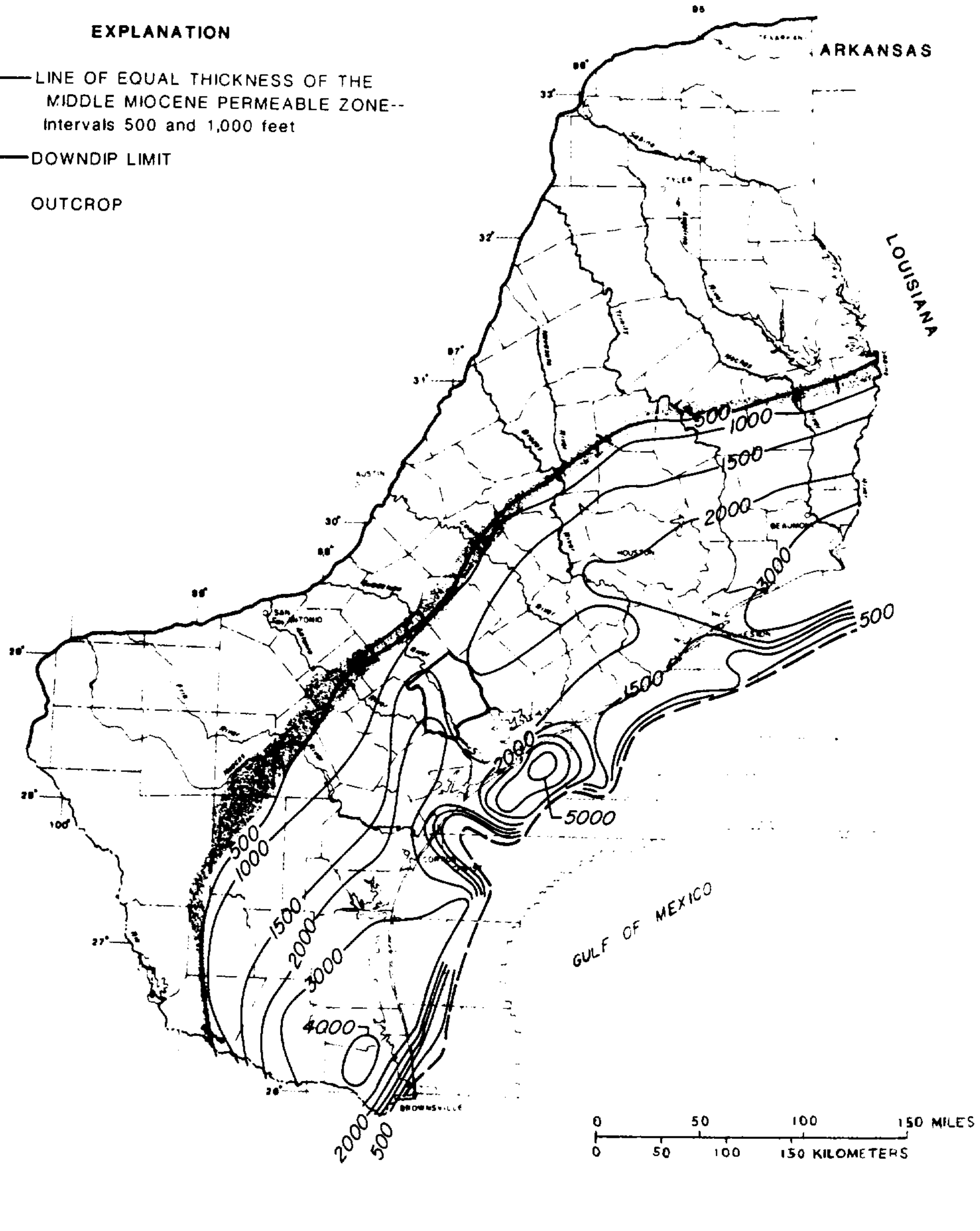
FIGURE 5-14

EXPLANATION

——2000—— LINE OF EQUAL THICKNESS OF THE MIDDLE MIOCENE PERMEABLE ZONE-- Intervals 500 and 1,000 feet

— — — — DOWNDIP LIMIT

OUTCROP



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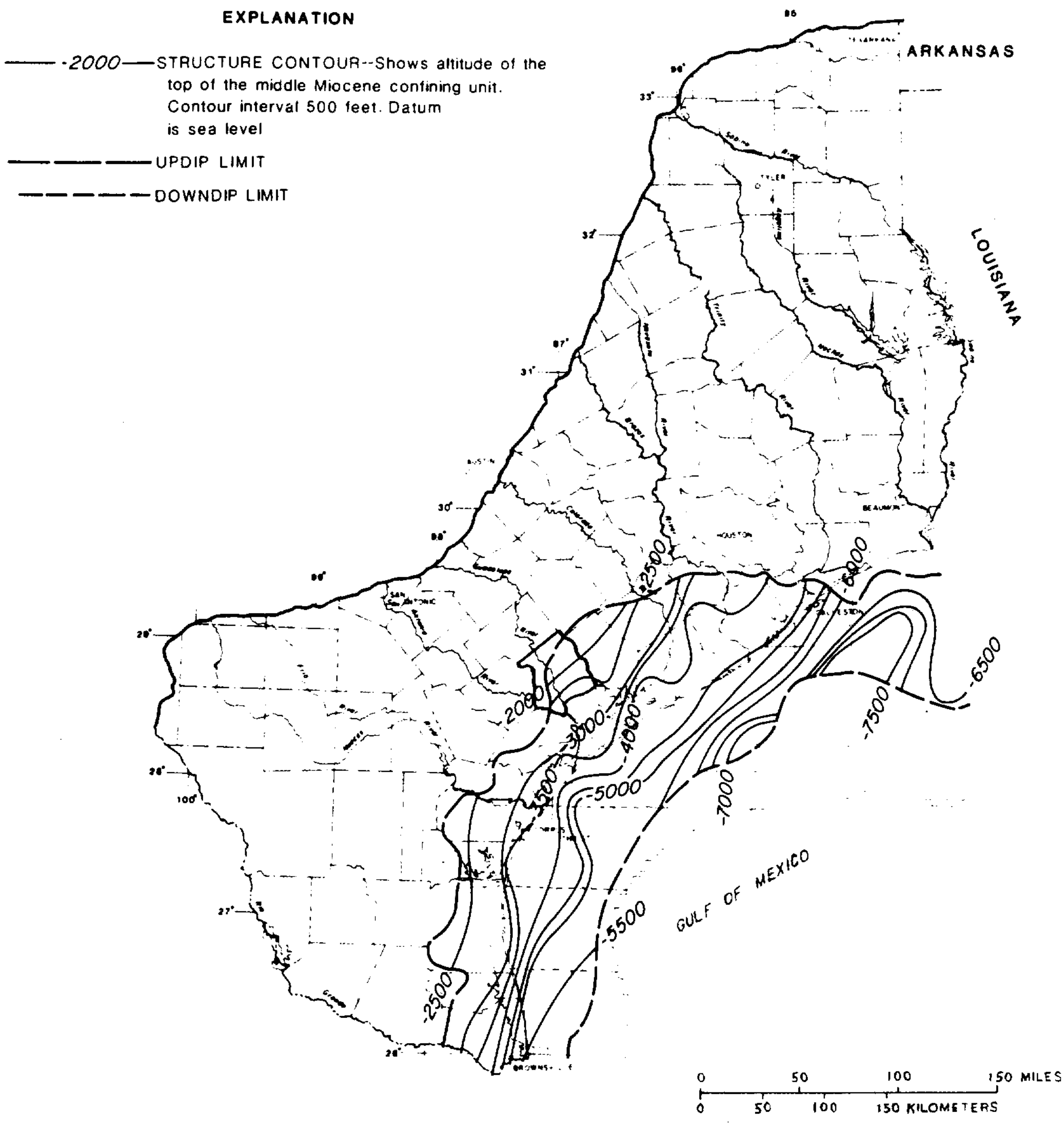
THICKNESS OF THE MIDDLE MIOCENE PERMEABLE ZONE. (SOURCE: RYDER, 1988)

FIGURE 5-15



ALTITUDE OF THE TOP OF THE MIDDLE MIOCENE CONFINING UNIT. (SOURCE: RYDER, 1988)

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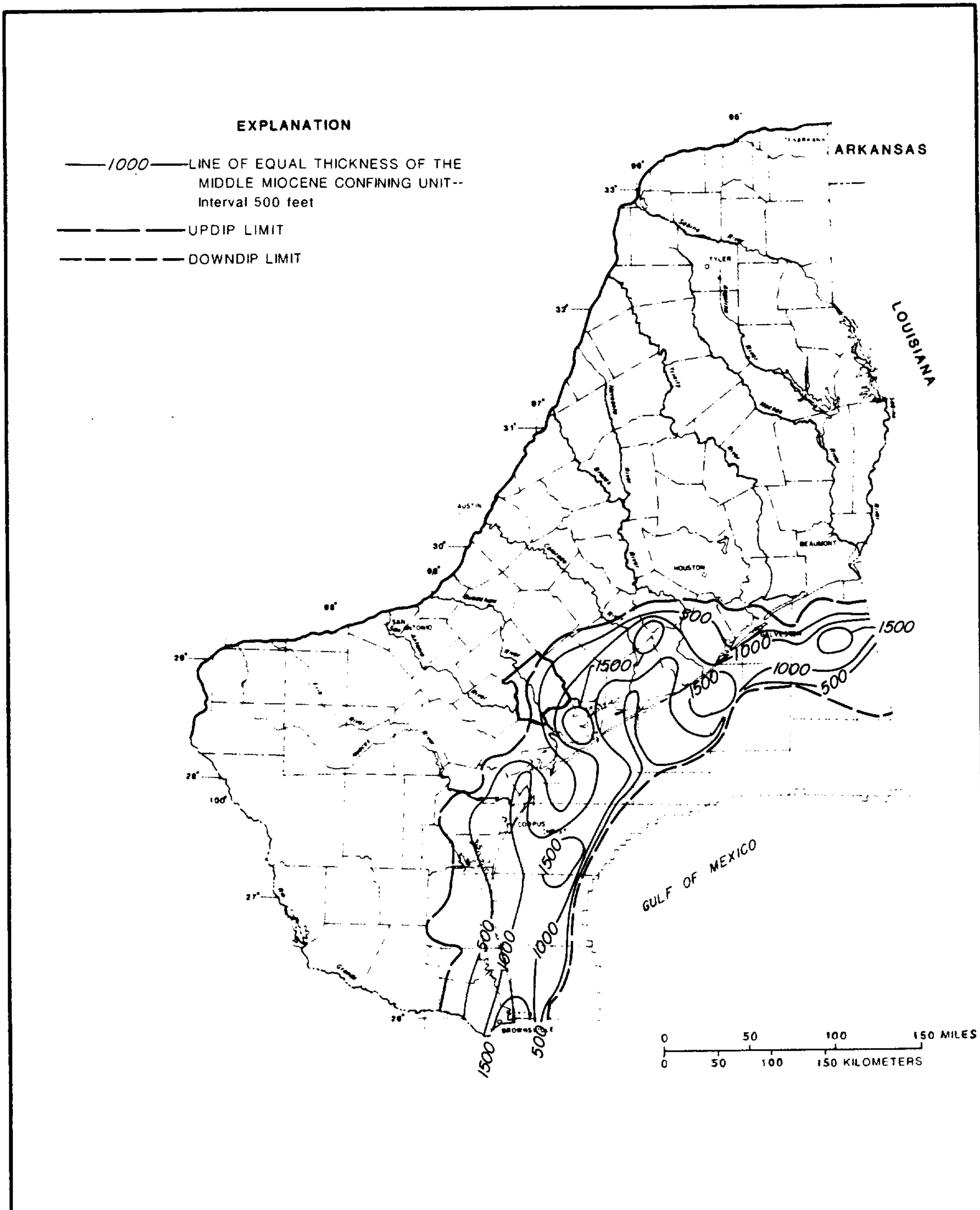
FIGURE 5-16



THICKNESS OF THE MIDDLE MIOCENE CONFINING UNIT. (SOURCE: RYDER, 1988)

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FIGURE 5-17

ranging from about two miles in the Rio Grande valley to about 18 miles at the Guadalupe River in the central area. The top of the unit ranges in altitude from about 500 feet, NGVD, in the outcrop area to more than 5,500 feet, below NGVD, in the east in the Gulf of Mexico (see Figure 5-18). Thickness of the unit ranges from zero feet in the outcrop area to more than 4,000 feet in the east in the Gulf of Mexico (see Figure 5-19). This zone is locally known as the Evangeline Aquifer.

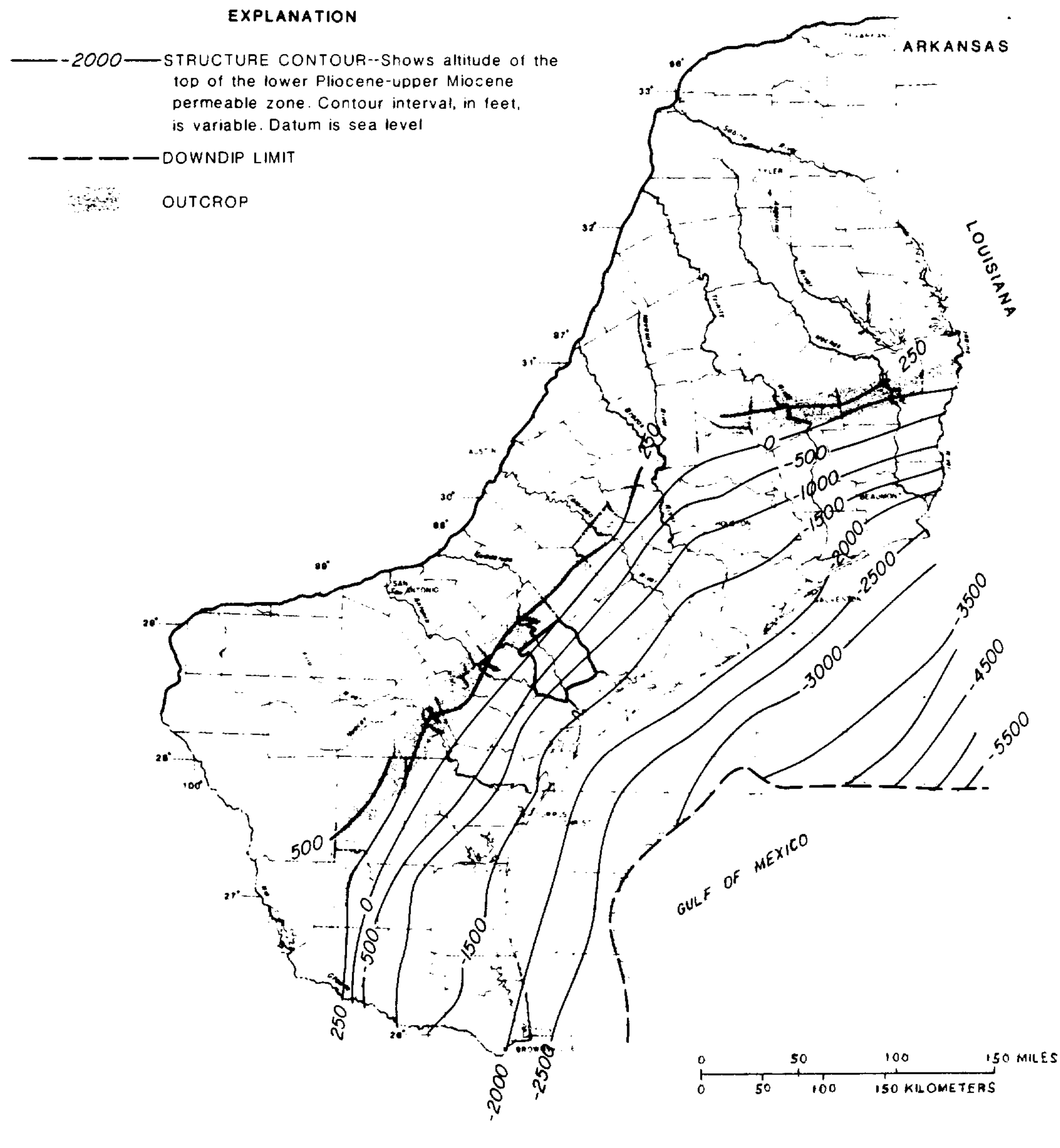
Lower Pleistocene-Upper Pliocene Permeable Zone

The lower Pleistocene-upper Pliocene permeable zone consists of sands and clays in the upper part of the Goliad Sand of Pliocene age, and of sands and clays of the Willis Sand and Bentley Formation of early Pleistocene age (see Table 5-2). The unit is neither underlain nor overlain by a confining unit; it directly overlies the lower Pliocene-upper Miocene permeable zone and underlies the Holocene-upper Pleistocene permeable zone (Ryder, 1988).

The outcrop area of the permeable zone is relatively wide. Its width ranges from about nine miles in the east to about 23 miles at the Brazos River (see Figure 5-9). The top of the unit ranges in altitude from 250 feet, NGVD, in the outcrop area to more than 1,100 feet, below NGVD, in the Gulf of Mexico (see Figure 5-20). Thickness of the unit ranges from zero feet in the outcrop area to more than 4,000 feet in the east in the Gulf of Mexico (see Figure 5-21) (Ryder, 1988). This zone is locally known as the Chicot Aquifer.

Holocene-Upper Pleistocene Permeable Zone

The Holocene-upper Pleistocene permeable zone is the uppermost hydrogeologic unit in the coastal lowlands aquifer system. It overlies the lower Pleistocene-upper Pliocene



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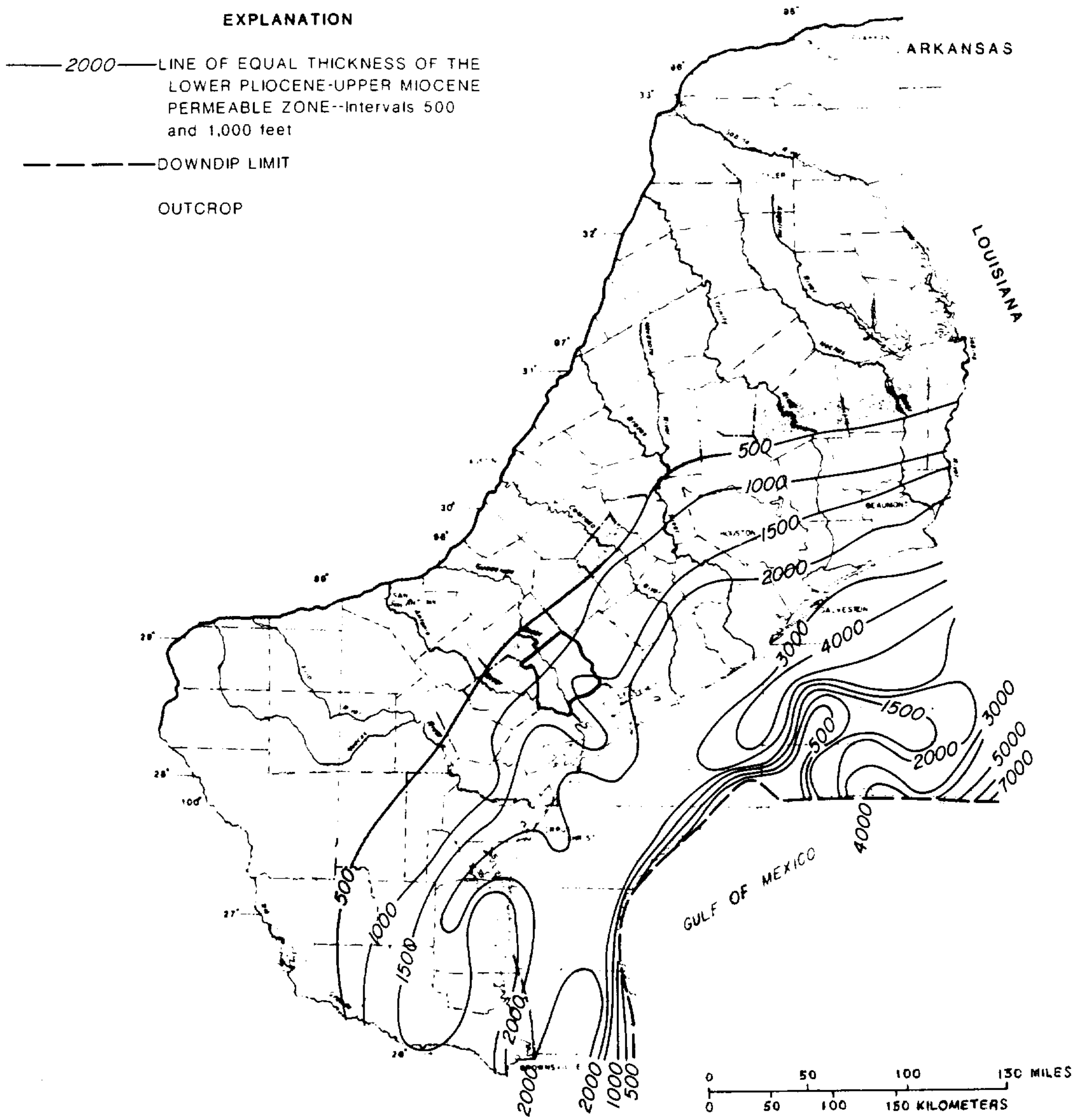
ALTITUDE OF THE TOP OF THE LOWER PLIOCENE UPPER MIOCENE PERMEABLE ZONE. (SOURCE: RYDER, 1988)

FIGURE 5-18



THICKNESS OF THE LOWER PLIOCENE-UPPER MIOCENE PERMEABLE ZONE. (SOURCE: RYDER, 1988)

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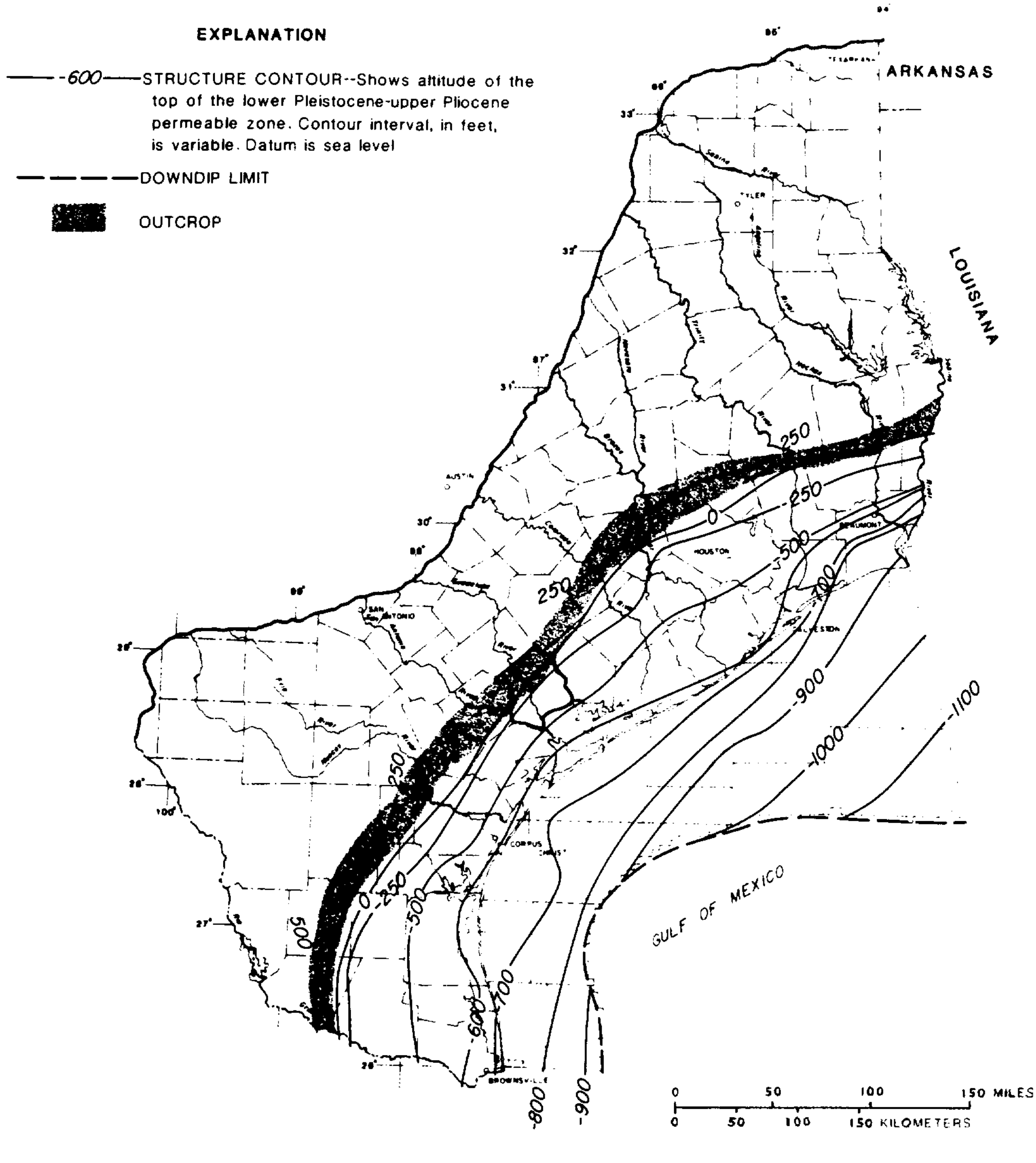
FIGURE 5-19



ALTITUDE OF THE TOP OF THE LOWER PLEISTOCENE-UPPER PLIOCENE PERMEABLE ZONE. (SOURCE: RYDER, 1988)

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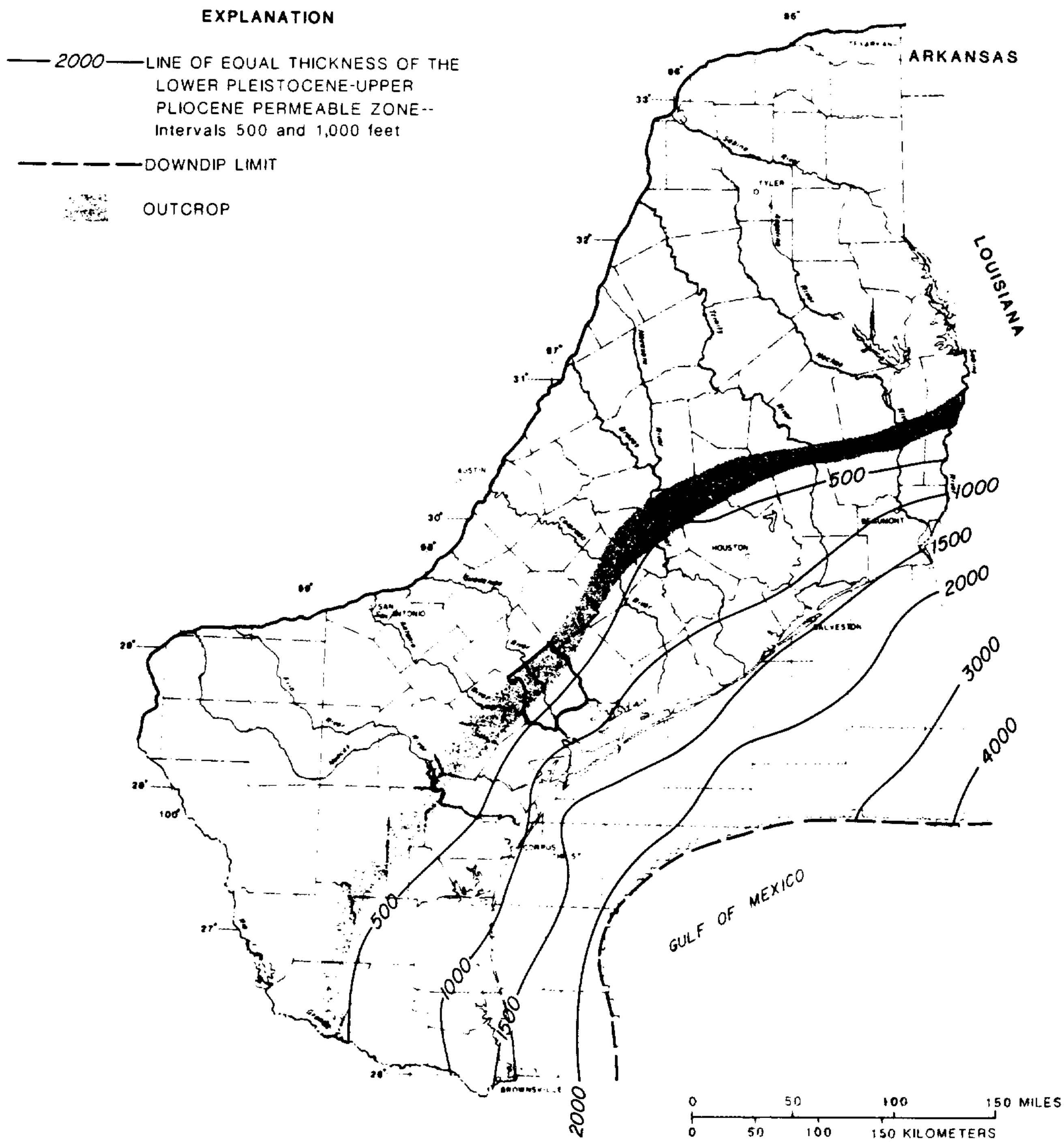
FIGURE 5-20



THICKNESS OF THE LOWER PLEISTOCENE-UPPER PLIOCENE PERMEABLE ZONE. (SOURCE: RYDER, 1988)

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FIGURE 5-21

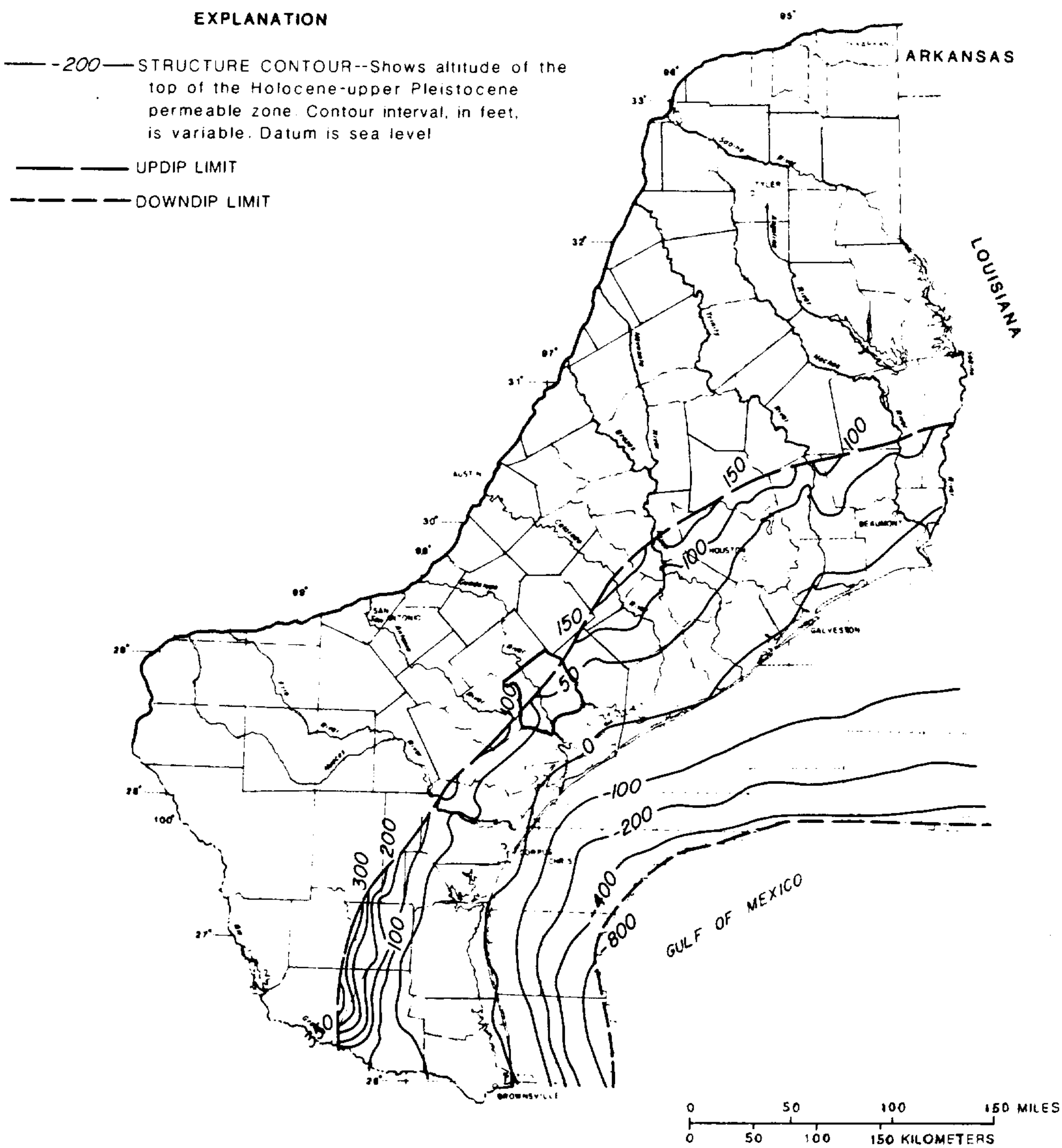
permeable zone, and its top is land surface inshore and sea bottom in the Gulf of Mexico. The unit consists of Holocene and upper Pleistocene sands and Clays (see Table 5-2). Locally, the unit may include Holocene alluvial deposits (Ryder, 1988).

Since it is the surficial unit, the permeable zone has the largest outcrop area of all units in the Texas Coast aquifer systems (see Figure 5-9). The top of the unit ranges in altitude from 350 feet, NGVD, in the west to more than 800 feet, below NGVD, in downdip areas in the Gulf of Mexico (see Figure 5-22). Thickness of the unit ranges from zero feet at the updip limit to more than 900 feet offshore in the east (see Figure 5-23) (Ryder, 1988).

5.3.3 Hydrogeology

For the purposes of this study, the Texas lowlands aquifer system and the geologic units that comprise this system are subdivided into two individual aquifers. They will be referred to as the Chicot Aquifer and the Evangeline Aquifer. These two aquifer systems are used throughout Victoria County as the primary source of water. The aquifers are underlain by the Burkeville confining system, which is also referred to as the Middle Miocene confining unit. This confining unit is the lowest unit considered in this study. The Burkeville confining layer, which is composed of the upper part of the Fleming Formation, consists mainly of clay but contains some layers of sand. The Burkeville restricts the flow of water except in areas where it is pierced by salt domes and in areas where it contains a high percentage of sand. See Table 5-2 for location of these aquifers relative to the geology of the area.

Another waterbearing unit in Victoria County and the surrounding region is known as Valley Alluvium. This unit or hydrogeologic formation gets its water from rivers and creeks that run through them. For purposes of water availability in Victoria County, the Valley Alluvium is considered in this study.



ALTITUDE OF THE TOP OF THE HOLOCENE-UPPER PLEISTOCENE PERMEABLE ZONE. (SOURCE: RYDER, 1988)

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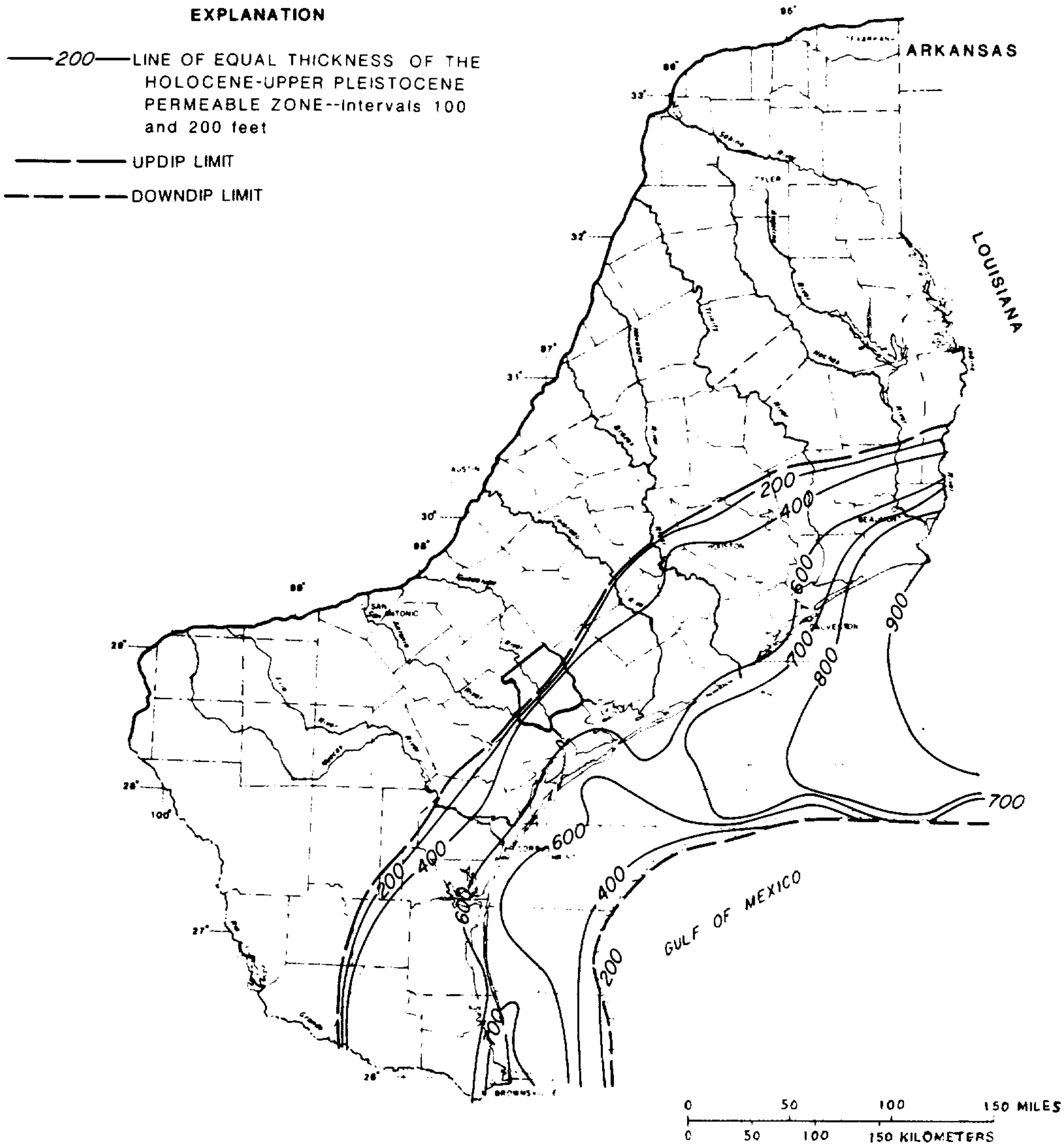
FIGURE 5-22



THICKNESS OF THE HOLOCENE-
UPPER PLEISTOCENE PERMEABLE ZONE.
(SOURCE: RYDER, 1988)

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FIGURE 5-23

To get an idea as to the ability of these aquifers to produce water, several physical parameters about the aquifers hydraulic characteristics are needed. Hydraulic characteristics such as transmissivity and hydraulic conductivity are important and vary throughout the study area. These aquifer parameters are important measures in understanding the behavior of any aquifer system. The transmissivity of a water-bearing formation is a measure of its ability to transmit water. This physical parameter is defined as the number of gallons of water that will move in one day through a one-foot wide vertical strip of the full height of the formation, when the hydraulic gradient is one foot per foot (Guyton, 1984).

The hydraulic conductivity of an aquifer is the rate of flow in gallons per day through a cross-sectional area of one square foot under a hydraulic gradient of one foot per foot. Hydraulic conductivity is a measure of the characteristics of the aquifer itself without relation to its thickness. The approximate average hydraulic conductivity of an aquifer can be determined by dividing the transmissivity by the thickness of the aquifer (Guyton, 1984).

Chicot Aquifer

The Chicot Aquifer is composed of the Willis Sand, Bentley Formation, Montgomery Formation, Beaumont Clay, and Holocene alluvium. The Chicot includes all deposits from the land surface to the top of the Evangeline Aquifer (see Table 5-2).

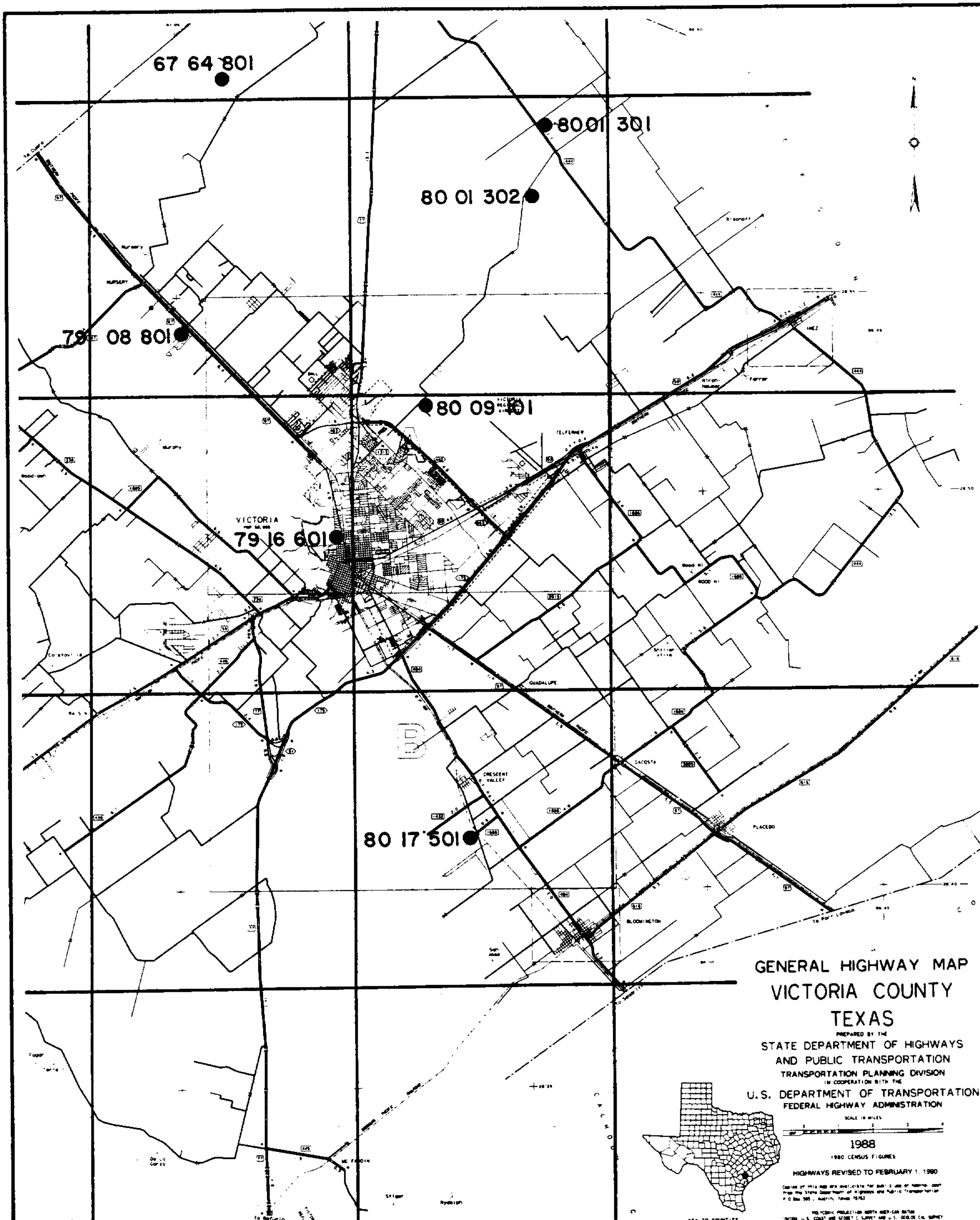
In much of the coastal area, the Chicot Aquifer consists of discontinuous layers of sand and clay of about equal total thickness (Carr, et al., 1985). However, in some parts of the coastal area (mainly within the Houston area), the aquifer can be separated into an upper and lower unit (Jorgensen, 1975). The upper unit can be defined where the altitude of its potentiometric surface differs from the altitude of the potentiometric surface in the lower unit. If the upper unit of the Chicot Aquifer cannot be defined, the aquifer is said to be undifferentiated. The aquifer is under water-table conditions in its outcrop areas, becoming confined in the downdip direction (Carr, et al., 1985).

Although the data are sparse for the Chicot Aquifer, there are limited data that give an idea of the Chicot Aquifer parameters of transmissivity and hydraulic conductivity. The report by Guyton (1984) states that the U.S.G.S completed a sequence of digital modeling studies for simulation of groundwater hydrology of the Chicot Aquifer along the Gulf Coast of Texas. In the area shown in Figure 5-24, the transmissivities of the Chicot Aquifer, determined by the USGS modeling study, range from about 20,000 gallons per day per foot to about 60,000 gallons per day per foot.

Evangeline Aquifer

The Evangeline Aquifer, which consists mostly of discontinuous layers of sand and clay of about equal total thickness, is composed of the Goliad Sand and the uppermost part of the Fleming Formation. Because the Chicot and Evangeline Aquifers are geologically similar, the basis for separating them is primarily a difference in hydraulic conductivity, which in part causes the difference in the potentiometric surfaces in the two aquifers. Similar to the Chicot, the Evangeline Aquifer can exhibit a different potentiometric surface at the top than at the bottom. This is the reason for separation of permeable zones of the Lower Pleistocene-Upper Pliocene permeable zone and the Lower Pliocene-Upper Miocene permeable zone. The aquifer is under water-table conditions in its outcrop areas, becoming confined in the downdip direction (Carr, et al., 1985).

Although the data are not as sparse for the Evangeline as they are for the Chicot, the data base is still relatively incomplete. Guyton (1984) performed pump tests in sands that were characteristic of the Evangeline Aquifer. The range of transmissivities were found to be between 26,000 and 87,000 gallons per day per foot and averaged 46,000 gallons



MAP OF WELL LOCATIONS

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FIGURE 5-24

per day per foot. Tests performed on the City of Victoria wells ranged from 26,000 to 59,000 gallons per day per foot and averaged 43,000 gallons per day per foot. The hydraulic conductivities determined from the tests range from 100 to 230 gallons per day per square foot and averaged 170 gallons per day per square foot.

The U.S.G.S. digital modeling study that produced transmissivities for the Chicot Aquifer also produced transmissivities for the Evangeline Aquifer. These transmissivities ranged from 45,000 to 60,000 gallons per day per foot.

Valley Alluvium

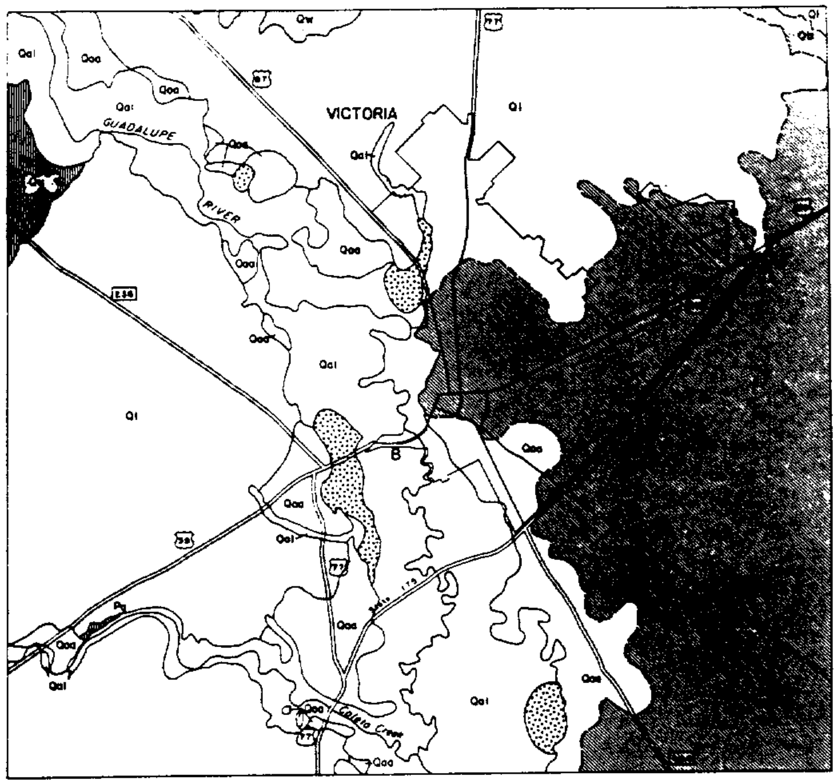
The alluvium in the study area is located in and under the river valleys that exist in the area. The Guadalupe River Valley dissects Victoria County and is responsible for most of the alluvium deposits in the study area. It is of particular interest to this study because of its proximity to the City of Victoria, and because of its proximity to the city wells used for water supply. The Guadalupe River has cut a valley into the Coastal Plain and has meandered in this valley over a lateral distance of more than a mile. The river has over geologic time cut deeper courses than the present river bottom. As these older courses were abandoned and/or backfilled (maybe due to rises in sea levels), deposits of clay, silt, sand, gravel, and boulders were deposited in them (Guyton, 1984).

Mr. Dale Sparks, manager of the Heldenfels Construction pits located northwest of Victoria and north of the City Park, reports there are about 8 to 10 feet of soil and fine material above the gravel, and that gravel thickness ranges from 20 to 75 feet and averages about 30 feet at the locality of the pits. Mr. Sparks reports that the material excavated is about 40 percent sand and 60 percent gravel with the gravel sizes as large as three inches in diameter. The figures quoted by Mr. Sparks support previous estimates indicating that the total thickness of alluvium, including the alluvial soil, in this locality may range from 28 to 85 feet (Guyton, 1984).

A water well contractor, Mr. J.E. Leeper, reports that the gravel, and presumably the Guadalupe River alluvium, extends to a depth of about 100 feet in some parts of the valley. Electric and drillers' logs of abandoned City wells 6 and 9, located near Water Plant 1 in the Park, indicate that the depth to the base of the alluvium at these sites is 64 and 93 feet, respectively. The drillers' log of Well 56 in the report by Guyton (1984) indicates the depth to the base of the gravel is 49 feet at this site. Records by the Texas Highway Department of borings made to investigate conditions for construction of bridges for the crossing of the Guadalupe River by Highway 59 indicate that the maximum thickness of alluvium penetrated by the borings was about 45 feet at this site. The locations of the borings and the major gravel pits are shown in Figure 5-25 (Guyton, 1984).

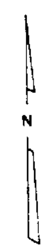
Sites for visual inspection of the gravel are few because most of the gravel in gravel pits and along the river are under water (Guyton, 1984). In the thin beds that could be seen, the material was poorly sorted, containing a wide range of grain sizes. This was verified by inspection of freshly excavated material before it was screened and washed. The grain sizes in this material were reported to range from clay to small boulders. The limited visual inspection did indicate, however, that relatively thin well-sorted layers may exist in the alluvial column. Due to the bedding, vertical hydraulic conductivity of the gravel may be relatively low (Guyton, 1984).

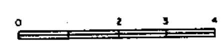
There is no evidence of pump tests or modeling studies that estimated the transmissivities or hydraulic conductivities of the valley alluvium in the study area.



EXPLANATION

- Qal RECENT ALLUVIUM
- Qoa OLDER ALLUVIUM
- Qb BEAUMONT FORMATION
- Ql LISSIE FORMATION
- Qw WILLIS FORMATION
- Pg GOLIAD FORMATION
- AREAS OF MAJOR GRAVEL MINING OPERATIONS
- B— LOCATION OF BORINGS FOR BRIDGE CONSTRUCTION





Notes: Base Map from Texas Department of Highways and Public Transportation General Highway Map, February 1983
Geology Adapted from University of Texas Bureau of Economic Geology, Geologic Atlas of Texas, Beeville–Bay City Sheet, 1975

GEOLOGY OF VICTORIA COUNTY AREA

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FIGURE 5-25

5.4 WATER DEMANDS AND WATER LEVELS

5.4.1 Water Demands

To be able to assess the water supply future for Victoria County, the existing and future water demand for the area must be considered. On an annual basis, 85 MGD (95,087 acre-feet/year) of raw water is used in Victoria County. This number includes surface water and groundwater supplies. Non-municipal users are the largest water users in the county, as shown in Section 3.0. The non-municipal use is 71 MGD (80,000 acre-feet/year) of the 85 MGD (95,087 acre-feet/year) of total use; therefore, only a small portion of the raw water use in the county is for municipal uses. Of this 85 MGD (95,087 acre-feet/year), approximately 49 MGD (55,000 acre-feet/year) is supplied by surface waters. The cities in the county use groundwater as their primary water source, but the option of using surface waters is possible.

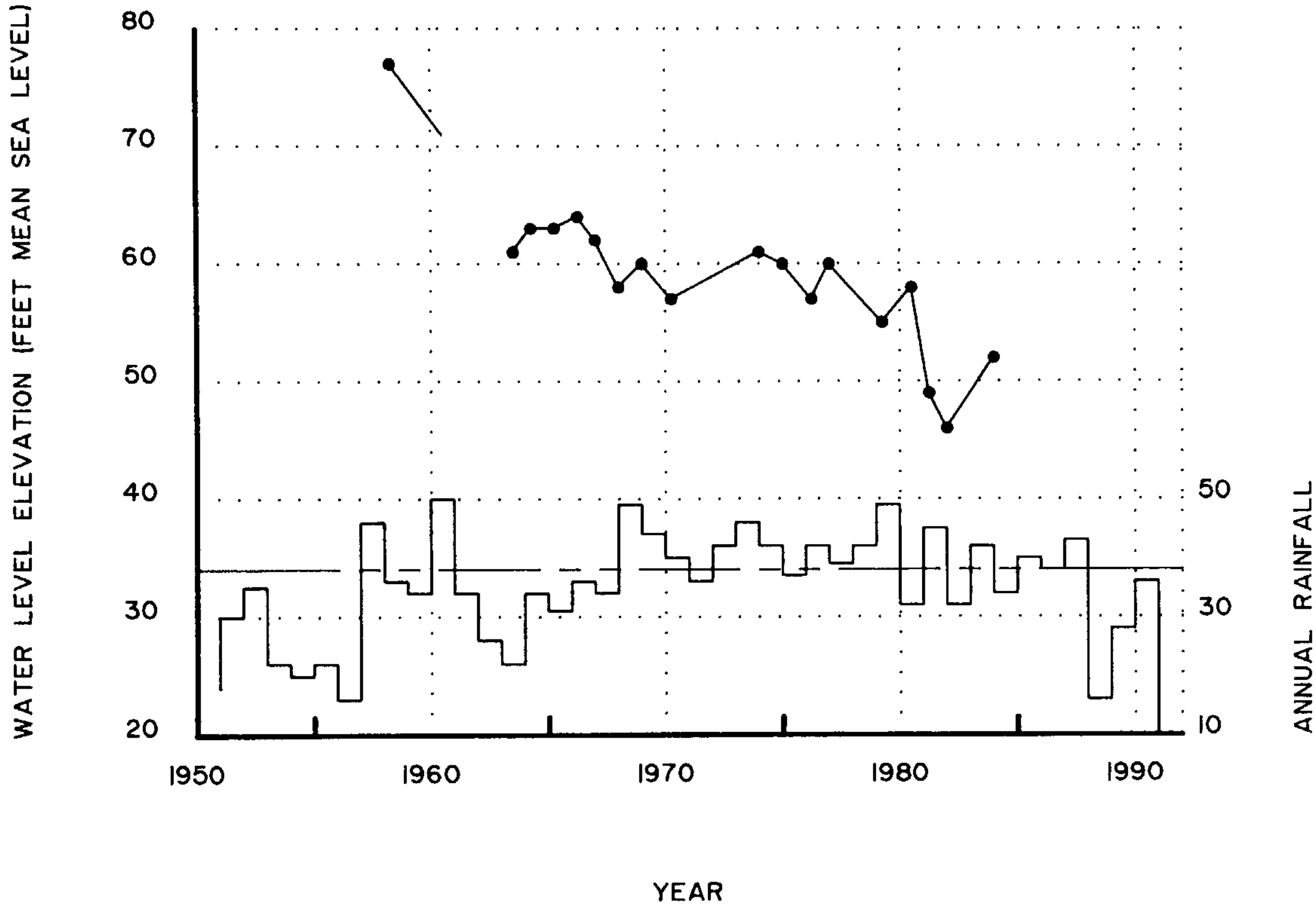
Projected water use in the year 2040 was also shown in Section 3.0. The municipal water use is estimated on projected population and per capita water use. Non-municipal uses are estimated based on industry and economic forecasts. The estimated water use in the year 2040 is 146 MGD (163,262 acre-feet/year). The largest increase in water use is projected to come from the manufacturing sector of the non-municipal water users, which grows from 24 MGD (27,036 acre-feet/year) in 1990 to 80 MGD (90,147 acre-feet/year) in 2040. Only moderate increases in water use from the cities in the county are expected. Since approximately 49 MGD (55,000 acre-feet/year) of water to meet the 1990 demands came from surface waters and the balance in groundwater, the increased need for water in 2040 will have to be met from one or both of these two sources.

5.4.2 Groundwater Levels

Groundwater levels are important indicators of an aquifer's condition and its ability to continue producing water. The groundwater level data for Victoria County are sparse compared to most coastal areas on the Texas coast. Figure 5-24 is a map of the locations of the wells used to check the trends groundwater levels have experienced since the year 1950. Most of the data are incomplete and some wells contain only a few points of measurement along the period of record. All of the wells that gave enough data to graph in order to develop a trend in the groundwater levels seem to be experiencing a decline (see Figures 5-26, 5-27, 5-28, 5-29, 5-30, 5-31 and 5-32). The wells used for the trend analysis are state monitoring wells; therefore, they have no direct influence from pumping except revealing the cone or cones of depression that have occurred due to the water supply wells in the area.

If pumping at a constant rate continues over time, an equilibrium will develop and the cone of depression will stabilize. This is only true if the current rate of pumping has not surpassed the safe yield of the aquifer. If either the safe yield of the aquifer has been exceeded or the rate of pumping increases, the cone of depression will increase. Considering the projected increases in county water demands, and assuming that at least a part of that demand will be met by groundwater, it can be expected that water levels in the future will continue to fall. The graphs of the monitoring wells shown in this study do not indicate that the water levels are reaching an equilibrium at this time.

Another trend considered while analyzing the groundwater level time series was the response the groundwater levels had to monthly precipitation (see Figure 5-33). Detailed data used to plot Figure 5-33 indicate that groundwater levels demonstrate more of a seasonal variation than a variation in response to monthly precipitation. For example, the water levels are always lower in July, August and September, due to irrigation (both



STATE WELL #79-08-801
EVANGELINE AQUIFER

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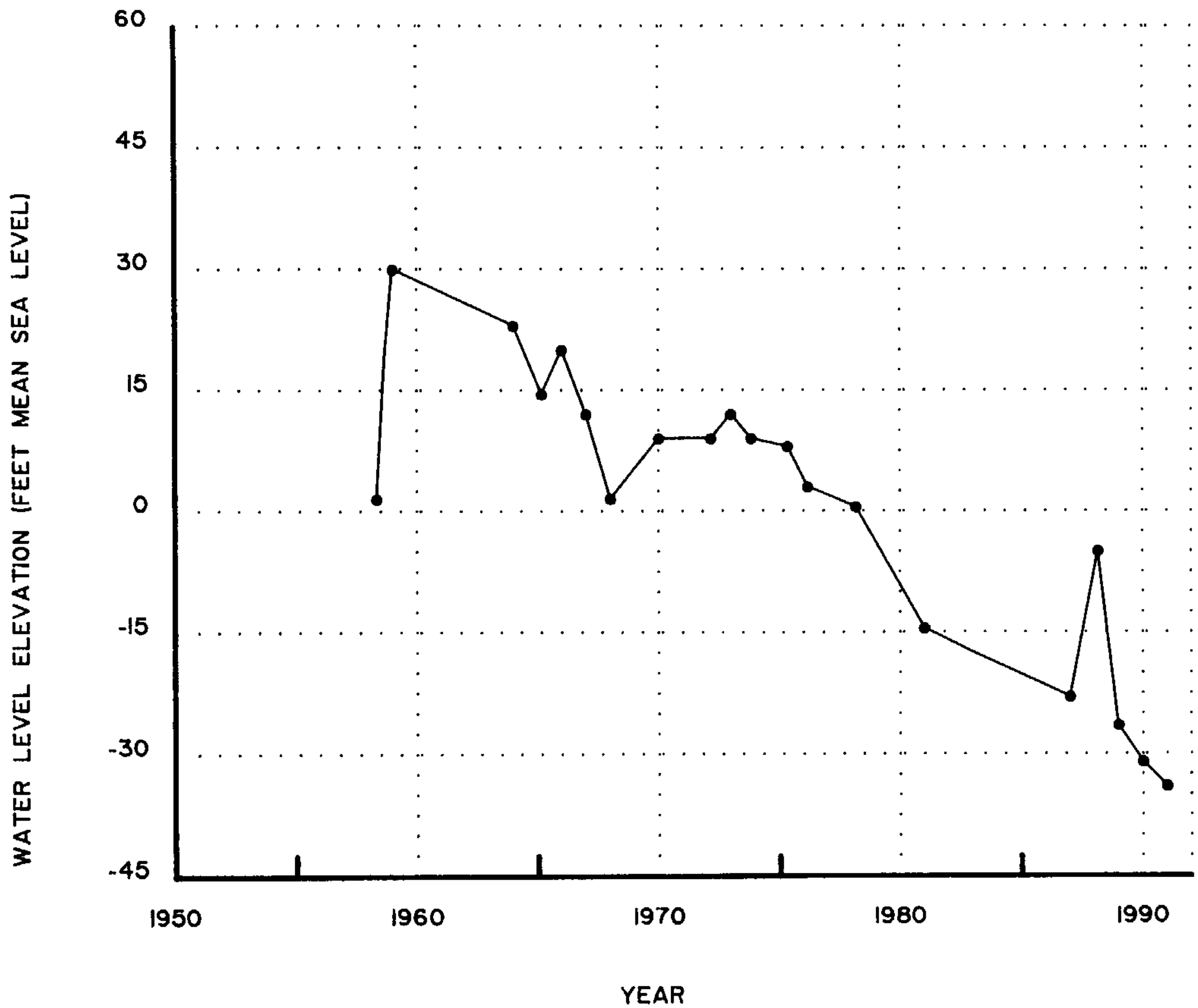
FIGURE 5-26



STATE WELL #80-09-101
EVANGELINE AQUIFER

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FIGURE 5-27

STATE WELL #80-01-301
EVANGELINE AQUIFER

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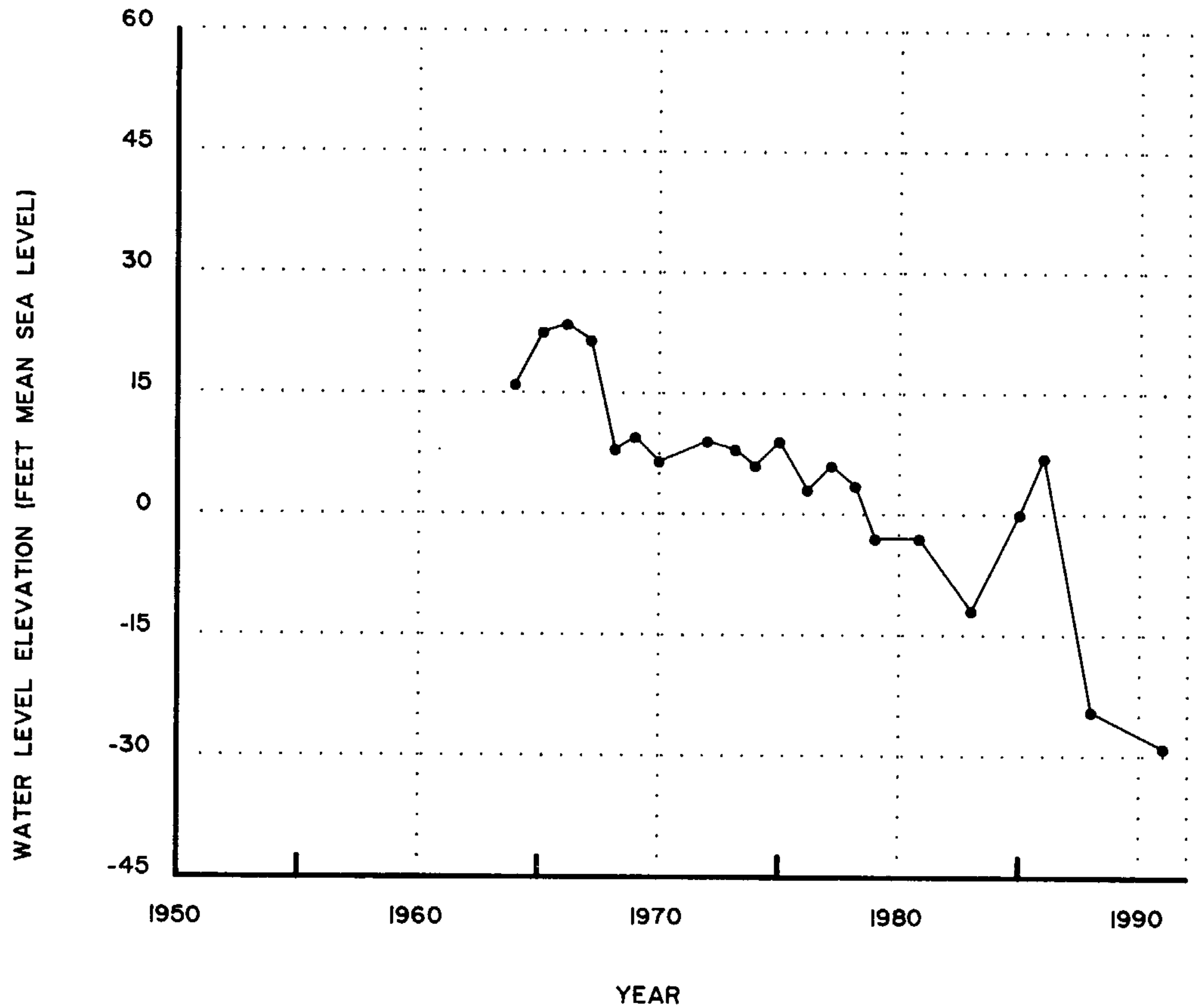
FIGURE 5-28



STATE WELL #80-01-302
EVANGELINE AQUIFER

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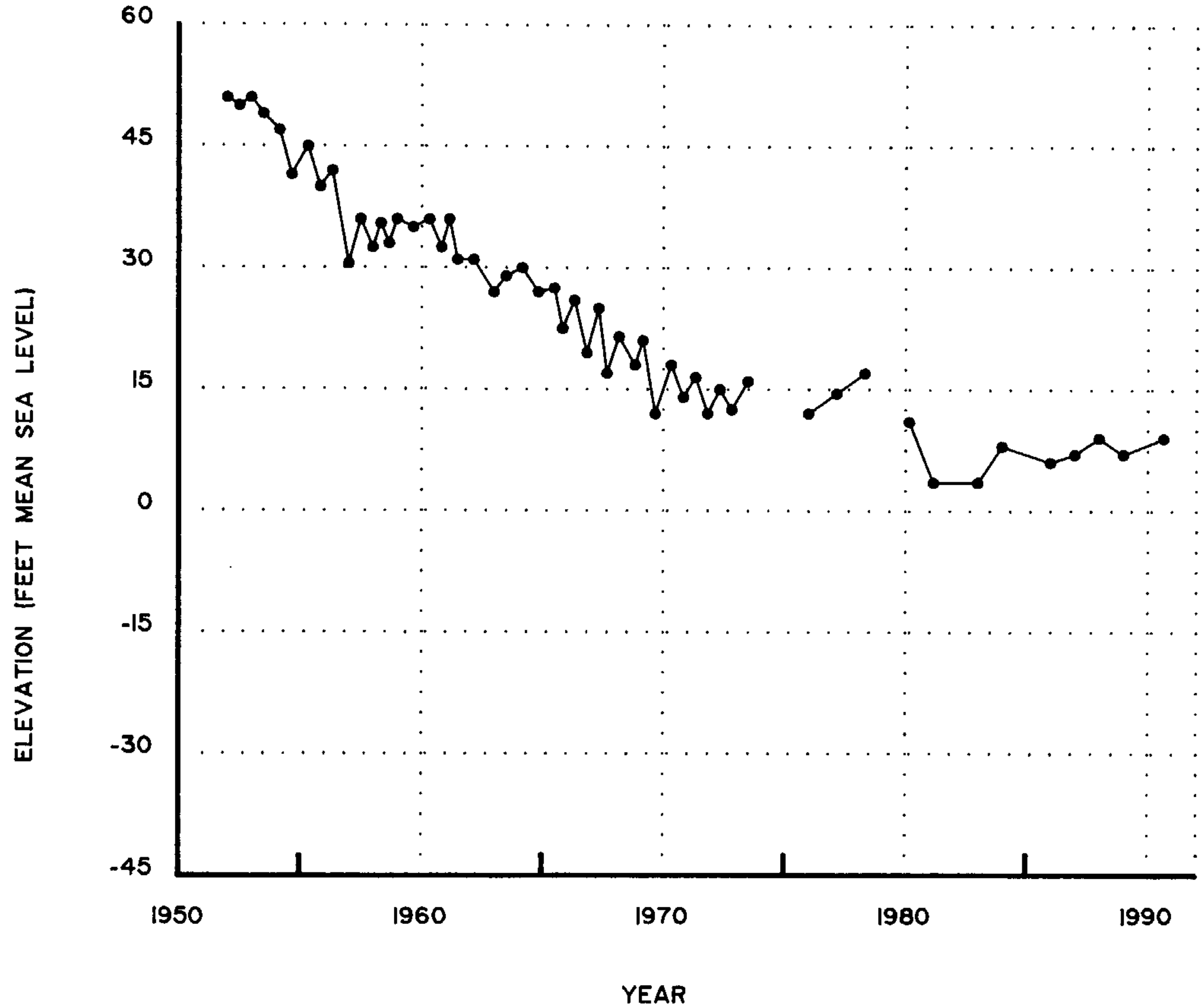
FIGURE 5-29



STATE WELL #80-17-501
EVANGELINE AQUIFER

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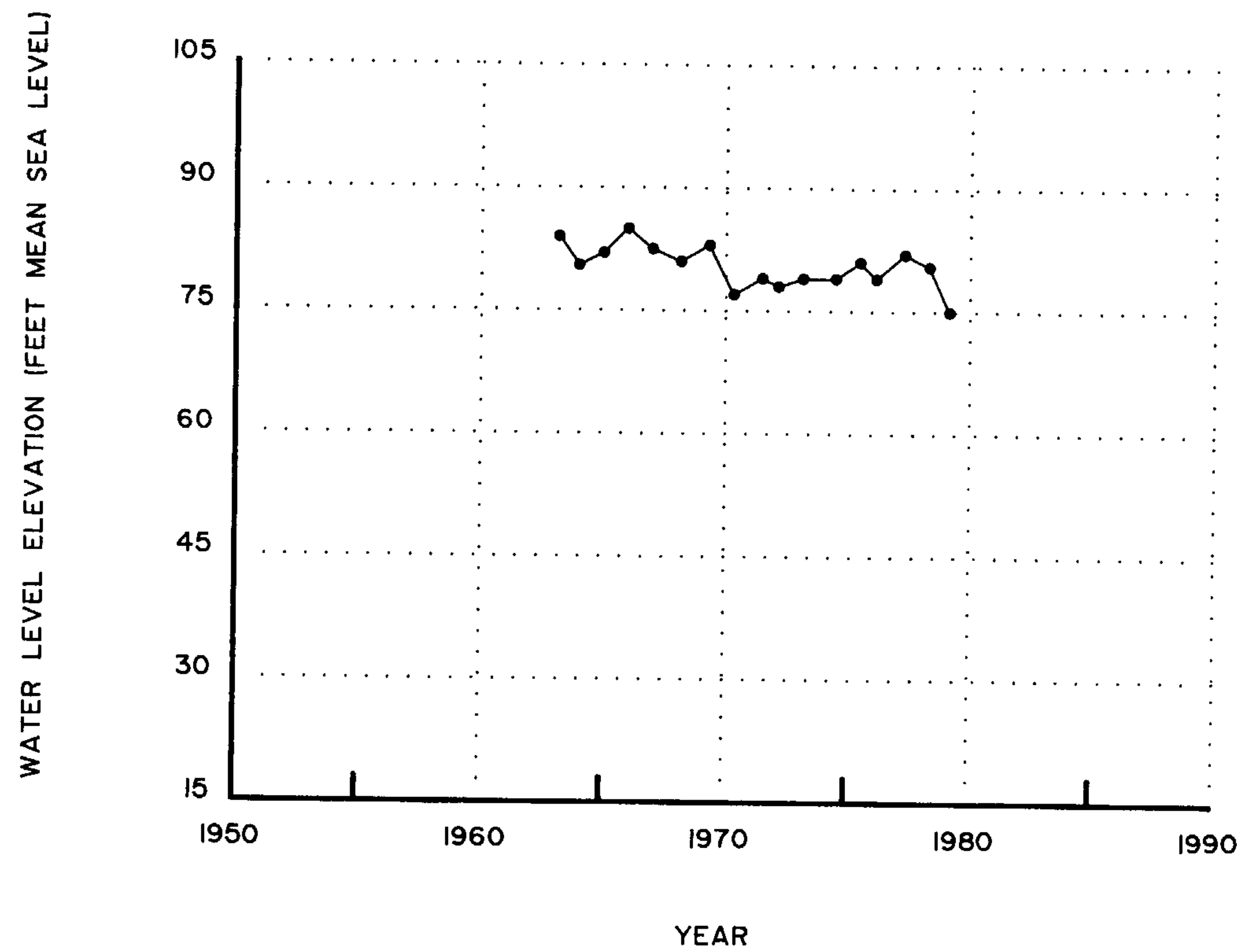
FIGURE 5-30



STATE WELL #67-64-801
EVANGELINE AQUIFER

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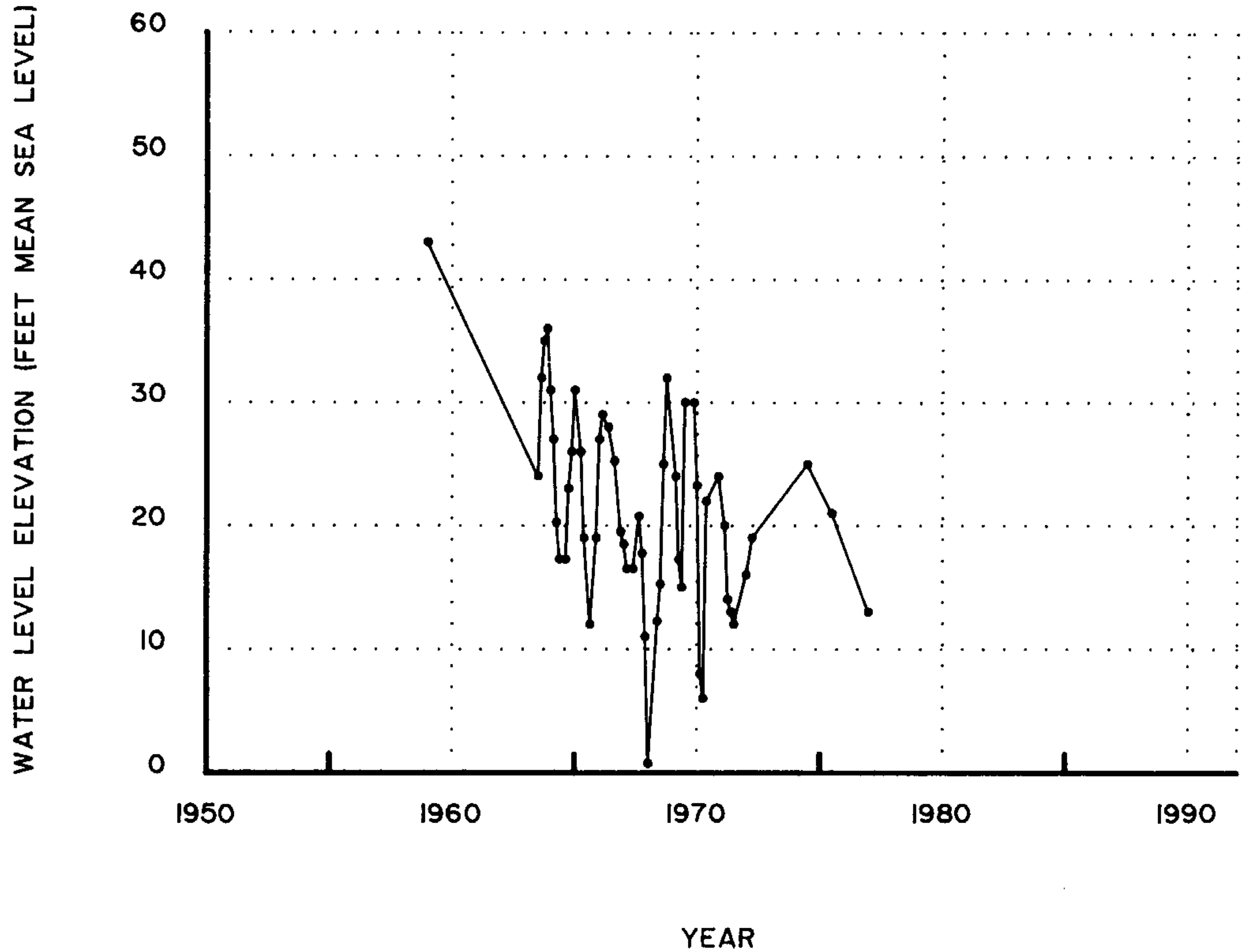
FIGURE 5-31



STATE WELL #79-16-601
CHICOT AQUIFER

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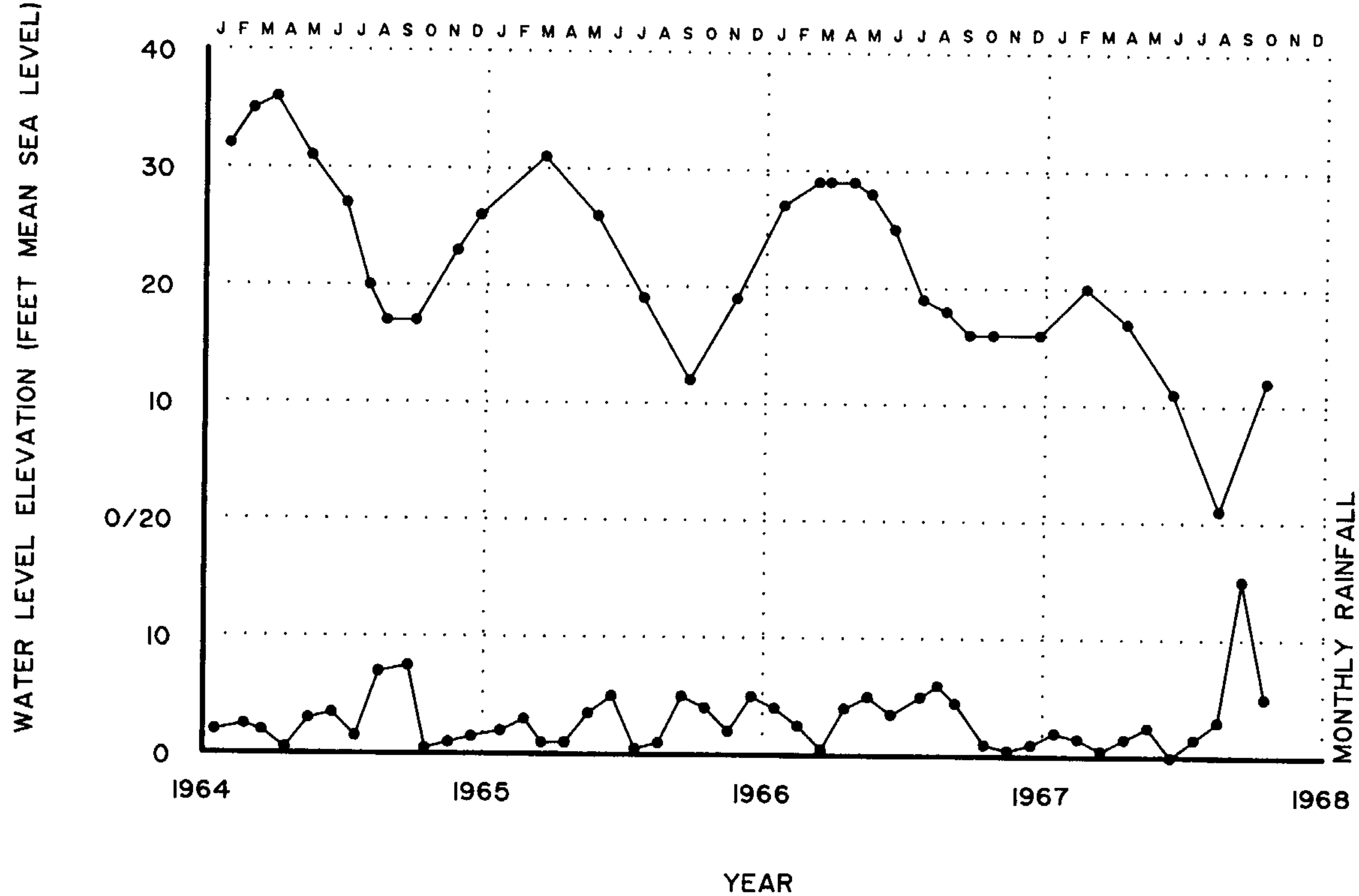
FIGURE 5-32



STATE WELL #79-16-601
CHICOT AQUIFER

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FIGURE 5-33

agricultural and for lawns), in those months than in January, February and March, when water demand is smaller. The lowering of the water levels in the summer may also be due to less effective recharge. Effective recharge is precipitation less evapotranspiration. Because evapotranspiration is very high in the summer, the potential for recharge is small. Therefore, it is probably a combination of demand and lack of effective recharge that is causing the variations in water levels shown in Figure 5-33.

Although there are a few wells in Victoria County that are monitoring wells, the data base for the County is sparse. The problems with the existing data include no long term data, insufficient number of wells used for monitoring purposes, and incomplete records for the existing monitoring wells. With existing data, it is possible to demonstrate that the water levels have been falling since at least the 1950s. The declines vary throughout the region but seem to be the greatest in the vicinity of the City of Victoria. The water levels have declined even though there has not been a change in effective recharge. So the aquifer is responding to increased demands.

5.5 CONCEPTUAL MODEL

5.5.1 Introduction

To better conceptualize the water budget of Victoria County, a mass balance of the county has been developed. This mass balance provides a concise description of the actions and interactions of the water resources in the study area. It is also a starting point in the attempt to develop a calibrated simulation model for the purpose of becoming more knowledgeable about aquifer action/reaction scenarios.

5.5.2 Mass Balance

The first steps in putting together a mass balance is to define the components of the water budget in the particular study area. For Victoria County, the components include inflows to the system, outflows of the system, and change in storage within the system. The equation is as follows:

$$\text{INFLOW} - \text{OUTFLOW} = \text{CHANGE IN STORAGE}$$

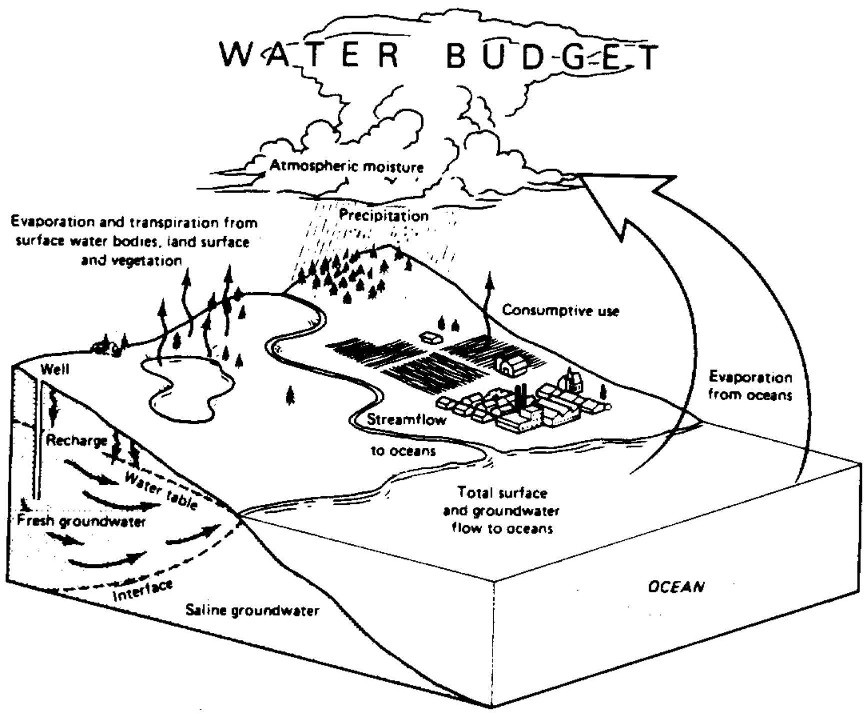
Victoria County has several variables for each component of this mass balance. A table with parts of the mass balance data base can be found in Appendix C. The data are for the period 1970 to 1990.

With all of the components broken down into specific variables, the equation for a mass balance expands into the following:

$$P + SI + GI - E - SO - GO - CU = \text{CHANGE IN STORAGE}$$

where:
- P = Precipitation,
- SI = Surface Water Inflow,
- GI = Groundwater Inflow,
- E = Evapotranspiration,
- SO = Surface Water Outflow,
- GO = Groundwater Outflow, and
- CU = Consumptive Use.

The inflows to the system in the study area come primarily from three sources: precipitation, surface-water inflow, and groundwater inflow (see Figure 5-34). Specifically for Victoria County, precipitation comes in the form of rainfall at an average of 38 inches/year (see Figure 5-3). The second form of inflow to the system is surface-water inflow. This comes primarily from the San Antonio River, Coleto Creek, and



HYDROLOGIC BUDGET OF COTERMINOUS UNITED STATES
(U.S. GEOLOGICAL SURVEY.)

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FIGURE 5-34

Guadalupe River. The Guadalupe River is the most important source because it dissects the County and travels within a large area of alluvium deposits in the flood plain.

Groundwater inflow to the system comes from recharge that occurs in the aquifer outcrops just north of the county. Once infiltration into the system has taken place, the groundwater moves south and southeast through the county. Groundwater inflows can also occur due to losing streams. This can especially be the case in parts of Victoria County where the stream beds are underlain by large deposits of alluvium. These losing streams tend to recharge aquifers that have potentiometric surfaces below the surface elevation of the river or lake.

Outflows to the system consist of evapotranspiration, surface-water runoff, groundwater outflows, and consumptive uses. Specifically for Victoria County, potential evapotranspiration averages 61.58 inches/year. This is not the actual evapotranspiration but only the amount that could occur if there were enough soil moisture to meet all the evapotranspiration demand. Surface-water runoff is a major outflow. This runoff results from water that does not have time to infiltrate into the groundwater system before it reaches a stream or river and runs into the Gulf of Mexico. Groundwater outflows leave the County primarily in the direction of the Gulf of Mexico. The groundwater is pushed along by higher potentiometric heads in the recharge areas north of the study area. Another way groundwater can leave a system is by flowing into a gaining river which flows outside the study area.

The last major outflow to a regional water budget is the consumptive uses. These can occur by taking from surface waters or groundwaters and using the water for a variety of purposes. Some of the uses include public water supplies, industry consumption, and agricultural/irrigation. Although some of these uses put some of the water back into the system, such as infiltration from irrigation, much of the water is lost from the system.

To put together a mass balance of a system such as the one described above, the interactions within the system must also be understood. The major interactions in the Victoria County study include surface water and groundwater interactions, especially through the alluvium deposits, recharge characteristics such as runoff versus infiltration after rainfall events, increased evapotranspiration and infiltration due to irrigation, and change in storage due to consumptive uses. These all come together to form a system that can be simulated using a computer model. Once the model is complete, the effects of increased pumping in the Victoria County can be predicted. This aids in future planning of the counties water resources.

To produce a simplified steady-state (no change in storage) mass balance and to estimate the recharge of the aquifer system, the above equation can be expressed as follows:

$$P - E - SO = CU$$

The analysis of this mass balance is shown in Appendix C. Based upon data for Victoria County for the period 1970 to 1990, the potential annual average recharge in Victoria County is 2.4 inches. This value is a maximum. Since potential evapotranspiration exceeds precipitation for several months at a time, soil moisture depletion must be replenished prior to recharge occurring. Accounting for this compensation is not possible in this simple mass balance. The annual average recharge will be varied in the calibration runs of the digital model so that measured groundwater levels can be reproduced. The recharge value developed in this manner will be more reliable than the value computed above.

5.6 REGIONAL GROUNDWATER MODEL

5.6.1 Purpose and Scope

The computer modelling study is an important feature of the Regional Groundwater study for the City of Victoria and Victoria County. The primary objectives of the study are:

- Simulate the flow of groundwater in Victoria County under existing conditions specifically focused on reproducing the large drawdowns observed in the vicinity of the City of Victoria.

- Predict the effect of projected future pumping on the drawdowns in existing wells.

This is a planning level model designed to show at a regional scale the potential impacts of projected future ground water withdrawals.

5.6.2 Description of the Groundwater Modelling Software

The model of groundwater flow that was used in this study is a fully three-dimensional, dynamic finite element model, DYNFLOW. The model has been developed by CDM engineering staff.

The governing equation for three-dimensional groundwater flow that is solved by DYNFLOW is:

$$S_s(d\varnothing/dt) = d(K_{ij}d\varnothing/dx_j)/dx_i \qquad i,j = 1,3$$

where the state variable Ø represents the piezometric head, $\mathbf{K}_{ij}$ represents the hydraulic conductivity in the principal directions in an orthogonal reference frame, $\mathbf{S}_s$ is the specific storativity (or specific yield under phreatic conditions), $\mathbf{x}_j$ is a cartesian coordinate and $\mathbf{t}$ is time.

The above equation is solved in conjunction with the specified boundary conditions. DYNFLOW accepts various types of boundary conditions which enable the accurate representation of real life situations mathematically. The boundary conditions include:

- fixed head boundaries (lakes, rivers, well locations)
- mass flux boundaries (rainfall, infiltration, pond leakage, no flow streamlines)
- rising water boundaries that are hybrid boundaries (specified head or specified flux depending on the system status).

DYNFLOW uses a triangular element in plan view, which gives wide flexibility in grid variation over the area of study. Each hydrogeologic unit is represented as one or more layers in the model. A layer is sandwiched between two levels. Within each level of the model, an identical horizontal grid is used, but the thickness of each model layer (vertical distance between levels in the model) can vary at each point in the grid.

The DYNFLOW code has been reviewed and validated by the International Groundwater Modelling Center of the Holcomb Research Institute (van der Heijde, 1985).

5.6.3 Model Description

Model Area

The study area along with the major water bodies and roads is shown in Figure 5-35. The major streams in the model include the San Antonio River, Coleto Creek, Guadalupe River, Arseno Creek, Garcitas Creek, Casa Blanca Creek, Marcado Creek, Placedo Creek and Lavaca River.

The study area for the Regional model includes all of Victoria County and parts of Refugio, Goliad, DeWitt, Lavaca, Jackson and Calhoun Counties. Although the aim of the modelling study is to represent the groundwater flow in Victoria County a larger area was considered to create appropriate boundary conditions for the model. As shown in Figure 5-36, the model extends all the way through Calhoun county to the Gulf of Mexico in the south and is bounded on the east by the Lavaca River. The northern boundary extends beyond Victoria County into DeWitt County to the upland limit of the Evangeline Aquifer outcrop area. The western boundary is formed by a line approximately parallel to the direction of regional groundwater flow, drawn from the updip limit of the Evangeline Aquifer to the Gulf of Mexico. The model incorporates a total area of some 3790 square miles.

Model Stratigraphy

A North-South cross-section (see Figure 5-37) passing through Victoria County is shown in Figure 5-38. Three hydrogeologic units the Beaumont clay, the Chicot Aquifer and the Evangeline Aquifer were considered in this study. The Chicot and Evangeline Aquifers are the sources of almost all the ground water supply for Victoria County. Also, groundwater flow in the Chicot and Evangeline Aquifers is effectively isolated from the underlying aquifers by a persistent clay zone called the Burkeville aquiclude. As a result

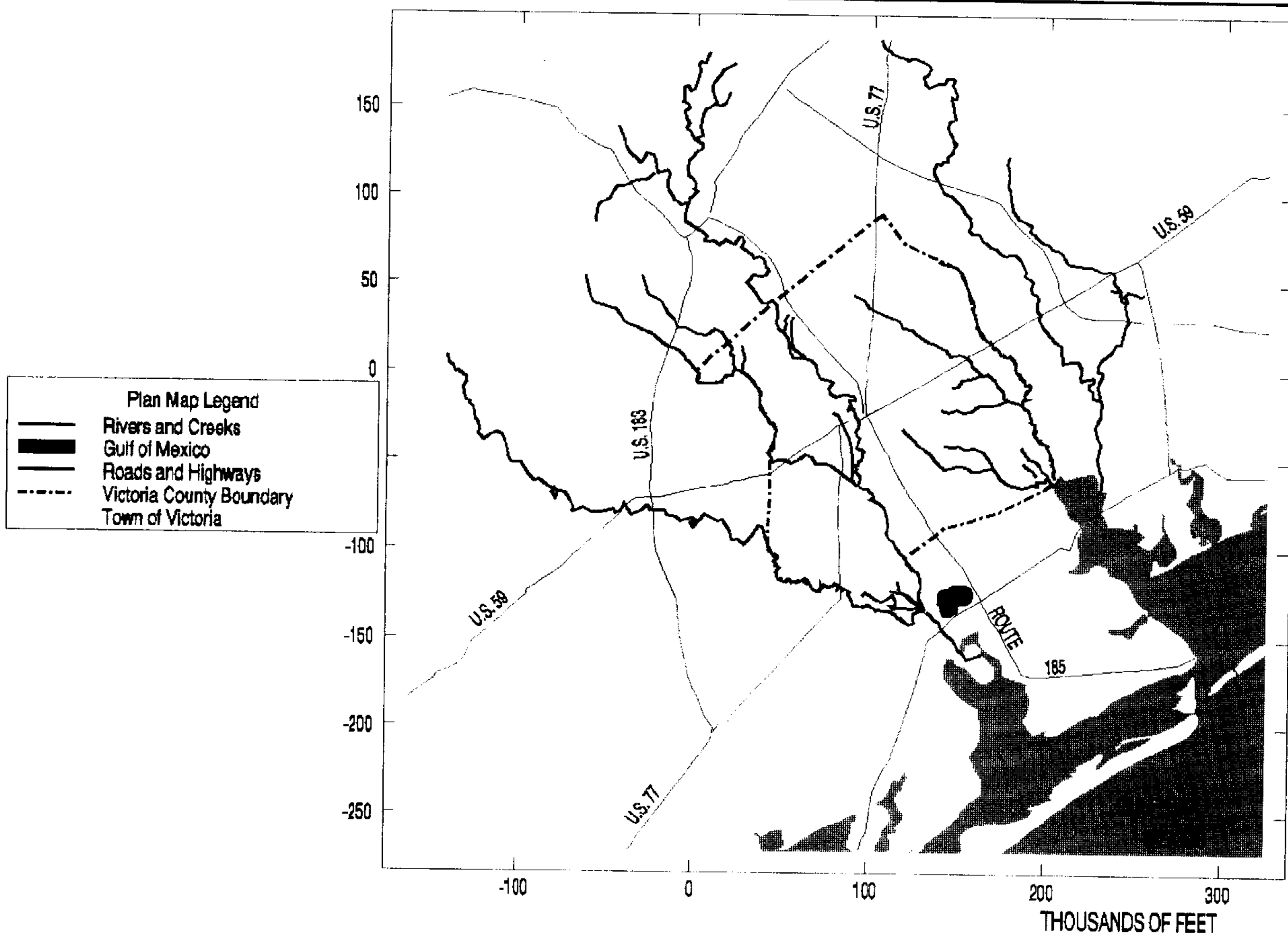


FIGURE 5-35

Study Area Geographic Features

Victoria County Regional Groundwater Model

CDM

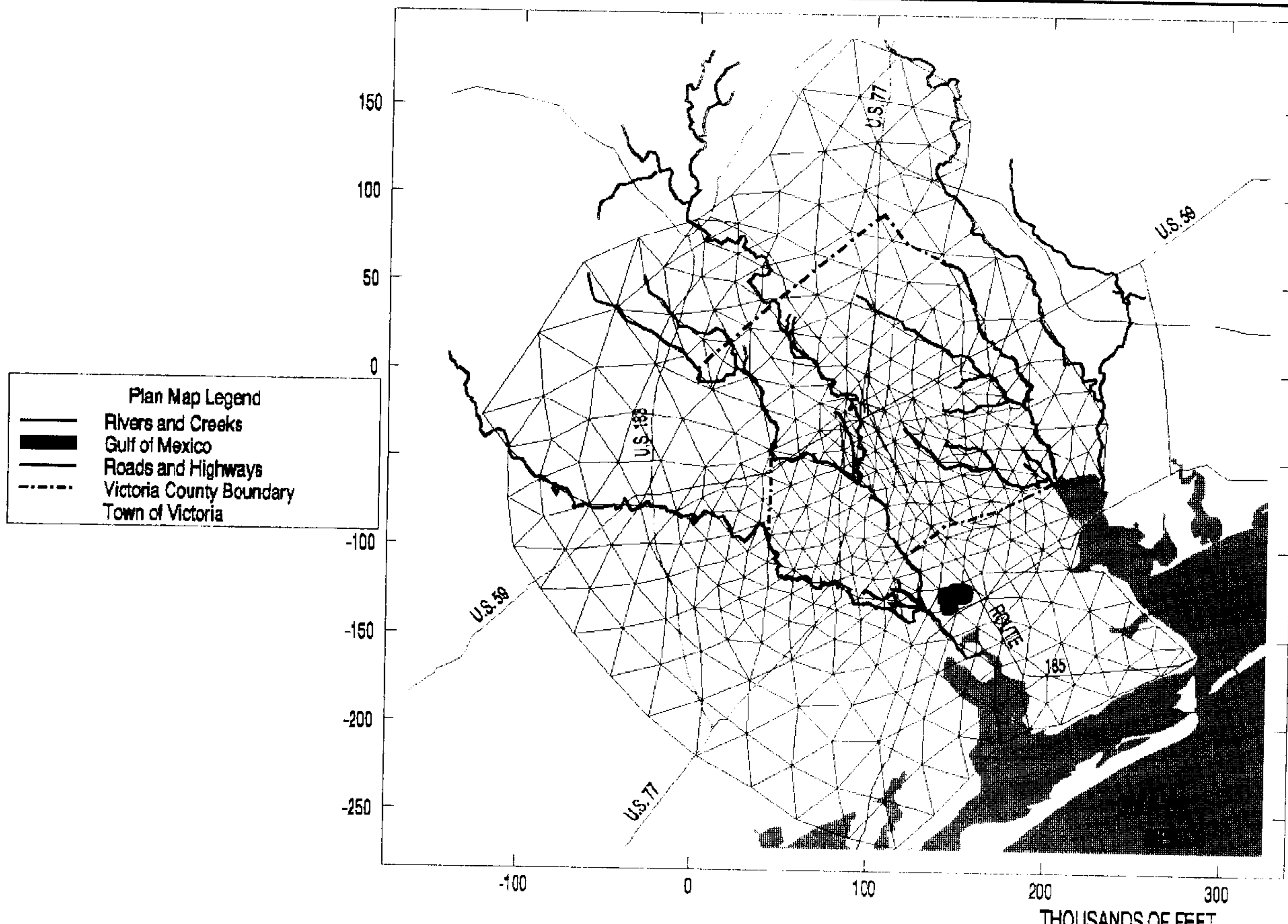


FIGURE 5-36

Finite Element Computational Grid
With Study Area Geographic Features

Victoria County Regional Groundwater Model

CDM

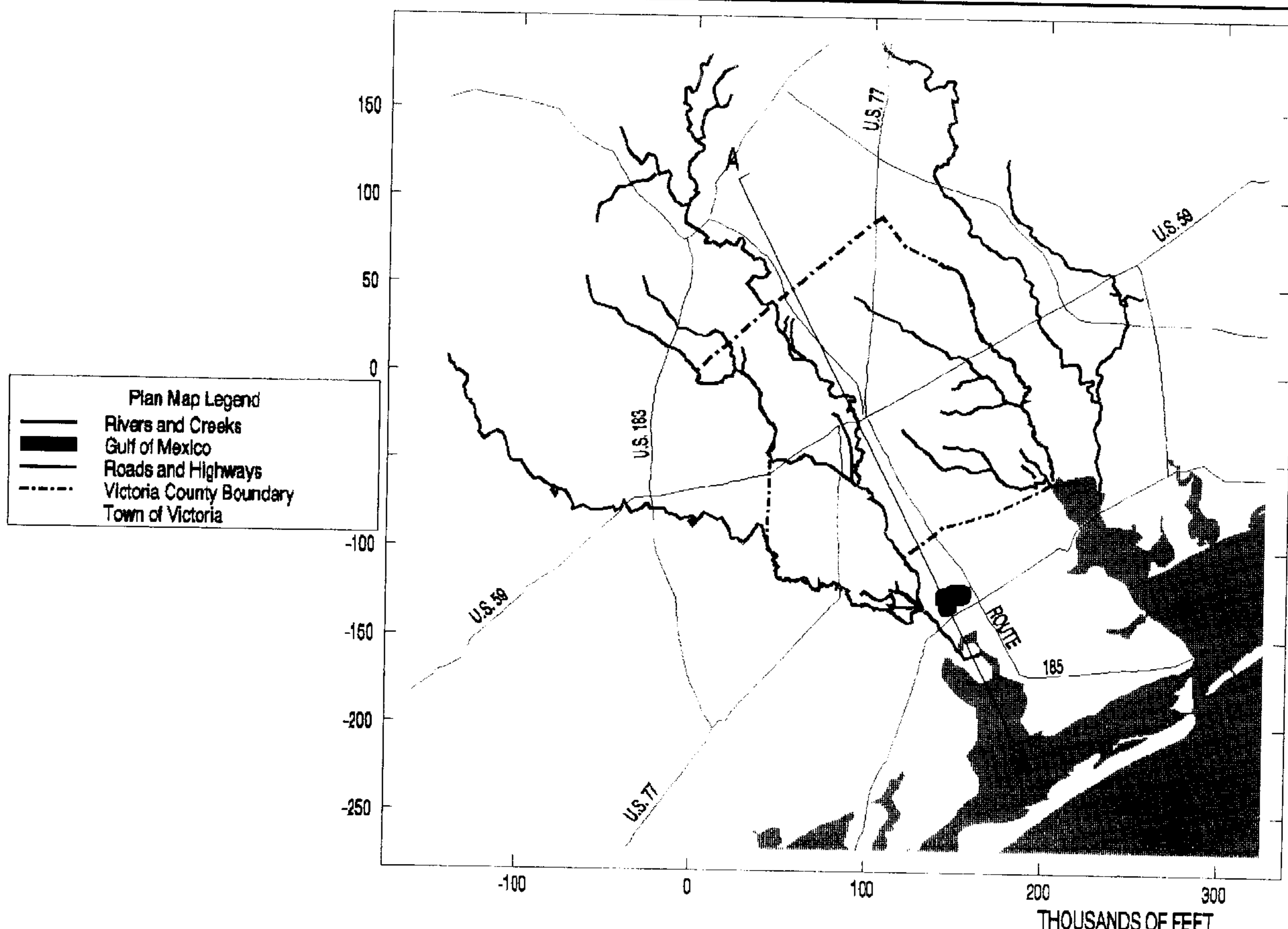


FIGURE 5-37

Study Area Geographic Features
Showing Location of Cross-Section A-A

Victoria County Regional Groundwater Model

CDM

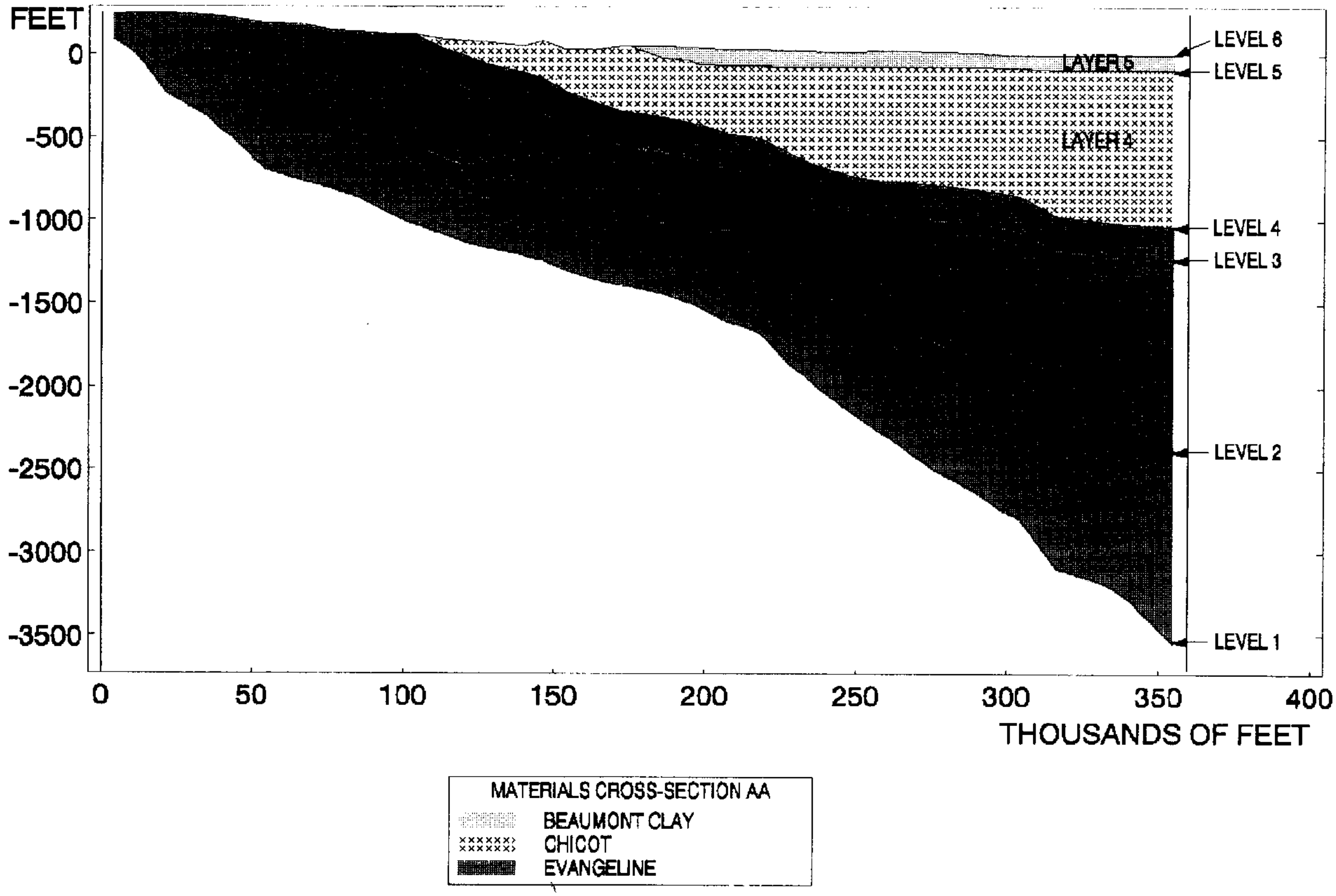


FIGURE 5-38

North-South Cross-Section (A-A) Showing Model Stratigraphy

Victoria County Regional Groundwater Model

CDM

of this, the underlying aquifers were not considered in the present study. It can be seen in Figure 5-38 that the Chicot and Evangeline Aquifers dip to the south-east with outcrops in Victoria County. The Beaumont clay overlies the Chicot Aquifer in the southeastern portion of the model area. Alluvial deposits found near the surface at some locations in the model area are not included in the digital model. The rivers and streams have been included as fixed head boundaries in the digital model and will recharge the aquifer where they are in contact with the aquifer much like the alluvial deposits. Not specifically modelling the alluvium will result in a slightly more conservative approach. A plan showing the outcrop areas of the various hydrogeologic units is shown in Figure 5-39.

The present model consists of 6 levels and 5 layers (see Figure 5-38). The levels are numbered in the ascending order from the bottom to the top, i.e. the base of the Evangeline Aquifer is Level 1 and the ground surface is Level 6. The layers are also numbered in an ascending order from the bottom to the top. The correspondence of the hydrogeologic units to the layers used in the model is described below:

- The Beaumont clay is represented by layer 5 in the model, bounded by Levels 5 and 6. Information about the extent and thickness of the Beaumont clay was obtained from available literature (Guyton, 1984). The elevations of the ground surface (Level 6) were obtained from regional and 7.5 minute USGS topographic maps.

- The Chicot Aquifer is represented by layer 4 in the model. Elevations of Level 4 (base of the Chicot Aquifer) were obtained from Carr (1985).

- The Evangeline Aquifer being relatively thick (about 2500 ft near the Gulf of Mexico), is represented by three layers (1-3) and four levels (1-4) in the model. This enables a reasonable representation of the pumping and provides for a better resolution of the vertical gradients. The elevation of

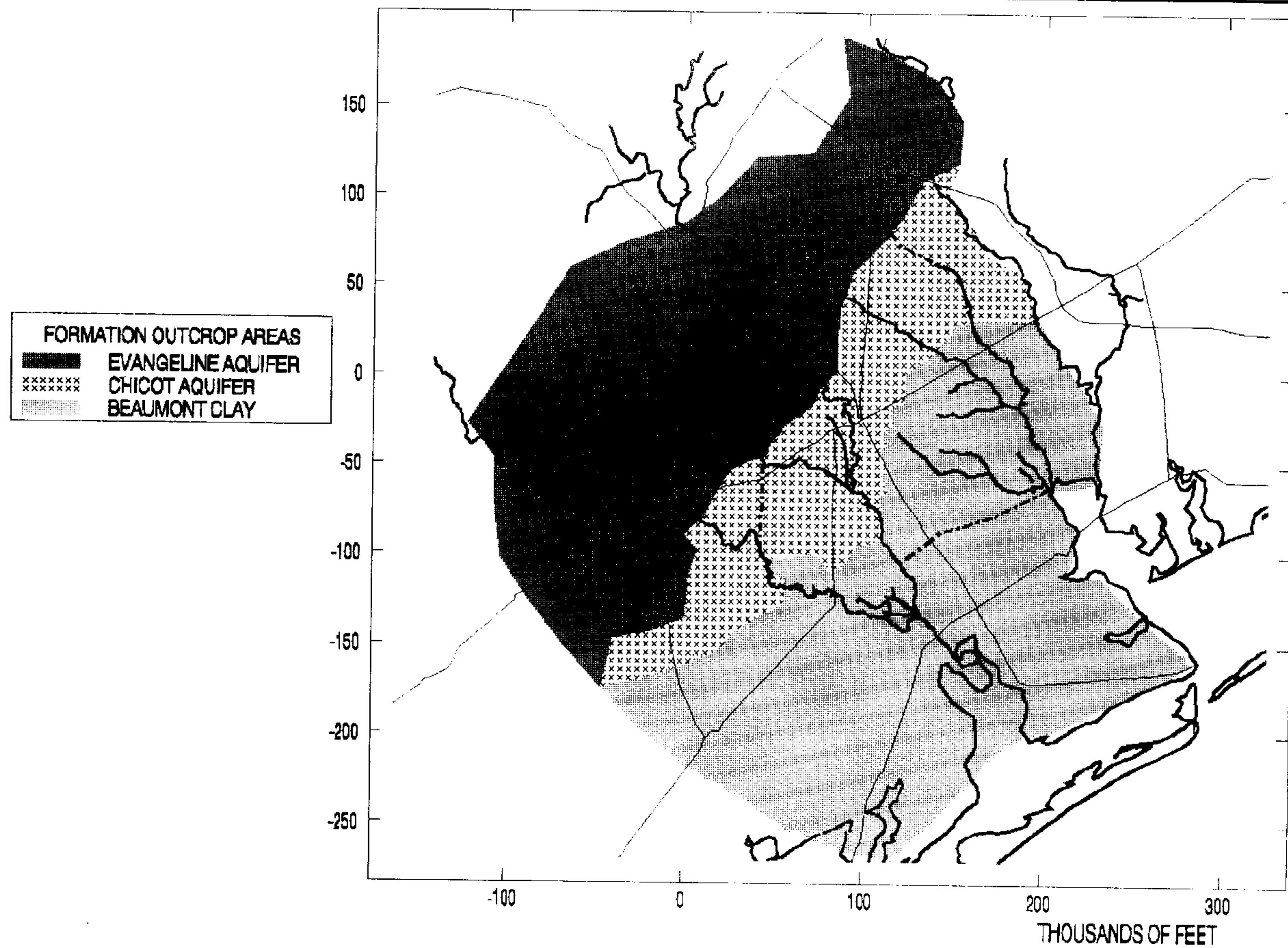


FIGURE 5-39

Plan Map Showing Outcrop Areas for Aquifer Units

Victoria County Regional Groundwater Model

CDM

Level 3 is 200 ft lower than the elevation of Level 4. Level 2 lies midway between Levels 1 and 3. The elevations of Level 1 (base of the Evangeline Aquifer) were obtained from Carr (1985).

Finite Element Grid

The model area was discretized as shown in Figure 5-36 into a grid consisting of 737 elements (triangles) and 394 nodes (vertices of triangles) for computational purposes. In the vertical dimension, as described above, the model area has 6 levels of nodes with 5 layers according to the layering scheme shown in Figure 5-38. The resulting three dimensional grid consists of 2364 nodes and 3685 elements.

Boundary Conditions

The following boundary conditions were specified in the model to develop the simulated flow fields.

- Recharge is assigned as a specified flux to the water table. An average value of 2 inches per year was used. This number was derived based on a hydrological mass balance (see Appendix C) discussed earlier in the report.

- Nodes at the ground surface except for those along the gulf coast were assigned a rising water boundary condition. If the phreatic surface is below the actual land surface elevation, the heads are free. If the phreatic surface rises to the ground surface, the heads are fixed at that elevation and water is discharged from the model at a rate consistent with the fixed head.

- Nodes at the surface along the gulf coast (Level 6) were assigned a fixed head boundary condition. Heads were fixed to represent mean sea level. This allows ground water discharge at the southern boundary of the model to the gulf.

- Perimeter nodes in Levels 2 through 5 along the northern boundary were assigned a no-flow boundary condition. This boundary condition does not allow any flow across the northern boundary and was considered appropriate since the northern boundary is bounded by the outcrop of the Burkeville confining unit.

- Perimeter nodes in Levels 2 through 5 on the western and eastern boundaries of the model are assigned a no-flow boundary condition. Since these boundaries are roughly parallel to the direction of the regional flow, it is expected that the flow across these boundaries will be insignificant. Hence a no-flow boundary condition was considered appropriate.

- Along the southern boundary, nodes below the surface (Levels 2-5) were assigned a no-flow boundary condition which constrains the flow into and out of the model at the Gulf of Mexico. Although this may not be representative of the actual behavior, due to the lack of further information, this boundary condition was used. Since this boundary is situated several miles south of the area of interest it is expected that the impact of this boundary condition would be insignificant. This was confirmed by sensitivity testing as discussed in a latter section of this chapter.

- The bottom of the model, Level 1 is assigned a no-flow boundary condition. As stated earlier, this is justified because the Burkeville confining system effectively isolates the flow in the Evangeline Aquifer from the underlying units.

- All public supply and major pumping are included in the model as specified fluxes at the appropriate node and level to represent the location and depth of the well. The method employed to assign the pumpage is discussed in the following sub-section.

Pumpage

Pumpage information on all the wells in Victoria County was obtained from the database maintained by the City of Victoria. Although the database provided an extensive amount of information about all the wells (approximately 5500) in Victoria County, two important pieces of information were missing:

1. The exact location of the wells
2. A time history of the water withdrawal from each well. Only the capacity of the pump installed at each well is recorded in the database.

Since it would be very difficult and costly to obtain this information, the following procedure was adopted. Only the wells which had pumps with capacities higher than 40 gpm were considered. This reduced the number of wells to a more manageable number of 578. The well numbering system used by the Texas Water Development Board was used to approximately assign the location of the pumping. For example, the pumpage associated with all wells numbered 69-07-xxx was assigned to the center of the 69-07 quadrangle. The pumpage was assigned as specified to the middle of the Evangeline Aquifer and to the bottom of the Chicot Aquifer.

It was ascertained that no major pumping centers are located in the model area outside of Victoria County. Because these areas are far from the city of Victoria which is the area of primary interest in this study, minor pumping outside Victoria County was ignored.

Aquifer Properties

Hydraulic properties were assigned to each aquifer material in the model. The properties assigned include:

- horizontal hydraulic conductivity (ft/day)
- vertical hydraulic conductivity (ft/day)
- specific storativity (1/ft)
- specific yield (a dimensionless number applicable only to the uppermost layer where the phreatic surface occurs)

Adopted values are listed in Table 5-3.

5.6.4 Model Calibration and Verification

To check the accuracy of the model, simulated water levels are compared with actual water levels measured at observation wells. Variables such as aquifer properties, recharge etc. are adjusted within reasonable ranges to values which result in the best representation of the measured heads. This procedure is called calibration. In this study, the calibration effort was focussed on reproducing present day observed drawdown conditions in the vicinity of the City of Victoria. Comparisons of simulated and observed water levels at other locations in the county are also presented here. Water level measurements made at 21 wells in July 1991 and 11 wells in June 1990 were used to calibrate the model. In addition to this, the sensitivity of the model to the boundary condition imposed along the

TABLE 5-3

HYDRAULIC PROPERTIES OF HYDROGEOLOGIC UNITS CONSIDERED IN THE MODEL

Material Name	Horizontal Hydraulic Conductivity (ft/day)	Vertical Hydraulic Conductivity (ft/day)	Specific Storativity (1/ft)	Specific Yield
Beaumont Clay	0.6	6×10^{-4}	5×10^{-7}	0.1
Chicot Aquifer	15.0	2.7×10^{-3}	5×10^{-7}	0.1
Evangeline Aquifer	7.0	2.7×10^{-3}	5×10^{-7}	0.1

gulf (Levels 2-5) was also studied. Furthermore, a transient simulation was performed from 1950 to 1990. Model simulated water level declines were compared qualitatively with observed water level declines. Details of the calibration simulations are described in the following paragraphs.

A steady-state analysis was performed to simulate the 1991 conditions. Figures 5-40 and 5-41 show the location and magnitude of the simulated pumping in the Chicot and Evangeline Aquifers respectively. It can be seen that most of the water (about 90%) is being pumped from the Evangeline Aquifer. Also the pumping is concentrated near the City of Victoria, the southern and north eastern parts of the county. The total water usage in all of Victoria County in 1991 is approximately 85 MGD (95,087 acre-feet/year) of which it is assumed that 50 MGD (55,000 acre-feet/year) is supplied by surface water. The remaining 35 MGD is met by groundwater of which 10 MGD is pumped around the vicinity of the City of Victoria. Since the model is being calibrated to water level measurements made in a summer month (July 1991), the pumpage near the City of Victoria was increased to 14 MGD to reflect the additional summer demand. Hence the overall amount of water pumpage assigned in the model was approximately 39 MGD.

Initial approximations of hydraulic properties were made based on values reported by Carr (1985). These values were then adjusted and the values which reproduce the measured observations most accurately are listed in Table 5-3. The vertical hydraulic conductivities of the Chicot and Evangeline Aquifers are representative of clay properties which is expected considering that these aquifers are characterized as interbedded clay and sand with approximately equal thickness of both.

The sensitivity of the model to the boundary condition imposed at the nodes along the gulf coast below the surface was also tested. Three types of boundary conditions were evaluated:

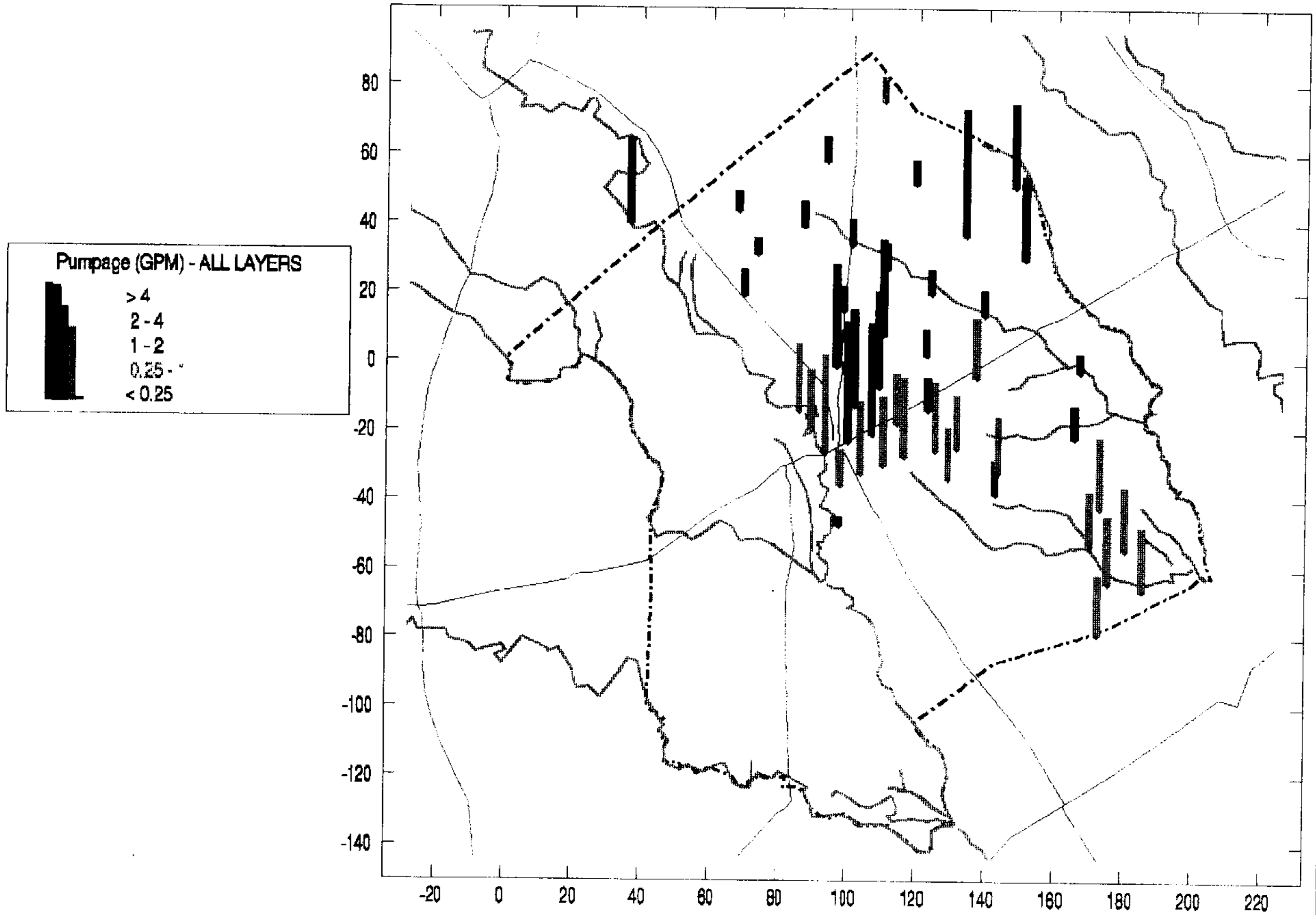


FIGURE
5–40

Bar Plot Showing Location of Simulated Pumping Withdrawal in MGD
From the Evangeline Aquifer in 1991

Victoria County Regional Groundwater Model

CDM

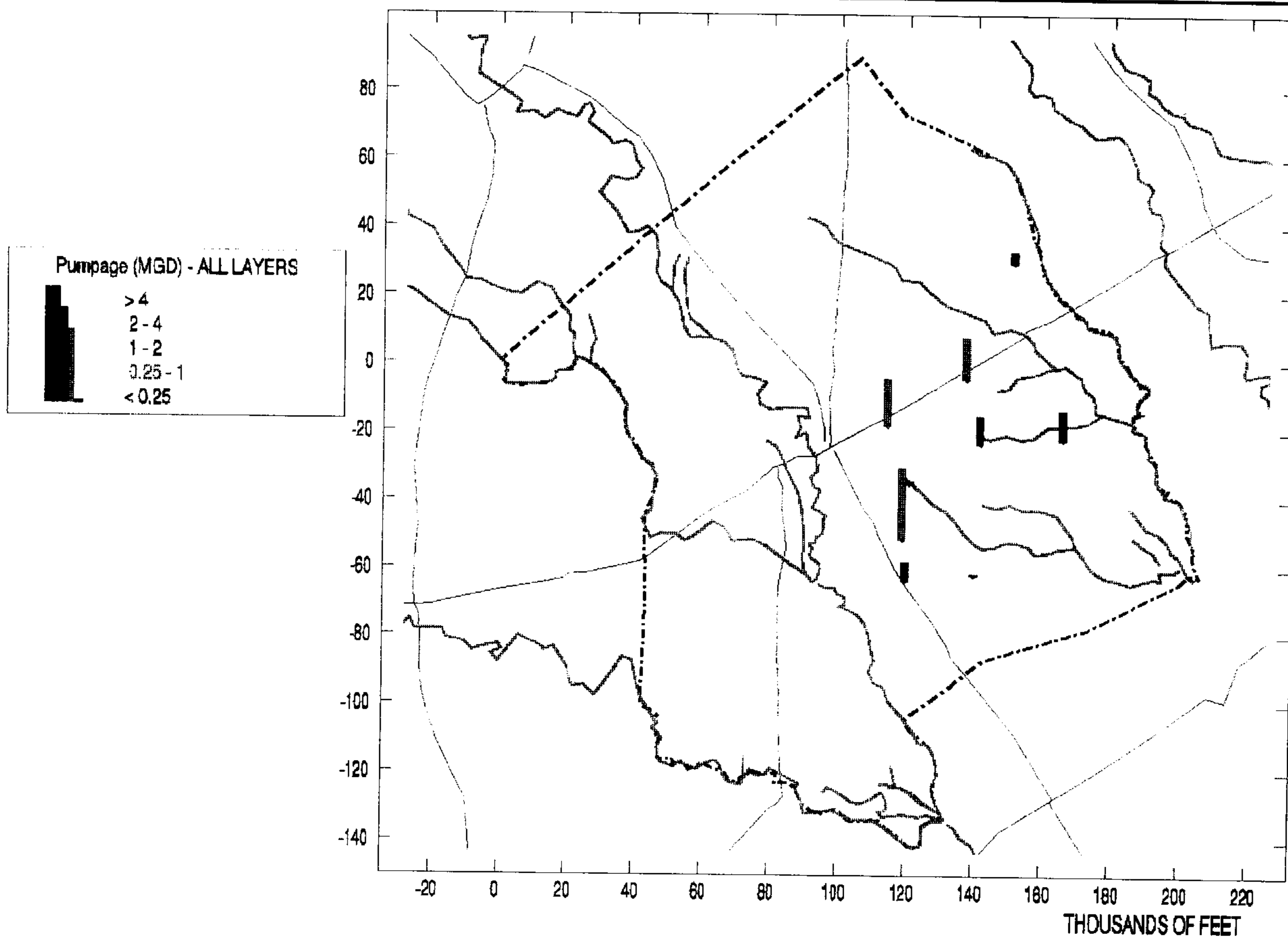


FIGURE 5-41

Bar Plot Showing Location of Simulated Pumping Withdrawal in MGD
From the Chicot Aquifer in 1991

Victoria County Regional Groundwater Model

CDM

- a no-flow boundary condition, which does not allow the flow of water across the southern boundary of the model.

- a fixed head boundary condition (heads fixed at sea level elevations) which allows for flow (inflow/outflow) through the southern boundary of the model beneath the gulf.

- a fixed head boundary condition with heads set to an equivalent fresh water head (40 ft. of sea water is equivalent to 1 ft. of fresh water)

It was observed that although the heads at the nodes in the vicinity of the gulf coast (southern part of Calhoun county) were sensitive to the type of boundary condition used, the heads in Victoria County were not significantly affected (deviations less than 0.5 ft). The no-flow boundary condition was used in all the other simulations described in this report.

Simulated 1990/1991 head contours is the Evangeline and Chicot Aquifers are shown in Figures 5-42 and 5-43, respectively. The flow in the Evangeline Aquifer is primarily northwest to southeast except in the vicinity of the City of Victoria where the influence of intensive pumping has created a cone of depression. The flow in the Chicot Aquifer is also quite similar except at the rivers where the flow lines curve indicating groundwater discharge.

The differences between model simulated water levels and measured water levels at wells in the vicinity of the City of Victoria are shown in Figure 5-44. Table 5-4 summarizes the comparison between model predicted and actual heads. The wells located in the vicinity of the City of Victoria are marked with an asterisk. The model predicts the water levels within 10 feet at most locations except for wells 79-16-903 and 80-09-401. This

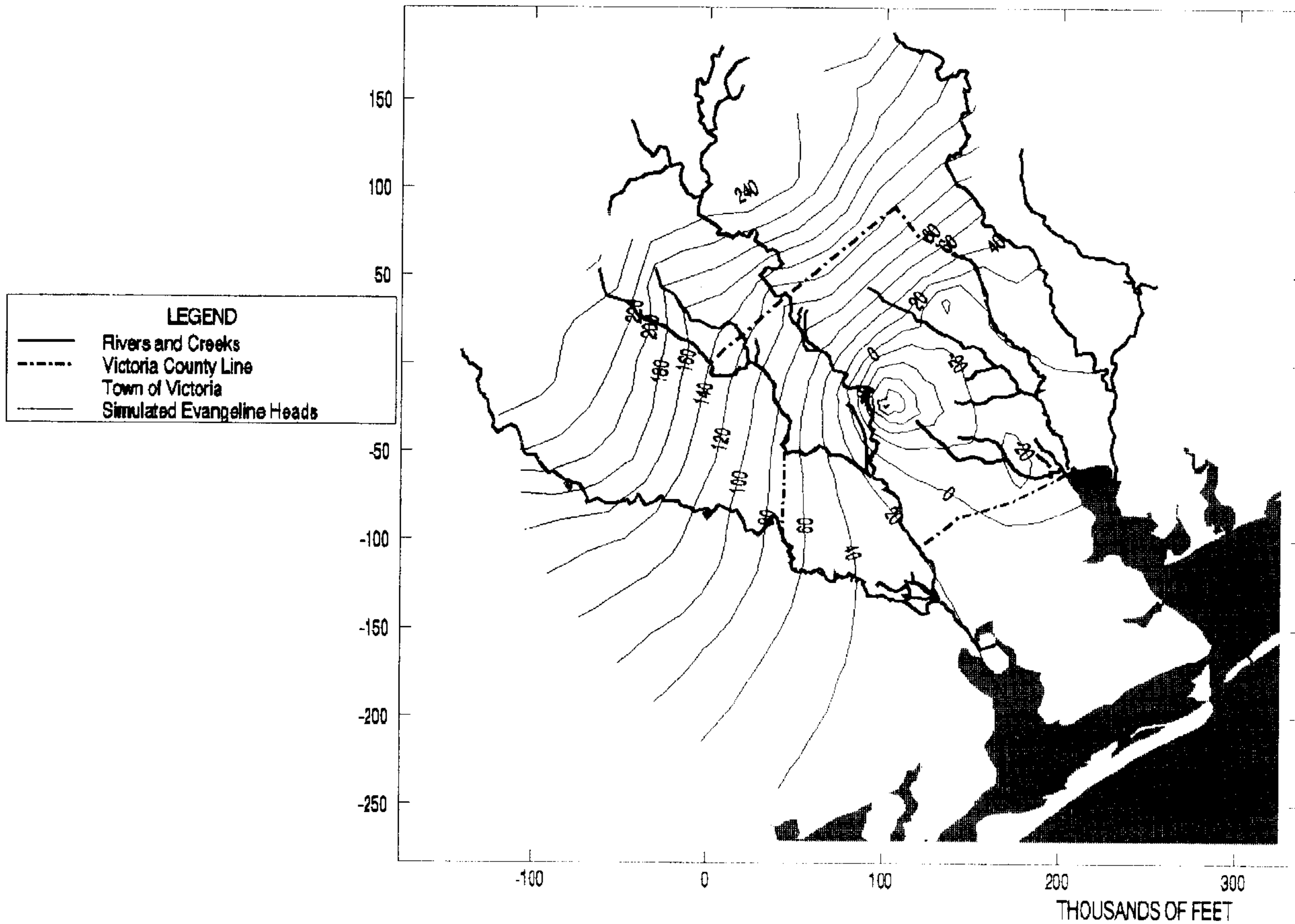


FIGURE 5-42

Simulated 1991 Head Contours in the Evangeline Aquifer

Victoria County Regional Groundwater Model

CDM

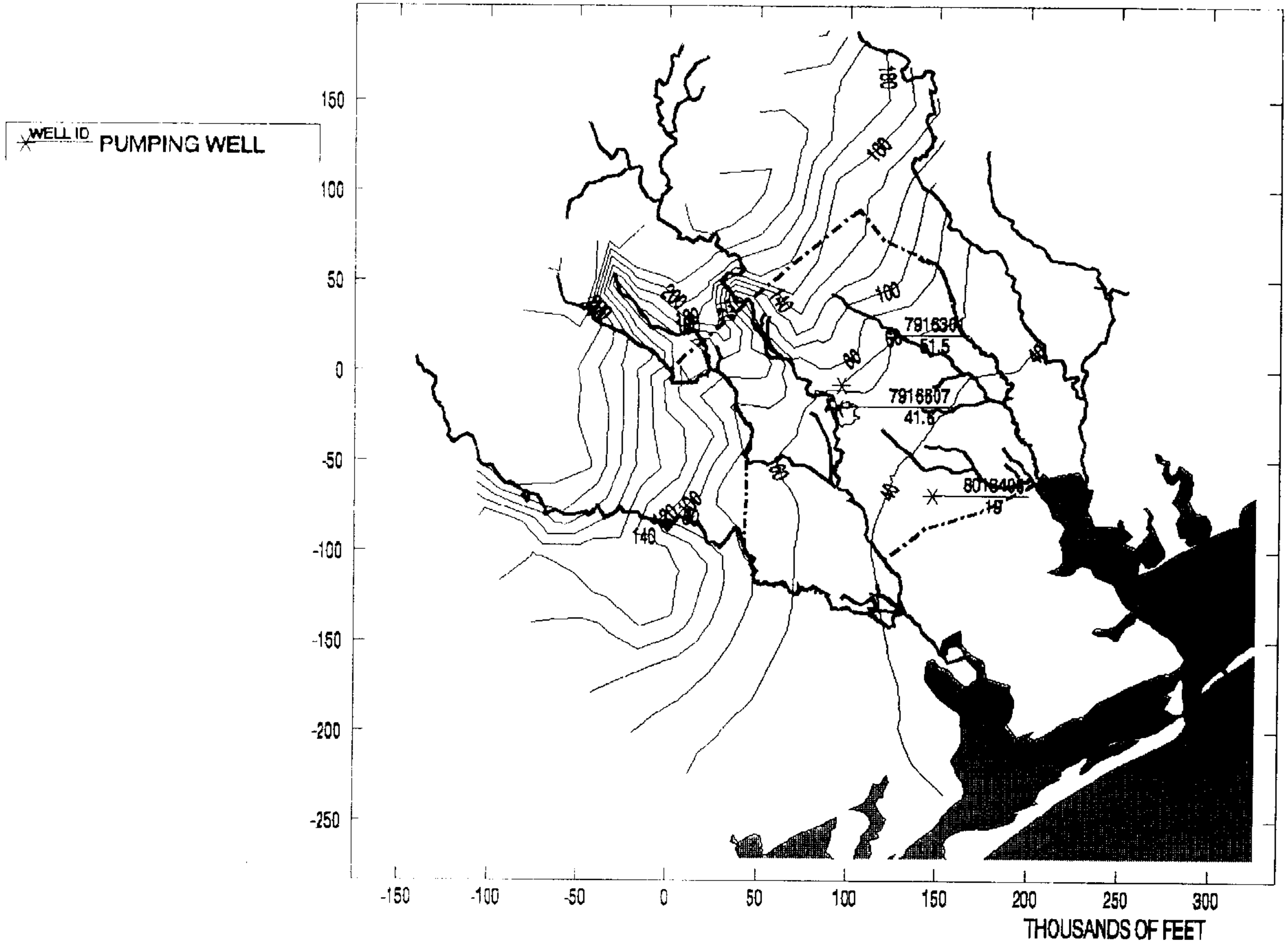


FIGURE 5-43

Simulated 1991 Heads at the Base of the Chicot Aquifer
With Observed Heads Posted at Wells

Victoria County Regional Groundwater Model

CDM

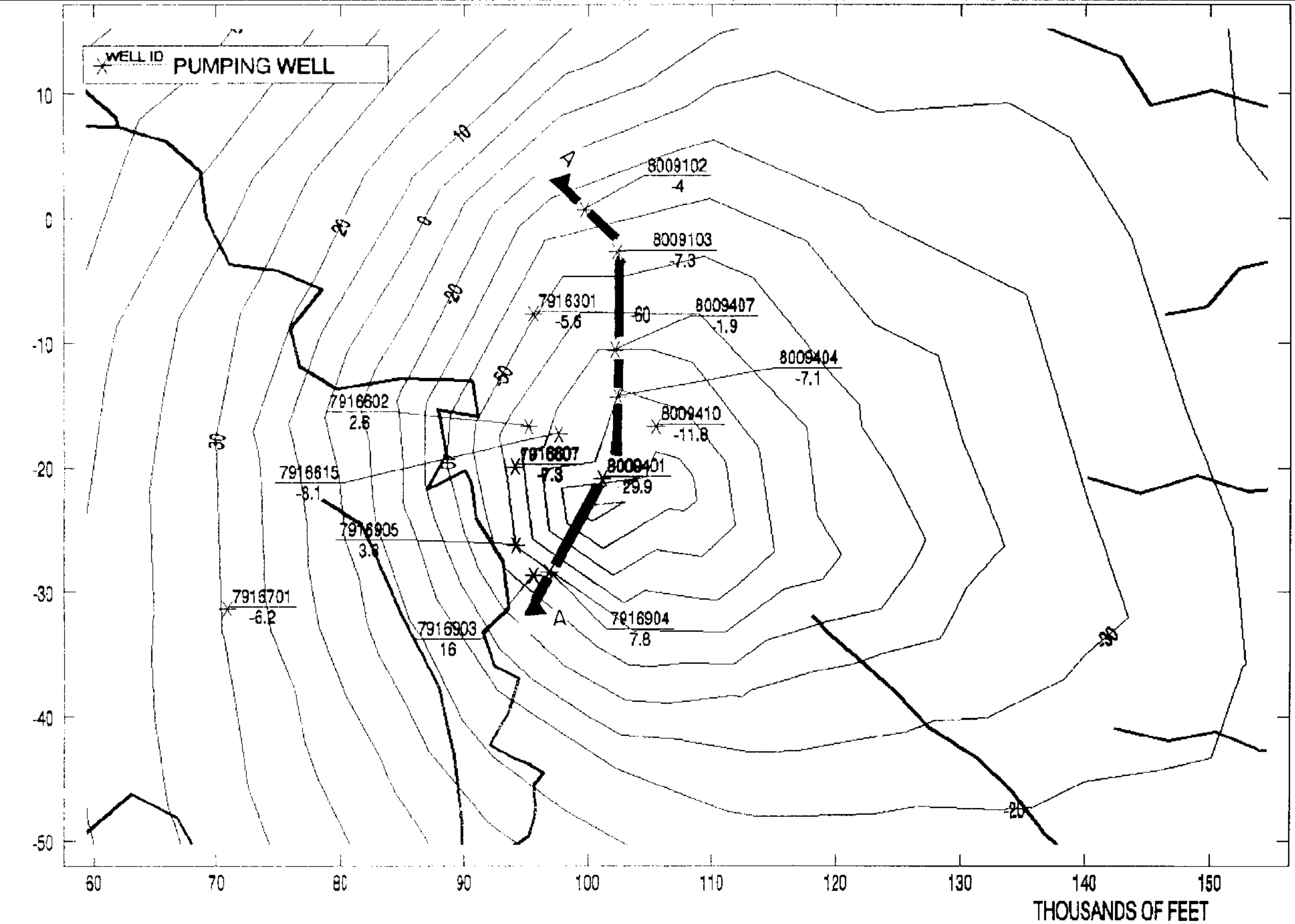


FIGURE 5-44	Plan Map Showing Simulated Head Contours in Vicinity of Victoria With Differences Between Calculated and Observed Heads (Calculated minus Observed) Victoria County Regional Groundwater Model	CDM

TABLE 5-4

COMPARISON OF CALCULATED AND OBSERVED WATER LEVELS

LAYER	WELL NUMBER	CALCULATED HEAD (ft)	OBSERVED HEAD (ft)	CALCULATED HEAD - OBSERVED HEAD (ft)
1	7907902	72	84	-12
1	8009103	-43	-36	-7
2	7907305	112	83	29
2	8001301	29	5	24
2	8001302	12	-29	41
2	8009101	-32	-34	2
2	8010101	-3	-5	2
2	8017101	4	18	-14
2	8017501	1	10	-9
2	7907904	84	80	4
2	7916602	-45	-48	3
2	7916701	37	43	-6
2	7916615	-57	-49	-8
2	7916903	-17	-33	16
2	7916904	-25	-33	8
2	7916905	-25	-28	3
2	8009102	-29	-25	-4
2	8009401	-36	-66	30
2	8009404	-59	-52	-7

TABLE 5-4

COMPARISON OF CALCULATED AND OBSERVED WATER LEVELS
(Continued)

LAYER	WELL NUMBER	CALCULATED HEAD (ft)	OBSERVED HEAD (ft)	CALCULATED HEAD - OBSERVED HEAD (ft)
2	8009406	-62	-50	-12
2	8009407	-44	-42	-2
2	8009410	-55	-43	-12
2	8017506	9	22	-13
2	8017904	11	11	0
2	8017905	10	7	3
3	7932602	38	22	16
3	8002102	52	-15	67
3	8010401	3	9	-6
3	8017906	14	2	12
4	7923601	62	72	-10
4	8011101	16	-4	20
4	8018401	16	15	1
4	8018601	17	7	10
4	7916301	46	52	-6
4	7916607	34	42	-7
4	8018403	21	19	2

is probably due to local effects which the regional model is not detailed enough to reproduce. In particular, the location and depth of applied pumping stresses in the model were somewhat approximate. Also, many of the monitoring wells have very long screens (see Figure 5-45) so that given the significant vertical gradients it is difficult to know the precise depth in the aquifer represented by the measured values. All the other wells where the deviations are high are located far away (more than 8 miles) from the City of Victoria. In particular model predicted values at wells 80-11-101, 80-02-102, 80-01-301 and 80-01-302 are consistently higher than measured heads. These wells are located in the northeastern part of the county which might have been influenced by the pumping in Jackson and Lavaca Counties which are not considered in the present study. However, the model predicts the regional flow pattern quite well and also reproduces the measured water levels in most of the wells used in the calibration.

Another exercise was performed to check the validity of the model. A transient simulation was performed from 1950 to 1990 to compare model predicted water level declines with actual drawdowns. Prior to initiating a transient simulation, a steady-state simulation for 1950 conditions was performed.

The water usage information in Section 3.0 of this report was used to simulate the pre-development flow conclusions in 1950. The water usage for the City of Victoria in 1950 was approximately one fifth (2 MGD) of the present usage (10 MGD). Assuming that water usage in the rest of the county had changed in a similar fashion, 1950 flow conditions were simulated by assuming total pumpage of 8 MGD (one fifth of the value used for the 1990 scenario).

Having simulated the pre-development flow in 1950, a transient simulation was then performed. To perform a transient simulation, two other hydraulic properties, specific storativity and specific yield, need to be input to the model. Values given by Carr, 1985 were used and are listed in Table 5-3. The pumpage was varied linearly from 8 MGD

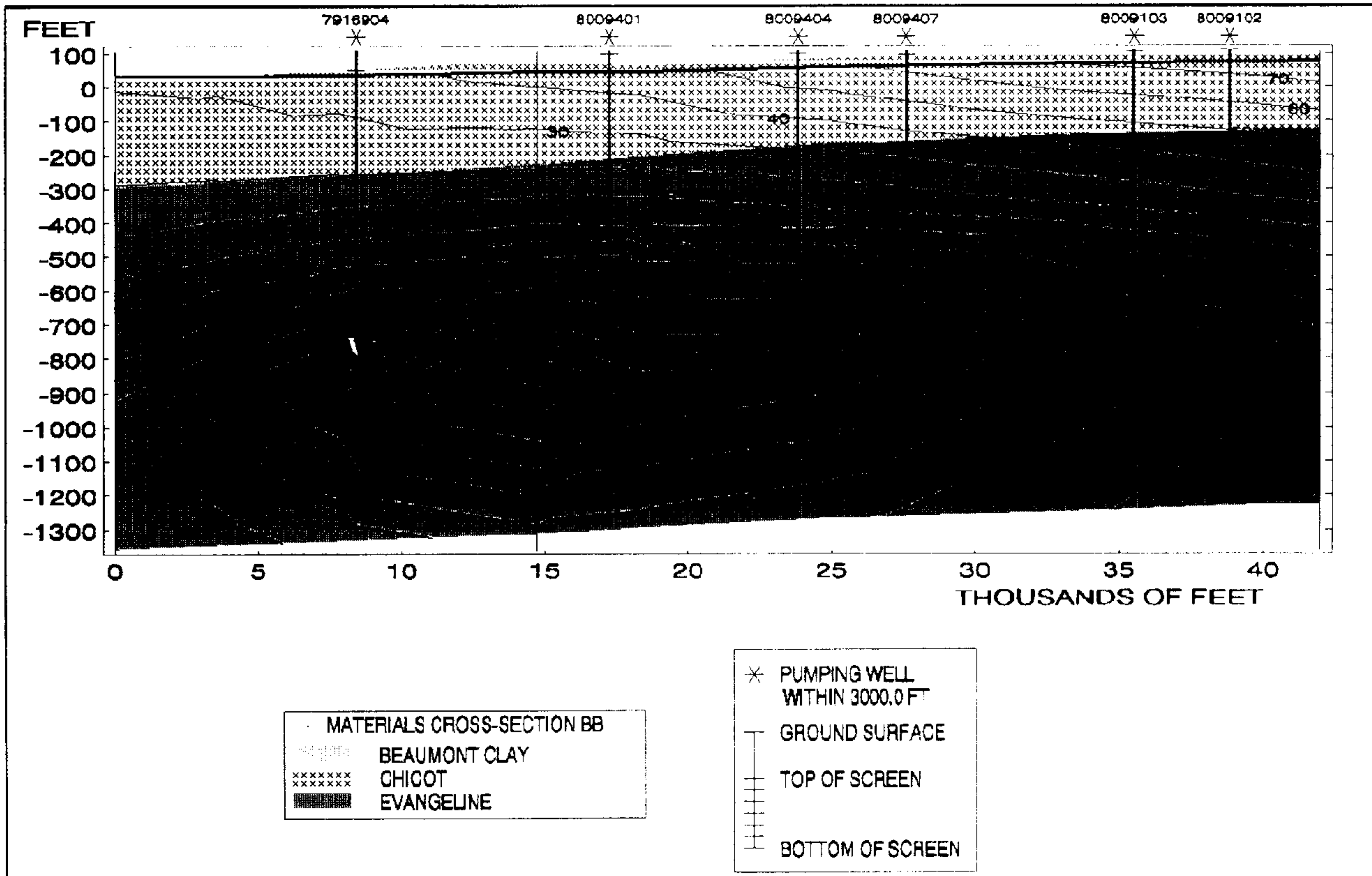


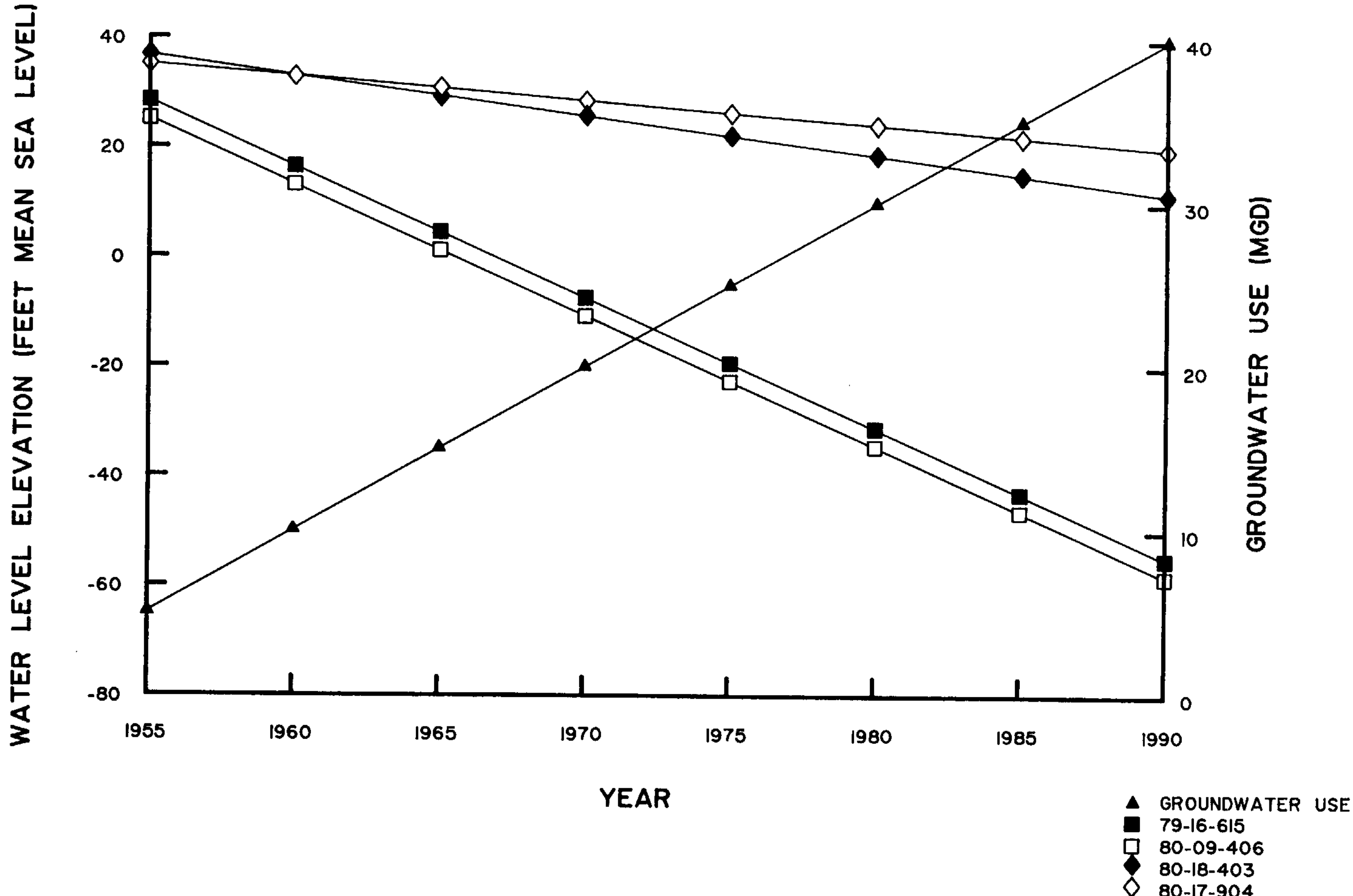
FIGURE 5–45	Cross-Section Showing Simulated 1991 Head Contours And Observed Heads at Pumping Wells Victoria County Regional Groundwater Model	CDM

in 1950 to 40 MGD in 1990 as shown in Figure 5-46. Water levels at selected wells (locations shown in Figure 5-47) are also shown in Figure 5-46. It can be seen that the water level declines sharply near the City of Victoria (79-16-615, 80-09-406), while at wells located further away from the City of Victoria, water level declines are much more gradual. Water level drawdowns from 1950 to 1990 in the Chicot and Evangeline Aquifers are shown in Figures 5-48 and 5-49, respectively. In can be seen that the maximum drawdowns occur in the heavily pumped area near the City of Victoria with values as high as 70 feet. Model predicted water declines are consistent with measured declines and the shape of the drawdown curves is also similar to those reported by Guyton (1984). Simulated drawdown in the Evangeline Aquifer (shown in Figure 5-49), near the northeastern border of Victoria County may be somewhat affected by the nearby model boundary condition. This means that groundwater conditions in adjoining Jackson County, not included in this study, may have some impact on local conditions in this part of Victoria County. However, the impact near the City of Victoria would be minimal.

Having ascertained the accuracy of the model, transient simulations were performed to study the effects of projected future pumping of the aquifers on the water levels in Victoria County.

5.6.5 Transient Simulations of Projected Future Conditions

Water demand projections in Section 3.0 of this report were used to assign the variation of pumpage with time. It is estimated that total water usage in Victoria County in the year 2040 will be 163,262 acre feet or approximately 143 MGD. Water demand is also estimated to increase by 60 percent in the City of Victoria from approximately 10 MGD to 16 MGD.



CDM
environmental engineers, scientists, planners, & management consultants

GROUNDWATER USE AND SIMULATED WATER LEVEL DECLINES
AT SELECTED LEVELS FOR THE PERIOD 1955 TO 1990

FIGURE 5-46

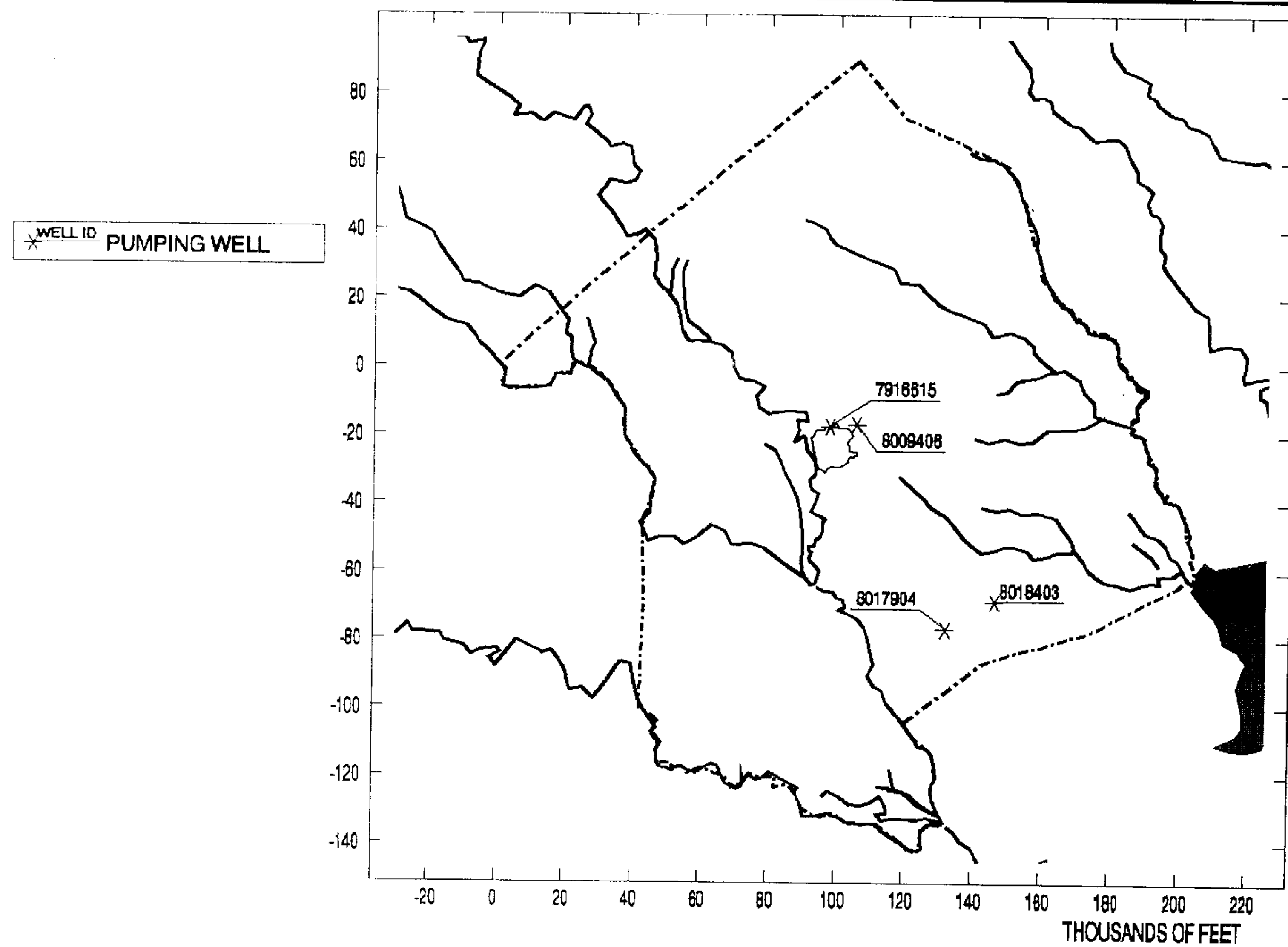


FIGURE 5–47

Plan Map Showing Location of Selected Wells

Victoria County Regional Groundwater Model

CDM

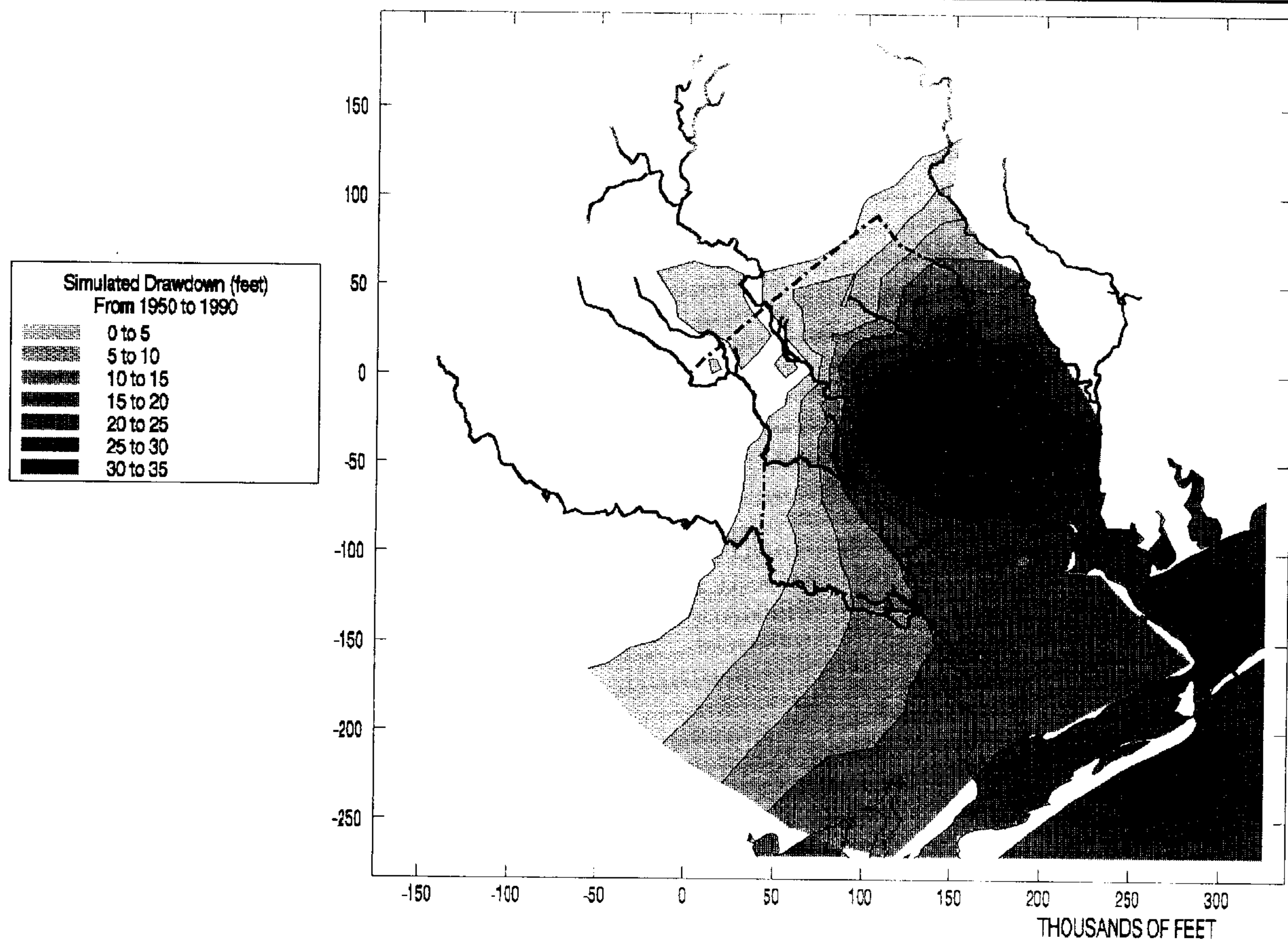


FIGURE 5-48	Contours of Simulated Drawdown at the Base of the Chicot Aquifer From 1950 to 1990 Victoria County Regional Groundwater Model	CDM

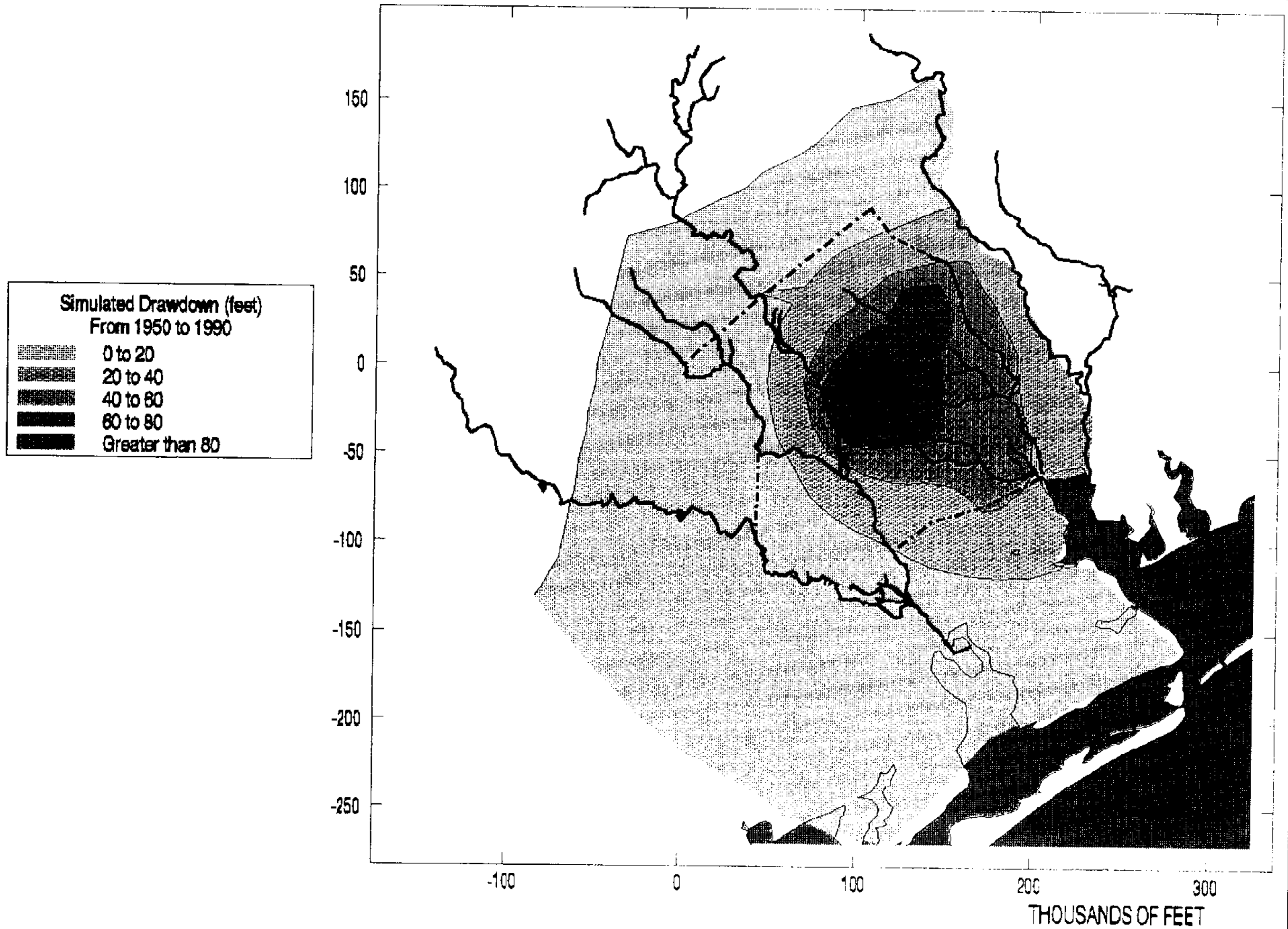


FIGURE 5–49

Contours of Simulated Drawdown in the Evangeline Aquifer
From 1950 to 1990

Victoria County Regional Groundwater Model

CDM

Transient simulations were performed from 1990 to 2040 to assess the impact of the projected future pumping on water levels in Victoria County. Two cases were considered as described below.

Case A

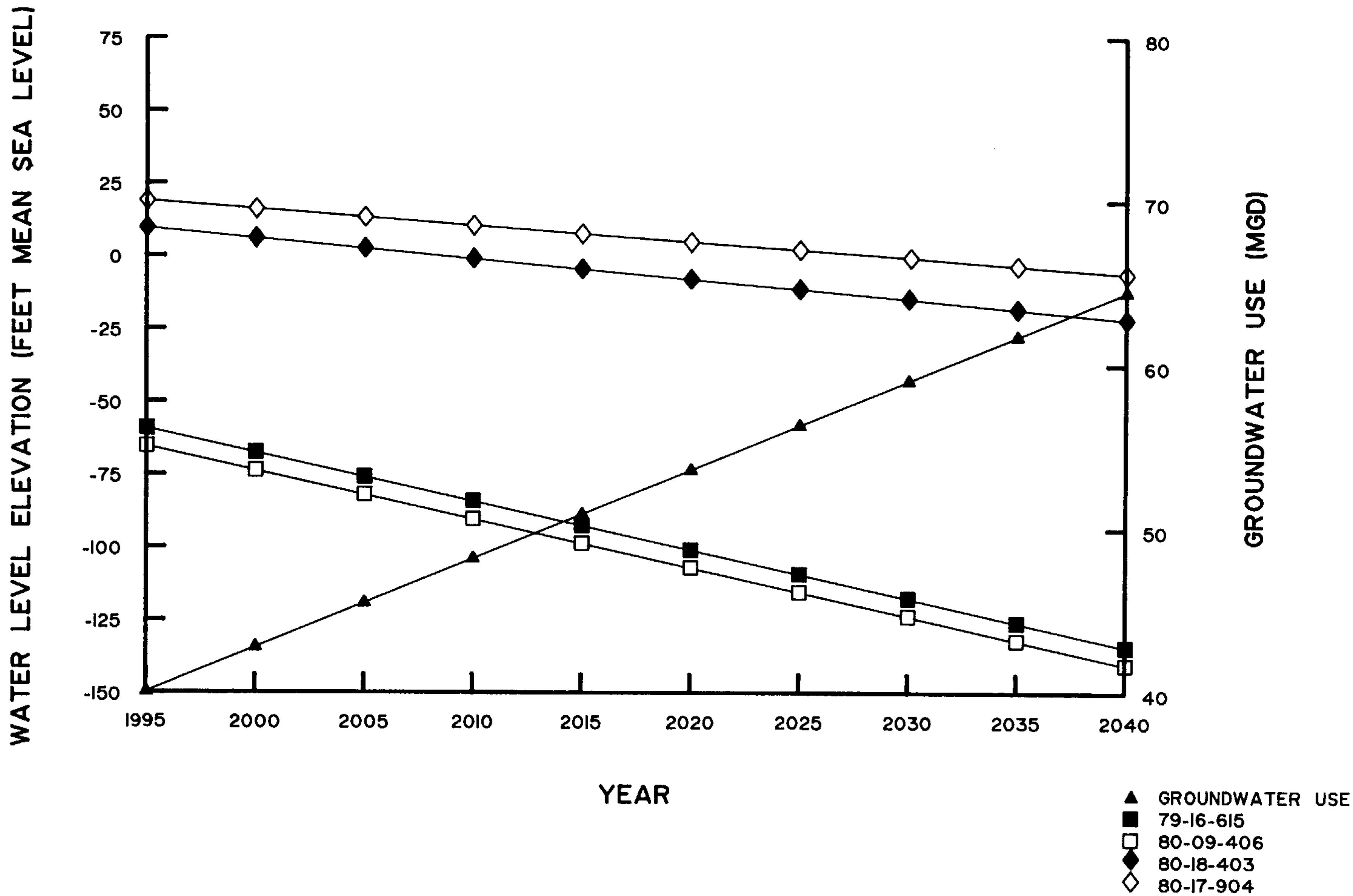
It was assumed that pumping increases everywhere in Victoria County by 60 percent and the total pumpage increases at a constant rate from 40 MGD in 1990 to 64 MGD in 2040. This would mean that the remaining demand of 79 MGD (143 MGD less 64 MGD) is met by surface water. The locations where pumpage was assigned were identical to the pumpage locations used in the 1991 steady state simulation (see Figures 5-40 and 5-41).

The variation of pumpage from 1990 to 2040 and the resulting simulated water levels at selected wells are shown in Figure 5-50. As mentioned earlier, the water level dips sharply near the City of Victoria (79-16-615, 80-09-406) while drawdowns in wells located further away are much more gradual.

Water level declines from 1990 to 2040 in the Evangeline and Chicot Aquifers are shown in Figure 5-51 and 5-52, respectively. It can be seen that maximum declines of up to 60 feet are observed in the vicinity of the City of Victoria while in the rest of the county water level decreases by 20 feet or less.

Case B

In this scenario, it is assumed that the surface water usage is restricted to 50 MGD and the rest of the 93 MGD (143 MGD less 50 MGD) is met by groundwater.



GROUNDWATER USE AND SIMULATED WATER LEVEL DECLINES
AT SELECTED WELLS FOR CASE A

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FIGURE 5-50

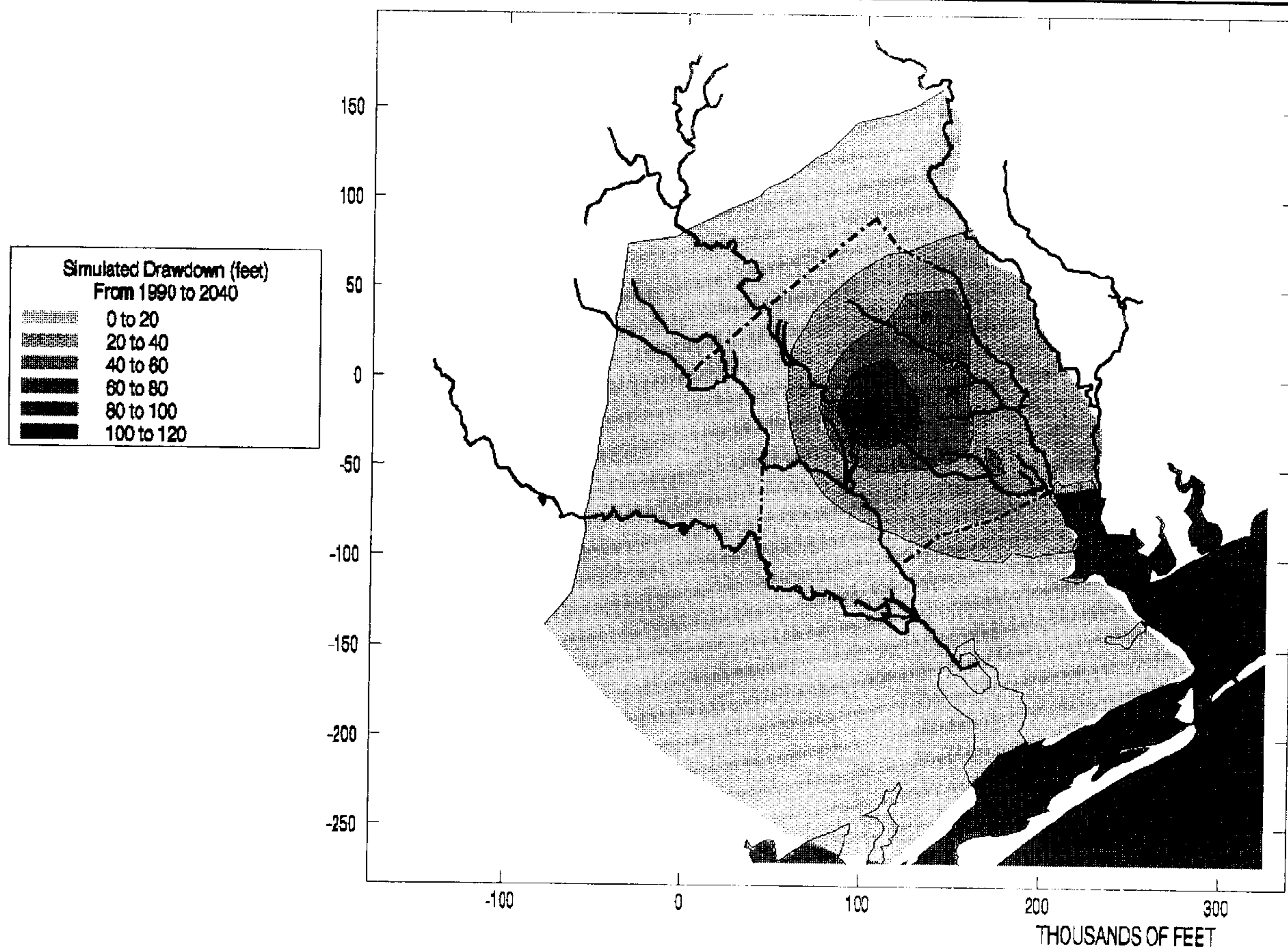

FIGURE 5-51

Contours of Simulated Drawdown in the Evangeline Aquifer
From 1990 to 2040
Pumping 64 MGD in 2040 (CASE A)
Victoria County Regional Groundwater Model

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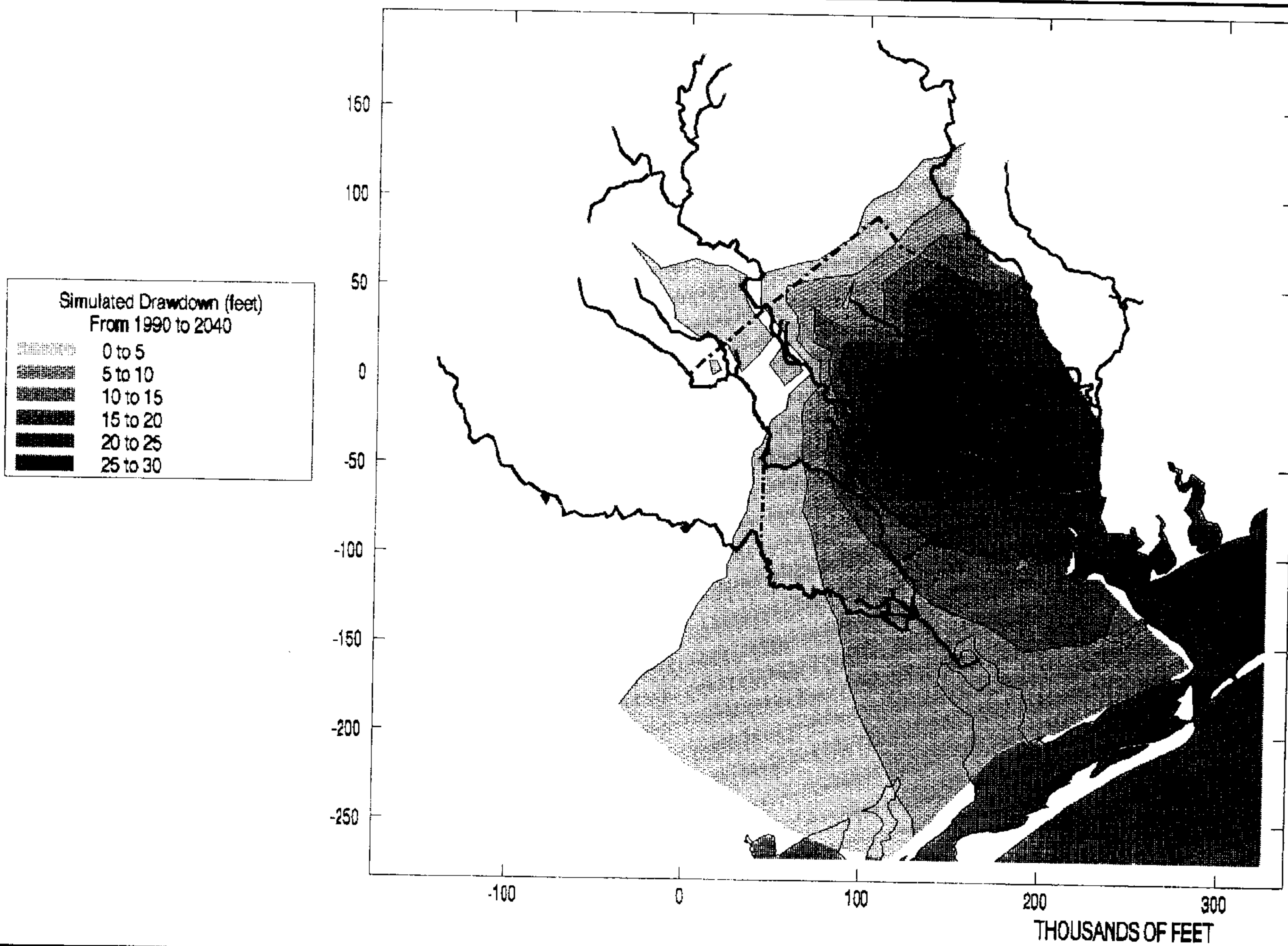


FIGURE 5-52

Contours of Simulated Drawdown in the Chicot Aquifer
From 1990 to 2040
Pumping 64 MGD in 2040 (CASE A)
Victoria County Regional Groundwater Model

CDM

This pumpage was assigned in the following manner:

- Pumpage increases at all locations where it exists now by 60 percent (similar to procedure adopted in Case A) from 40 to 64 MGD.

- The remaining 29 MGD (increasing from 0 MGD in 1990 to 29 MGD in 2040) was assumed to be withdrawn from the Evangeline Aquifer between Victoria and the southern end of the county.

The pumpage assignments for this scenario are depicted in Figure 5-53 and 5-54. Water level declines under this scenario are contoured in Figure 5-55 and 5-56. Drawdowns in this case are considerably higher than those predicted in Case A due to the increasing reliance on groundwater to meet the water demand.

Water level declines at selected wells and the pumpage variation over time are depicted in Figure 5-57. The behavior is quite similar to that observed in Case A except for one well. The water declines much faster in well 80-18-403 in Case B in comparison to that observed in Case A. This is due to the difference in pumpage assignments between Case A and Case B (see Figures 5-40 and 5-54).

It should be noted that in the simulations discussed above, the value of recharge used in the model was kept at a constant value of 2 inches/year. Due to this reason, water level declines will be more severe than the values predicted by the model in the event of a drought.

Thus, it can be seen that the aquifer system in Victoria County can meet the expected demands placed upon it under both Case A and Case B. It is also apparent that the water levels will continue to decline in response to the increased demands in Victoria County.

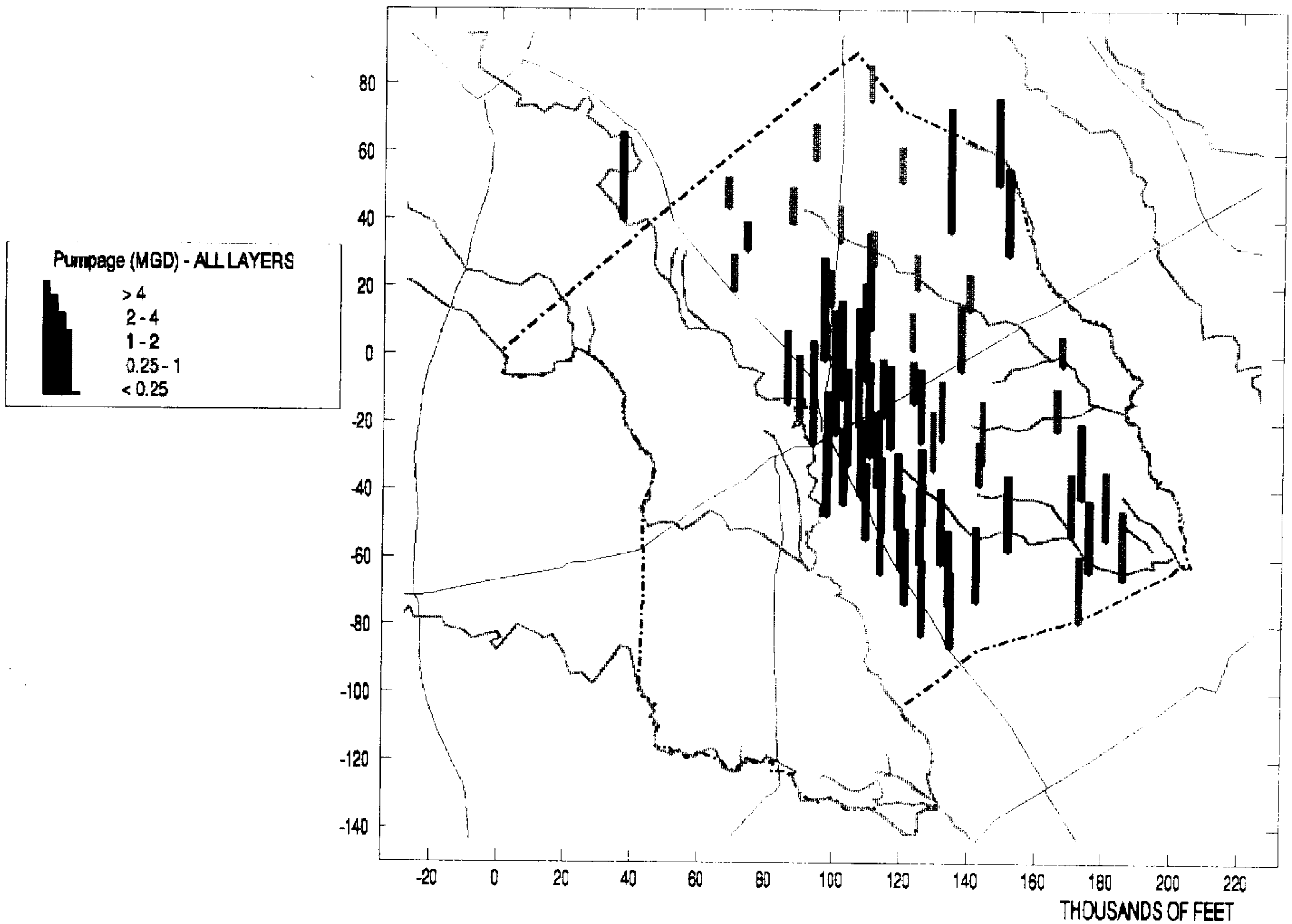


FIGURE 5–54

Bar Plot Showing Location of Simulated Pumping Withdrawal in MGD
From the Evangeline Aquifer in 2040
(CASE B)
Victoria County Regional Groundwater Model

CDM

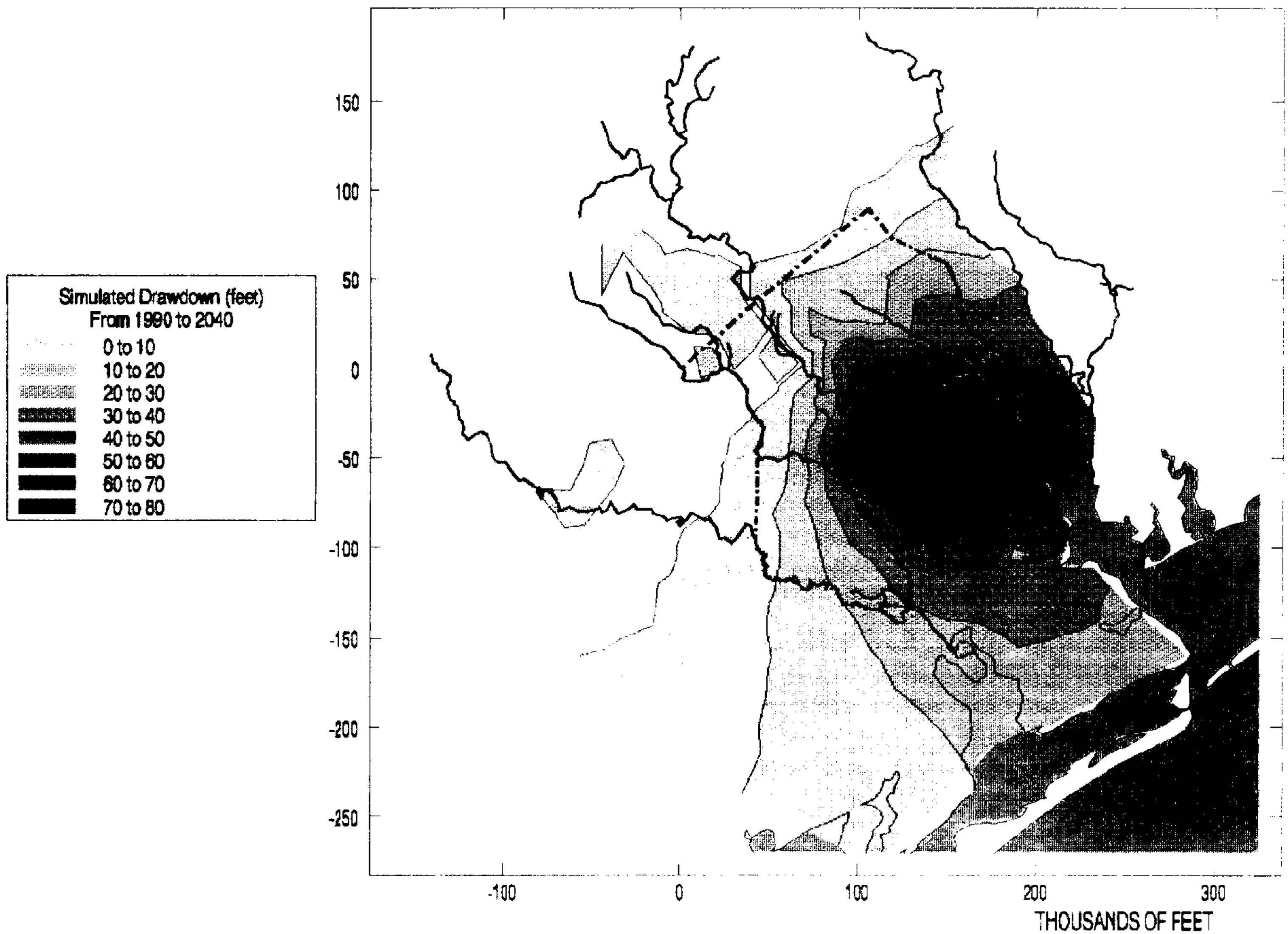


FIGURE 5-55

Contours of Simulated Drawdown in the Chicot Aquifer
From 1990 to 2040
Pumping 94 MGD in 2040 (CASE B)
Victoria County Regional Groundwater Model

CDM

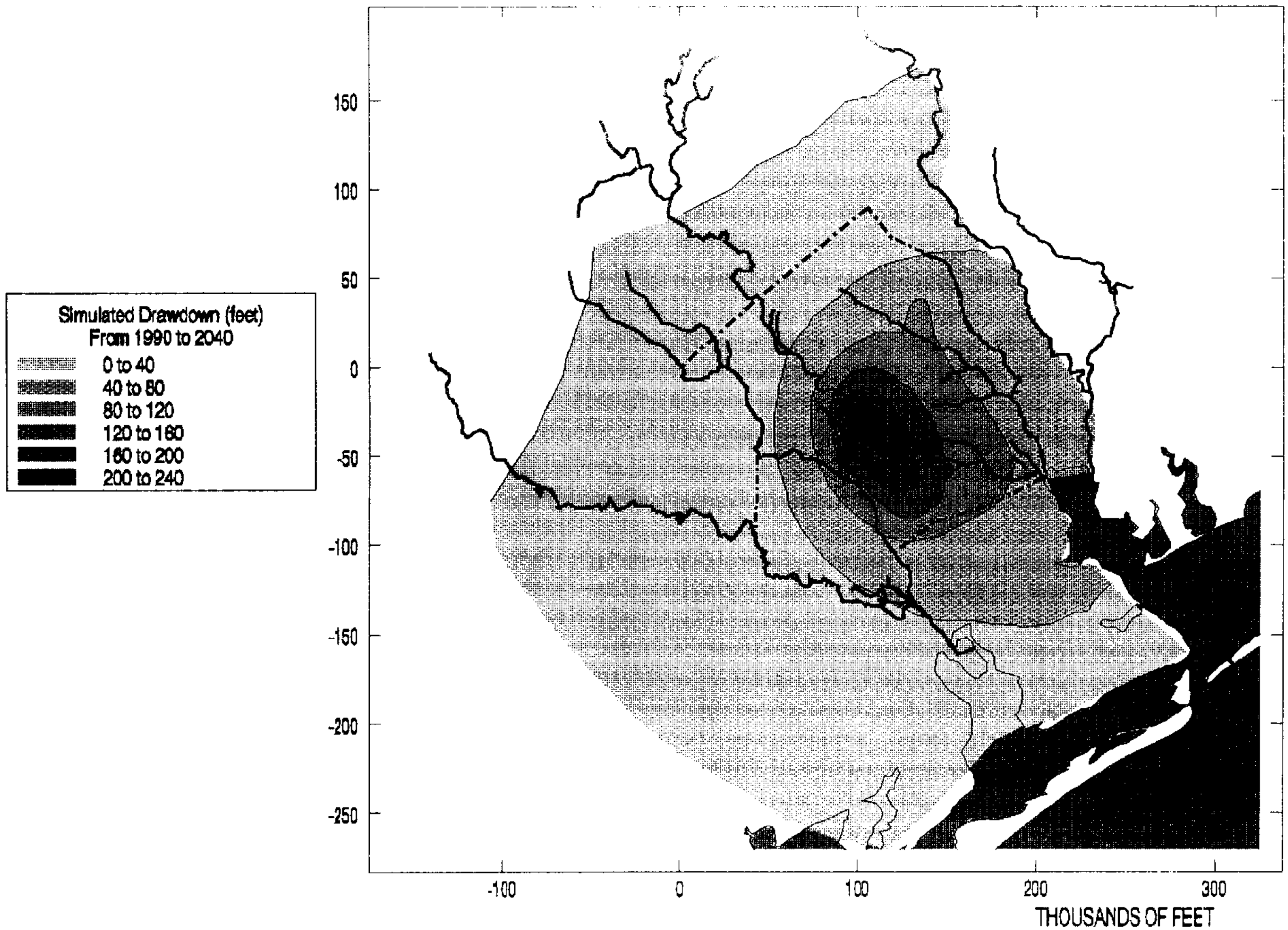
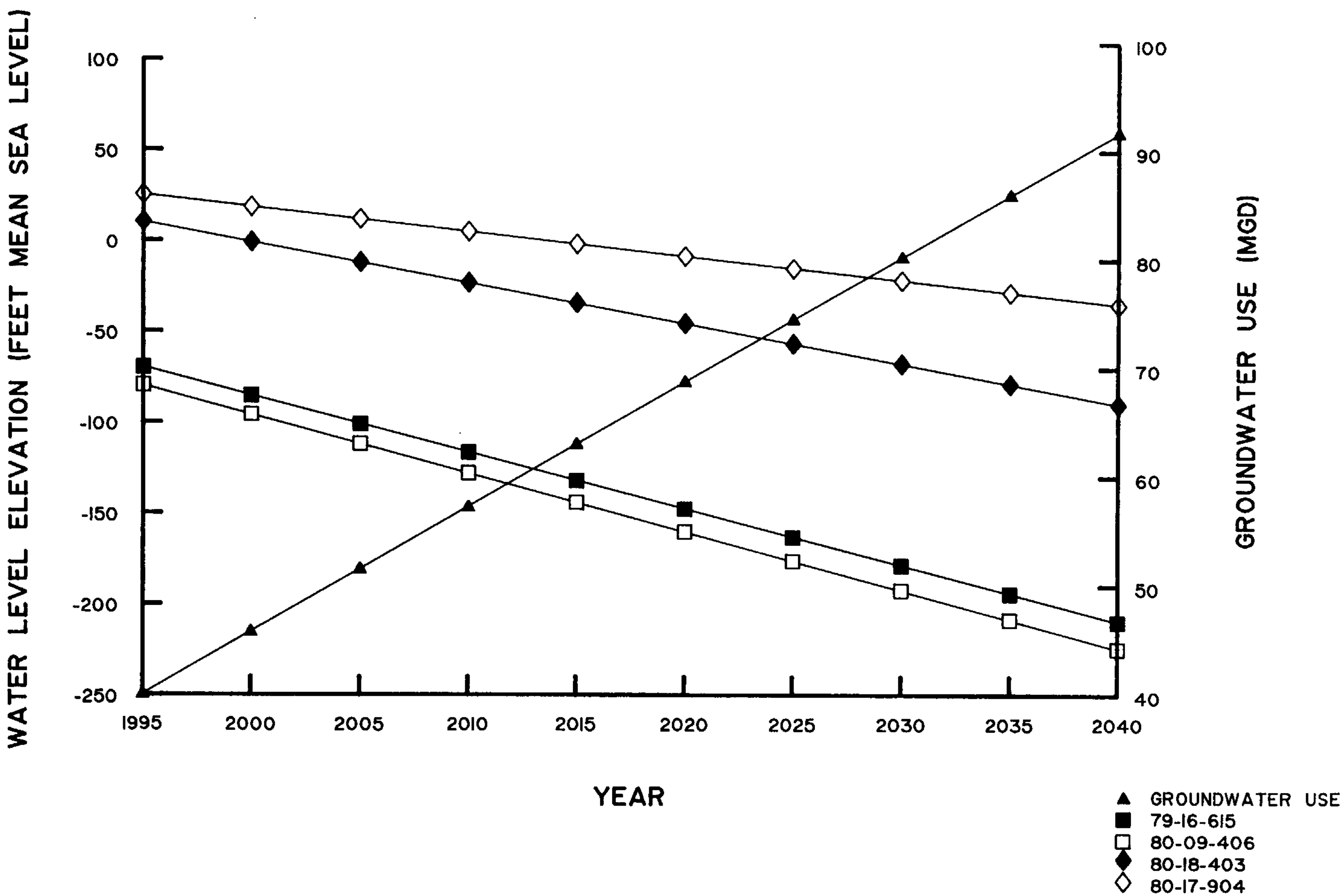


FIGURE 5-56

Contours of Simulated Drawdown in the Evangeline Aquifer
From 1990 to 2040
Pumping 94 MGD in 2040 (CASE B)
Victoria County Regional Groundwater Model

CDM



GROUNDWATER USE AND SIMULATED WATER LEVEL DECLINES
AT SELECTED WELLS FOR CASE B

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FIGURE 5-57

The magnitude of the drawdown depends on how the future demands are met. The influence of increased drawdowns on factors such as water quality and land subsidence are discussed in the following sections. The major concern that must be addressed if Victoria County relies on groundwater is not availability, but how continued water level declines impact water quality and subsidence, and how pumping from greater depths impacts the economics of groundwater usage.

5.7 WATER QUALITY

The groundwater produced in Victoria County is generally a good quality water suitable for municipal, industrial and irrigation uses. Recent water quality analyses of the City of Victoria's water as well as historical water quality analyses are presented in Table 5-5. The total dissolved solids (TDS) of the water is near 500 mg/L which is the U.S. EPA limit for TDS. The Texas Health Department recommends a maximum TDS of 1,000 mg/L. The City's water can be characterized as moderately hard, with a total hardness of 103 mg/L (measured as $CaCO_3$). The major ionic constituents in the water are bicarbonate and sodium.

Constituents included in Table 5-5 that occur in the County's groundwater which are of concern to municipal suppliers of water include iron, manganese, barium and hydrogen sulfide. Iron and manganese are included in the secondary drinking water standards and are limited by the U.S. EPA to 0.3 mg/L and 0.05 mg/L, respectively. These constituents do not harm humans, but do cause the water to appear turbid, interfere with laundering operations, impart objectionable stains on plumbing fixtures, and cause difficulties in distribution systems by supporting growths of iron bacteria. Iron also imparts a taste to water which is detectable at very low concentrations. (Sawyer, 1978)

TABLE 5-5

HISTORIC WATER QUALITY AT THE CITY OF VICTORIA WATER PLANTS

DATE: January 1978

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	33	10	152	.07	.35	0	366	10	107	na	124
PLANT 2	33	11	143	.05	.35	0	367	4	94	na	127
PLANT 3	36	14	124	.05	.27	0	378	4	79	na	149
PLANT 4	37	13	124	.05	.45	0	375	4	83	na	147

DATE: January 1979

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	29	9	158	.05	.29	0	354	3	109	na	109
PLANT 2	29	9	156	.02	.36	0	368	8	97	na	110
PLANT 3	34	12	133	.02	.46	0	376	2	81	na	134
PLANT 4	34	11	138	.02	.49	0	368	2	92	na	132

DATE: April 1980

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	32	7	159	.05	.44	0	355	15	115	na	109
PLANT 2	27	6	166	.04	.48	0	361	13	113	na	93
PLANT 3	37	11	140	.04	.49	0	376	3	99	na	137
PLANT 4	37	12	137	.05	.63	0	373	2	101	na	140

DATE: January 1981

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	30	7	156	.03	.27	0	359	13	104	na	105
PLANT 2	26	6	166	.02	.36	0	365	11	107	na	89
PLANT 3	na	na	na	na	na	na	na	na	na	na	na
PLANT 4	38	8	192	.02	.41	0	368	3	102	na	126

DATE: May 1982

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	30	8	161	.05	.27	0	356	10	112	na	108
PLANT 2	26	8	161	.02	.35	0	366	8	101	na	101
PLANT 3	33	12	136	.02	.26	0	377	2	86	na	131
PLANT 4	7	2	278	.02	.09	0	393	3	216	na	27

TABLE 5-5

HISTORIC WATER QUALITY AT THE CITY OF VICTORIA
(Continued)

DATE: August 1983

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	29	8	166	.07	.37	0	357	12	112	na	106
PLANT 2	24	8	177	.03	.28	2	357	12	114	na	95
PLANT 3	33	13	138	.02	.35	0	370	2	101	na	137
PLANT 4	47	10	156	.02	.07	0	348	7	148	na	162

DATE: October 1984

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	31	7	163	.03	.24	0	356	12	110	na	105
PLANT 2	28	7	170	na	na	0	360	14	110	na	97
PLANT 3	37	10	142	.02	.38	0	373	2	98	na	134
PLANT 4	55	4	165	na	na	0	360	6	148	na	153

DATE: April 1985

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	29	8	163	.03	.16	0	361	16	110	na	105
PLANT 2	26	7	170	.03	.27	0	362	13	116	na	94
PLANT 3	35	11	134	.02	.26	0	379	2	87	na	132
PLANT 4	55	10	140	.02	.07	0	356	7	136	na	180

DATE: October 1985

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	28	9	158	.05	.27	0	355	13	111	.8	109
PLANT 2	28	8	154	.04	.32	0	367	5	94	1.4	104
PLANT 3	27	8	159	.03	.44	0	371	3	101	1.2	102
PLANT 4	51	10	156	.02	.12	0	357	7	145	.7	169

DATE: January 1987

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	28	8	163	.04	.21	0	360	14	108	.68	104
PLANT 2	26	7	164	.03	.30	0	294	7	101	1.2	93
PLANT 3	30	11	149	.02	.31	0	370	2	96	1.2	118
PLANT 4	54	11	140	.02	.07	0	354	7	133	.67	180

TABLE 5-5

HISTORIC WATER QUALITY AT THE CITY OF VICTORIA WATER PLANTS
(Continued)

DATE: November 1987

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	29	8	165	.04	.24	0	357	12	109	.01	105
PLANT 2	26	7	175	.09	.41	0	360	14	119	1.1	92
PLANT 3	31	8	151	.03	.39	0	366	4	98	1.6	111
PLANT 4	56	9	142	.03	.22	0	350	7	136	.71	178

DATE: January 1988

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	29	7	159	.12	.39	0	360	10	110	.79	103
PLANT 2	25	7	171	.03	.28	0	364	13	118	.28	93
PLANT 3	31	9	149	.02	.39	0	371	3	103	1.2	116
PLANT 4	55	9	137	.02	.12	0	355	5	134	.12	176

DATE: January 1989

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	30	7	163	.03	.19	0	361	16	109	na	103
PLANT 2	26	7	172	.03	.32	0	364	14	116	na	96
PLANT 3	40	9	131	.02	.38	0	383	2	82	na	138
PLANT 4	56	11	138	.02	.27	0	351	8	132	na	185

DATE: January 1990

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	29	9	158	.04	.23	0	360	14	107	.78	107
PLANT 2	26	8	159	.02	.32	0	365	12	103	1.2	98
PLANT 3	26	8	157	.02	.31	0	372	5	99	1.4	99
PLANT 4	28	8	158	.03	.37	0	366	5	103	1.3	101

DATE: January 1991

	Ca	Mg	Na	Mn	Fe	CO_3	HCO_3	SO_4	Cl	Ba	T.H.
PLANT 1	29	4	173	.02	.04	0	355	20	115	.21	87
PLANT 2	27	5	174	.03	.34	0	359	14	118	1.2	90
PLANT 3	37	11	136	.03	.41	0	370	3	96	1.5	136
PLANT 4	44	5	162	.02	.11	0	354	7	138	.52	130

Barium is included in the primary drinking water standards and is limited by the U.S. EPA to 1.0 mg/L. Concentrations of barium in some of the City of Victoria's wells are slightly above 1.0 mg/L.

Hydrogen sulfide is included in the secondary drinking water standards and is limited by the U.S. EPA to 0.05 mg/L. The City of Victoria has reported the presence of hydrogen sulfide at the wells that serve Water Plants 3 and 4. Hydrogen sulfide is the most noticeable at Plant 4.

5.7.1 Groundwater Quality Origin

In general, the quality of groundwater is related to the formations that it comes in contact with and the constituents in the formation that the groundwater can reduce or oxidize as it flows from the recharge area to the discharge point. The two primary aquifers of the aquifer system are the Evangeline Aquifer (which is made up of the Goliad Formation) and the Chicot Aquifer (which is made up of the Willis Formation, the Lissie Formation and the Beaumont Formation). The Goliad Formation can be characterized as follows (Barnes, 1975):

> Clay, sand, sandstone, marl, caliche, limestone, and conglomerate; clay, commonly light shades of pink or green, locally contains calcareous concretions; sand and sandstone, medium to very coarse grained, in part crossbedded, mostly quartz, some black and red chert; conglomerate, black chert and dark siliceous granules and pebbles in calcareous (caliche) matrix; sandstone and conglomerate, locally well bedded; marl and limestone, poorly bedded or massive.

The Willis Formation can be characterized as follows (Barnes, 1975):

> Gravel, sand, silt, and clay; gravel, mostly siliceous, locally cobble-size quartz and chert, some petrified wood; sand, fine to very coarse grained; clay, silty, light yellowish gray, where deeply weathered, mottled red and light gray; iron oxide concretions locally abundant, some beds highly indurated by iron oxide cement.

The Lissie Formation can be characterized as follows (Barnes, 1975):

> Sand, silt, clay and minor amount of gravel; iron oxide and iron-manganese nodules common in zone of weathering, in upper part locally calcareous, some concretions of calcium carbonate.

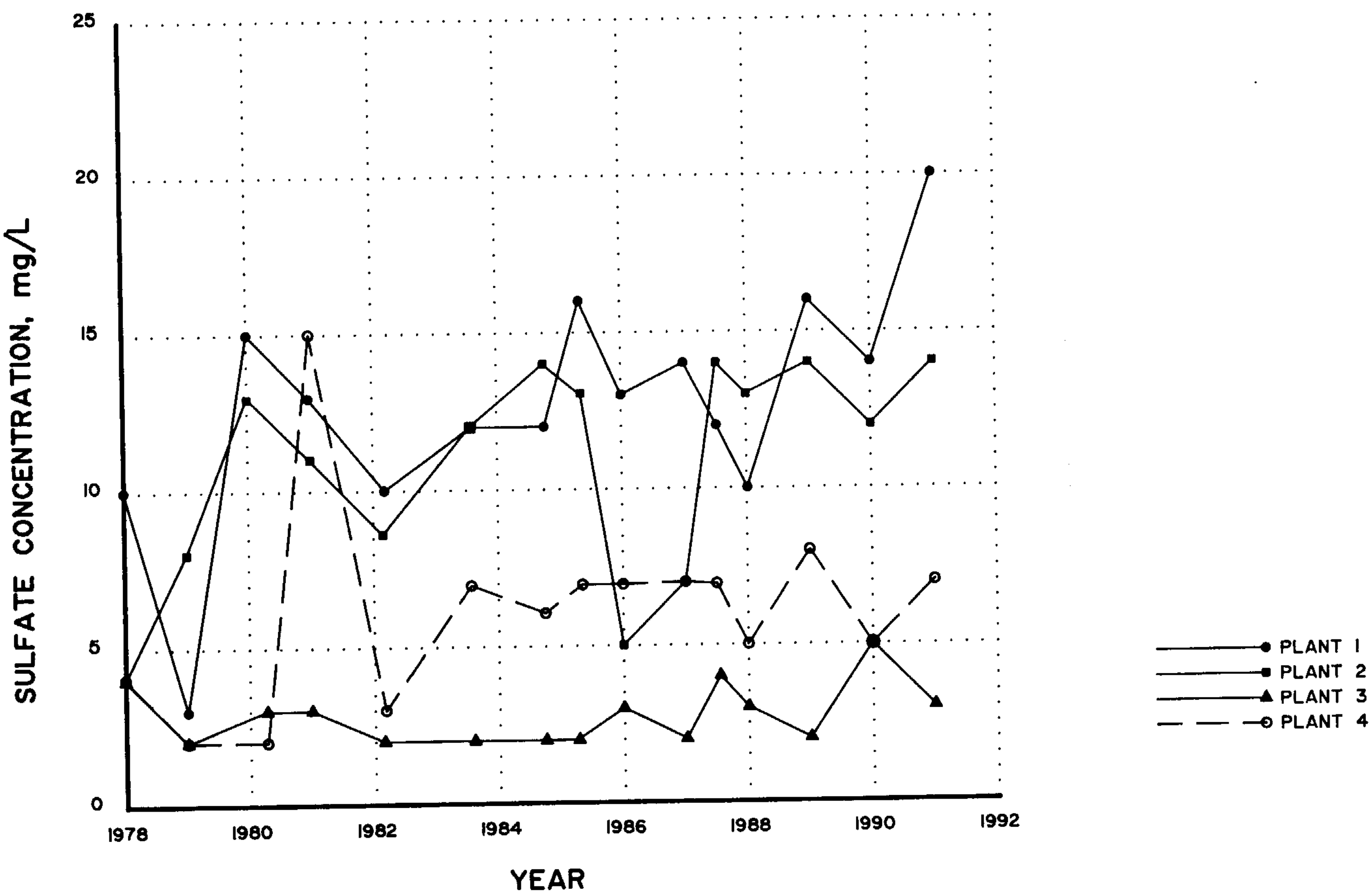
The Beaumont Formation can be characterized as follows (Barnes, 1975):

> ... mostly clay, silt, sand, and gravel; includes mainly stream channel, point bar, natural levee, and backswamp deposits, and to a lesser extent coastal marsh, mud flat, lagoonal, recent and older lake, clay dune, and sand dune deposits; gravel deposits mostly along Guadalupe River in vicinity of Victoria; concretions and massive accumulation of calcium carbonate (caliche) and concretions of iron oxide and iron-manganese oxides in zone of weathering.

As the water that falls upon the outcrop areas of the Evangeline and Chicot Aquifers percolates downward, it comes in contact with bacteria oxidizing organic material. Bacterial oxidation of organic material, either aerobic or anaerobic, produces carbon dioxide. When the carbon dioxide is dissolved into the groundwater it produces a weak acid which can dissolve calcium carbonate into calcium and bicarbonates, and can also dissolve iron-manganese oxides. Based upon this groundwater/carbon dioxide relationship and the description of the formations that comprise the aquifers above, the groundwaters that are in the Evangeline Aquifer would be expected to have dissolved constituents of calcium and bicarbonate, and the waters in the Chicot Aquifer would be expected to have dissolved constituents of calcium, bicarbonate, iron, and manganese.

As shown in Table 5-5, the County's groundwater does have high concentrations of bicarbonate, but does not have high concentrations of calcium. Rather, it is sodium that is the other dominant constituent. This can be explained by the sedimentary nature of the aquifer. Calcium carbonate is dissolved into calcium ions and bicarbonate ions. However, when the calcium ions come into contact with clay minerals with exchangeable sodium, the calcium ion is exchanged for two sodium ions. Waters with high bicarbonate and sodium concentrations have been reported in the Atlantic and Gulf Coastal Plains of the United States (Freeze and Cherry, 1979).

From a review of the water quality data listed in Table 5-5, it can be seen that the water from the City's four water treatment plants have similar concentrations of sodium, calcium and bicarbonate. This is indicative of the groundwaters of the Gulf Coastal Plains as described above and would indicate that the water at the City's four water plants were from a similar environment. However, other constituents measured at the plants seem to be characteristically different. For example, Figure 5-58 shows a plot of sulfate concentrations measured at the four water plants, and as can be seen, Plant 1 and Plant 2 have consistently higher sulfate concentrations than Plant 4 which has higher concentrations than Plant 3. Although sulfide concentrations at the plants are not taken, discussions with the City of Victoria staff indicates that Plants 3 and 4 have the highest concentrations of hydrogen sulfide and Plants 1 and 2 have the lowest concentration of hydrogen sulfide. The hydrogen sulfide concentrations are highest at the locations where the sulfates are the lowest.



SULFATE CONCENTRATIONS AT
THE CITY OF VICTORIA'S WATER PLANTS

FIGURE 5-58

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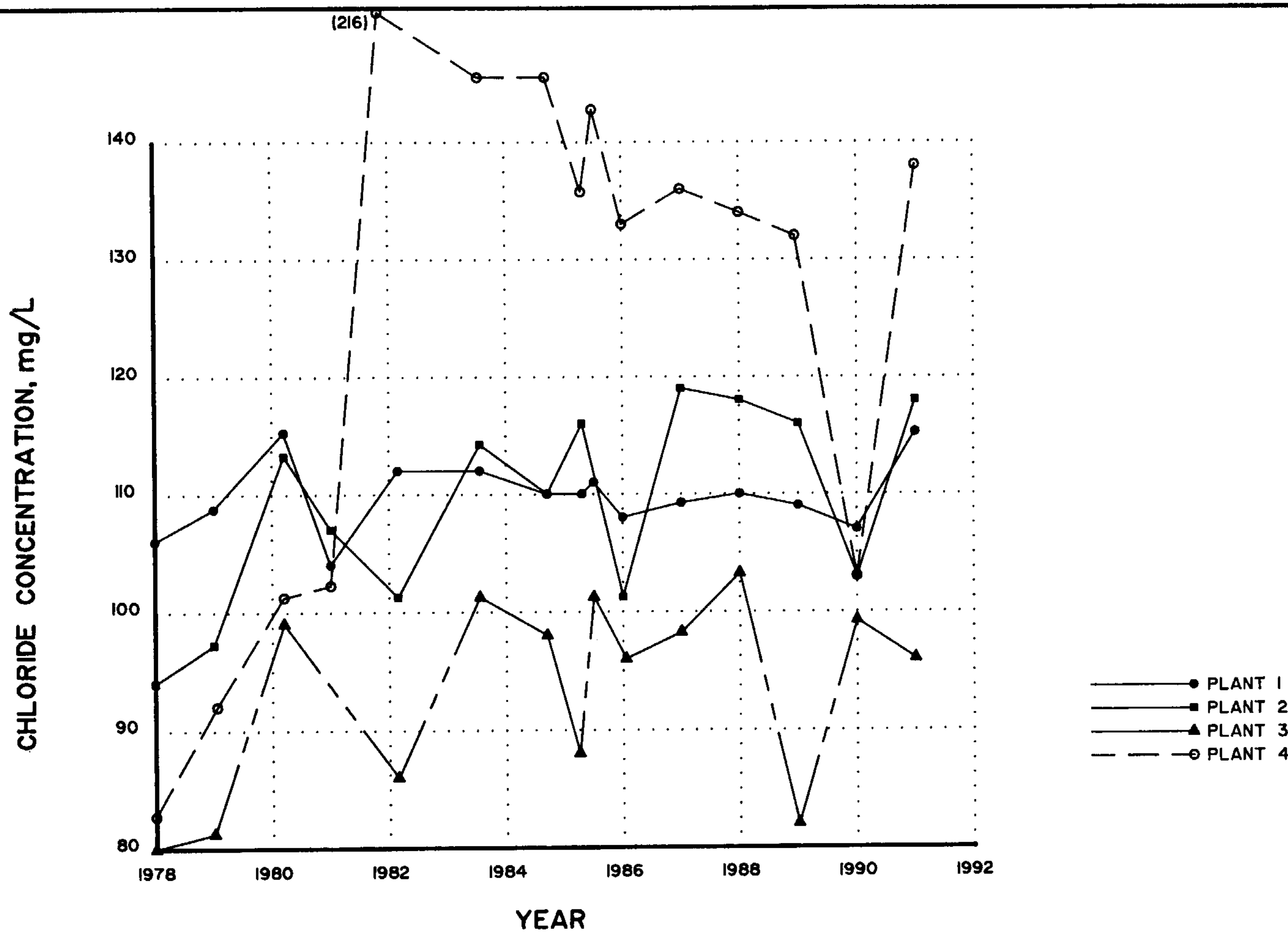
Sulfates are present in the groundwater due to weak acids in the groundwater dissolving sulfate compounds in the formation, such as gypsum and anhydrite. The description of the formations above did not specifically mention the presence of gypsum and anhydrite and the lack of these minerals explains why the groundwater has only small concentrations of sulfate. Sulfate in the groundwater is also undergoing reduction by bacteria in the formation and this is why the sulfate concentrations vary between wells. The reduction of sulfate to hydrogen sulfide is discussed in Section 5.7.3.

The chloride concentrations measured at the four water plants are also different. Figure 5-59 is a plot of the chloride concentrations measured at the City of Victoria's four water plants. As can be seen, Plant 1 produces a water with the most consistent concentration of chlorides varying from a low of 104 mg/L to a high of 115 mg/L. Plant 2 has similar concentrations to Plant 1, but the concentrations have varied more than the concentrations at Plant 1. Plant 3 has the lowest chloride concentrations, varying from 80 mg/L to 103 mg/L, and Plant 4 has the highest chloride concentrations with the highest measurement of 216 mg/L.

Chlorides are present in the groundwater due to weak acids in the groundwater dissolving chloride minerals in the formation such as halite and sylvite. The description of the formation above did not mention these minerals, but they may be contained in trace amounts in the clay deposits in the aquifer. As the groundwater moves by these formations, the chloride ion is diffused through the clay (Freeze and Cherry, 1979). Chlorides could also be present in the groundwater due to seawater intrusion from the Gulf of Mexico, or from brackish water migrating upward from underlying formations.

5.7.2 Iron and Manganese

As stated above the Willis, Lissie and Beaumont Formations which comprise the Chicot Aquifer all contain iron and manganese oxides. These constituents are dissolved into the



CHLORIDE CONCENTRATIONS AT
THE CITY OF VICTORIA'S WATER PLANTS

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FIGURE 5-59

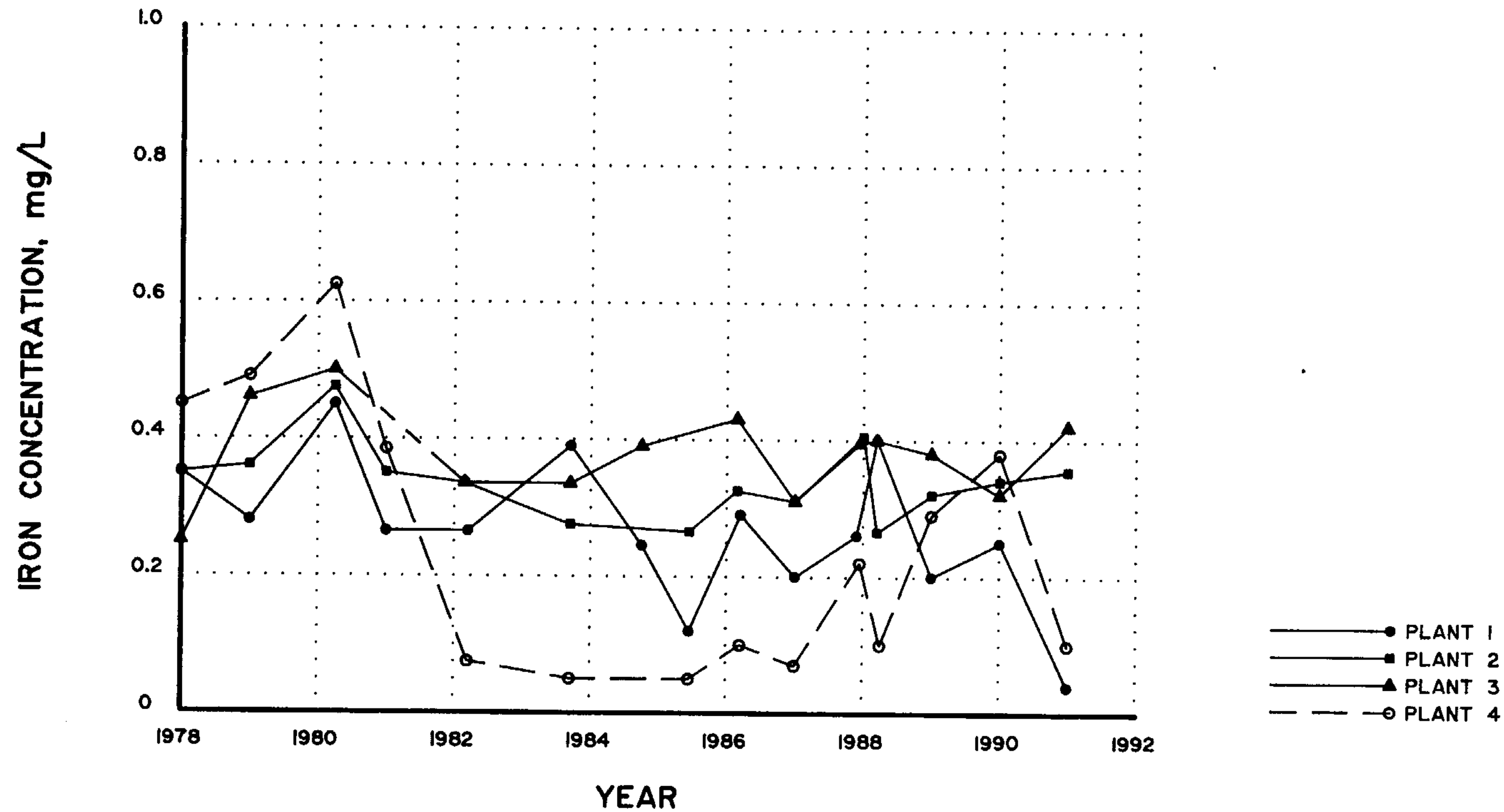
groundwater by weak acids that are formed by the presence of carbon dioxide in the groundwater. The description of the Goliad Formation, the formation which contains the Evangeline Aquifer, did not list iron and manganese oxides as being present. The City of Victoria obtains its water from the Evangeline Aquifer, but has been experiencing iron and manganese concentrations above the U.S. EPA drinking water standards. Figure 5-60 is a plot of the iron data obtained at the City of Victoria's water plants. A review of this figure shows that Plants 2 and 3 typically have higher concentrations of iron than do Plants 1 and 4.

The presence of iron and manganese in the water from the Evangeline Aquifer may be due to the presence of small amounts of iron and manganese oxides in the formation that are the source of these constituents. However, the most likely explanation of the source of iron and manganese is that when the water level in the Evangeline Aquifer is lowered, it allows water from the overlying Chicot Aquifer to move downward bringing the iron and manganese from the overlying formations into the Evangeline Aquifer.

In the future as water use increases, and the water level in the Evangeline Aquifer continues to decline, the water moving from the overlying formations into the Evangeline Aquifer will increase. Therefore, the iron and manganese concentrations can be expected to increase with increased water use.

5.7.3 Hydrogen Sulfide

Water that percolates into the formations that comprise the aquifer carry dissolved oxygen into the formation. Biologic activity consumes this oxygen and aerobic biologic activity ceases. If there is sufficient organic material at depth, anaerobic biologic activity can continue by progressively reducing nitrates, sulfates and finally organic material as the bacteria oxidize available organic material. The by-products of this anaerobic activity are nitrogen, hydrogen sulfide, methane, and carbon dioxide. Groundwaters where this type



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IRON CONCENTRATIONS AT
THE CITY OF VICTORIA'S WATER PLANTS

FIGURE 5-60

of activity is occurring would have low nitrate and sulfate concentrations, but would contain nitrogen, carbon dioxide and hydrogen sulfide. When this water is brought out of the formation, the gases in solution would leave the water as gas. Nitrogen gas and carbon dioxide gas would not have any noticeable affects; however, hydrogen sulfide produces a characteristic rotten egg smell and is corrosive to concrete, metals and galvanized steel when used by bacteria to produce sulfuric acid.

As discussed above, the sulfate concentrations are highest where the hydrogen sulfide presence is the lowest. Plant 1 and Plant 2 have the highest sulfate concentrations, and Plant 3 has the lowest. The difference in sulfate concentrations, and hence hydrogen sulfide concentrations, could be explained by how long the groundwater was in a reducing environment in the aquifer. Plants 1 and 2 receive their water from the wells that are the closest to the Guadalupe River. The Guadalupe has a deep alluvium that is in contact with the water bearing formations in Victoria County. Water from the wells that serve Plants 1 and 2 may enter the aquifer closer to the wells because of their proximity to the Guadalupe River; whereas, the water that is produced by the wells that serve Plants 3 and 4 have migrated from the recharge area for the Evangeline Aquifer near the DeWitt County line.

5.7.4 Barium

Barium is a naturally occurring earth metal. It occurs in nature as barium sulfate, also known as barite, and is commonly found in with beds or veins of metallic ores, more especially of lead, but also copper, silver, cobalt, manganese and antimony (Baker, 1932). Naturally occurring barium sulfate is practically insoluble in water or weak acids. One possible source of barium in the County's groundwater is that biologic activity in the groundwater bearing formation is reducing naturally occurring barium sulfate to barium sulfide, using the oxygen in the oxidation of organic material. Barium sulfide is slightly soluble in water, but is dissolved easily by weak acids, even by carbon dioxide. When barium sulfide is dissolved it produces a free barium ion and hydrogen sulfide. This reaction explains the presence of barium and some of the hydrogen sulfide in the County's groundwater.

Another possible source of barium is from crude oil tank bottoms. In the Saratoga Oil Field in Hardin County, barite has been found as buckshot-like concretions inside the screens in the oil wells (Baker, 1932). Barite is also used in the preparation of drilling muds (Baker, 1932). When the crude oil was placed in earthen lined tanks or the drilling mud was prepared in earthen lined tanks the barium contained in these materials settled to the bottom of the tanks. The construction of these earthen tanks in earlier times did not preclude the leaching of these materials into the ground. The leaching of these materials would transport barium into the formations used as a water source by the County of Victoria.

5.7.5 Chlorides

Figure 5-59 shows the chloride concentrations at the City of Victoria's four water plants. As stated above, the plants have characteristically different chloride concentrations. Chlorides are limited to 250 mg/L by the U.S. EPA, and to 500 mg/L by the Texas Health Department. The current concentration averages about 100 mg/L. Chlorides are not harmful to humans, but do impart a "salty" taste to the water at concentrations above 250 mg/L. The current chloride concentrations and their distribution are a concern because they may indicate that the brackish waters that underlie the fresh water in the aquifer or seawater from the Gulf of Mexico are migrating toward the City's well field. This migration will occur as the water levels in the aquifer are lowered. If the chlorides are originating from seawater intrusion or from upward movement of brackish water, then continued lowering of the water level in the aquifer will result in increased chloride concentrations. Based on the data in Figure 5-59 it is difficult to state that there is a trend of increasing chloride concentrations. Also unusual is that Plant 4 has the highest chloride concentrations and it is the most distant from the Gulf of Mexico and is not at the deepest part of the well drawdowns.

As pumping from the aquifer continues to increase with an accompanying increase in drawdowns, the chloride concentration of the groundwater can be expected to increase. Management of the drawdowns will become extremely important for the City and County to maintain good water quality.

5.7.6 Surface Pollutants

From the 1950s to 1990, the water levels in the City of Victoria's well field have declined by approximately 60 feet. This drawdown in water levels increase the zone of groundwater capture and increases the groundwater gradients, which increase groundwater velocities. These processes will make the City's, and in general the entire County's, water supply more susceptible to pollutants at or near the surface. Evidence of this contamination may already be present in the form of barium in the City's water which may be originating in crude oil tank bottoms. Other pollutants that have migrated into the water supply of other cities, especially in the industrial northeast, are hydrocarbons from leaky underground storage and halogenated solvents used in dry cleaners.

As water withdrawals from the aquifer increase, the water levels will continue to fall, and further increase the potential of surface pollutants entering the groundwaters in Victoria County. The potential for surface pollution will vary throughout the county, but can be worse near large urban areas and near manufacturing facilities.

5.8 LAND SURFACE SUBSIDENCE

One result of reducing the water levels in an aquifer is that it reduces the pore pressures in the formation and allows consolidation of the soils that comprise the formation.

Dewatering a lower formation will also dewater overlying formations and result in consolidation in the overlying formation. The sands in the aquifer are not very compressible; however, if any of the formations are comprised of compressible clays land surface subsidence will occur. The formations that comprise the Evangeline and Chicot Aquifers have interbedded clay layers that make up approximately 50 percent of the formation and these clays can be compressed when dewatered. The clay layer thickness in the Chicot Aquifer has been estimated to be 100 feet thick at the City of Victoria and the clay layer in the Evangeline Aquifer has been estimated to be 300 feet thick at the City of Victoria (Carr, 1985).

Based on measurements in the Houston area, the specific unit-compaction coefficients for the Gulf Coast Aquifer were estimated to be 1.0×10^{-4}/feet for the Chicot Aquifer and 1.8×10^{-5}/feet for the Evangeline Aquifer (Carr, 1985). The specific unit-compaction value relates the amount of land surface subsidence to the thickness of the clay and the amount of water level decrease in the aquifer. Based upon the estimate of the thickness of the clay layers in the aquifer at the City of Victoria the inelastic storage coefficients for the Chicot Aquifer and the Evangeline Aquifer are 1.0×10^{-2} and 5.4×10^{-3}, respectively. The inelastic storage coefficient is the product of the specific unit-compaction coefficient and the clay layer thickness. The inelastic storage coefficient when multiplied by the drawdown in water levels will yield an estimate of land surface subsidence.

Initial water level drawdowns do not initiate land surface subsidence. The drawdown in water levels must exceed the preconsolidation stress. The preconsolidation stress is an approximation of the maximum effective stress to which the clay layers were subjected prior to groundwater withdrawals (Carr, 1985). An estimate of the preconsolidation stress in the Houston area is 70 feet. Therefore, 70 feet of drawdown must occur before land surface subsidence will begin.

The water level drawdowns in the area of the City of Victoria have been estimated to be 120 feet since 1908 (Guyton, 1984). The measured water level declines since the 1950s have been measured to be approximately 60 feet near the center of the City of Victoria. Based upon a preconsolidation stress of 70 feet and the inelastic storage coefficient given above, the land surface subsidence that the City of Victoria should have experienced is in the order of 0.8 feet. The 1982 Texas Department of Water Resources Report 272 estimated that the area around the City of Victoria had experienced less than 0.5 feet of land surface subsidence in the period 1918 to 1973. In 1973 the water level declines in the vicinity of the City of Victoria were approximately 90 feet. Using the preconsolidation stress of 70 feet and the inelastic storage coefficients, the calculated land surface subsidence in 1973 with 90 feet of drawdown is 0.3 feet. It appears that the value of calculated land surface subsidence is consistent with the observed values.

If the City of Victoria and Victoria County obtain only a portion of their future water supplies from the Gulf Coast Aquifer (Case A), the water levels are predicted to fall by an additional 70 feet by the year 2040 in the Evangeline Aquifer and by 30 feet in the Chicot Aquifer in the vicinity of the City of Victoria. This water level decline is predicted to result in an additional 0.7 foot of land surface subsidence between 1990 and 2040 at the point of maximum water level decline. If the City of Victoria and Victoria County obtain all of their future water supplies from the Gulf Coast Aquifer (Case B), the water levels are predicted to fall by 130 feet in the Evangeline Aquifer and 60 feet in the Chicot Aquifer by the year 2040. This water level decline is predicted to result in an additional 1.3 feet of subsidence between 1990 and 2040 at the point of maximum water level decline.

Although most of the area within Victoria County is well above sea level, and an additional 1.3 feet of land surface subsidence would not result in flooding by the Gulf of Mexico, the subsidence could result in structural damage and could activate area faults.

The subsidence values calculated above are based upon data derived from the Houston area. The amount of subsidence experienced in Victoria County may vary from the predicted value, but the analysis indicates that subsidence will occur due to continued water level declines.

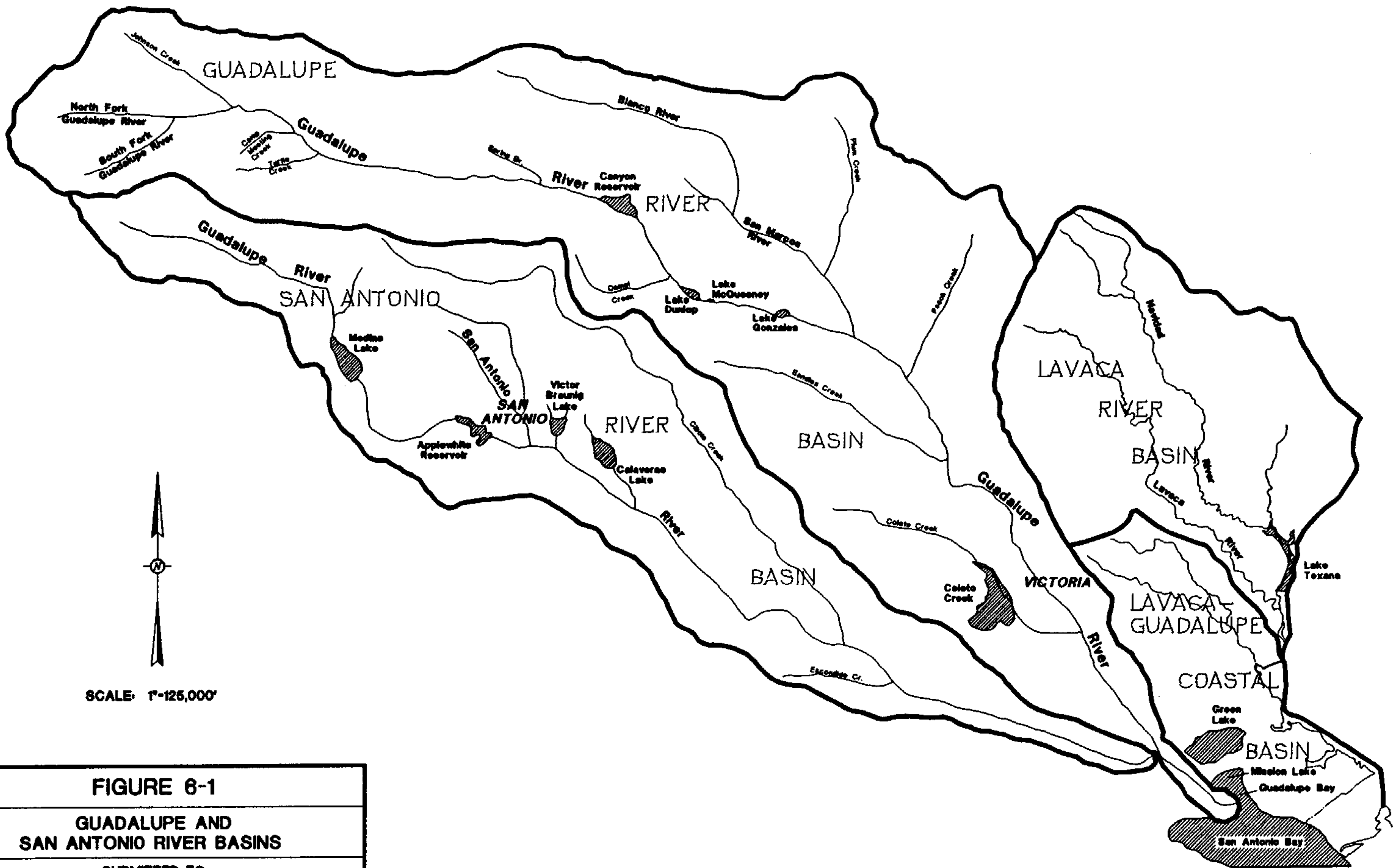
6.0 WATER DEVELOPMENT SCENARIOS

The analysis of the groundwater availability in Section 5.0 showed that there is water available for development to meet the needs of Victoria County through the planning period. Also stated in Section 5.0, is that factors such as water quality, subsidence and economics will govern whether groundwater will remain the best source of water in the region.

This section presents an analysis of alternatives to determine which water development scenarios may be attractive for the region in meeting the water quantity and water quality demands through the planning period. There are numerous water supply sources which could possibly serve the region.

Traditional planning requires examination of a number of widespread supply possibilities and implementation of a systematic elimination procedure to identify less desirable options and to settle on a small number of the most desirable options. This smaller set of options are examined in detail to decide which is the best option for future development. In an effort to identify all potential water supplies for Victoria Regional Water Supply Planning Study, all potential sources in the Guadalupe River Basin as far upstream as Canyon Reservoir as well as potential supplies from the San Antonio and Lavaca-Navidad River basins were examined (Figure 6-1).

What follows is a detailed description of ten potential surface water supplies for the Victoria service area plus a "no-action" alternative, which serves as a baseline condition.



SCALE: 1"=125,000'

FIGURE 6-1

GUADALUPE AND
SAN ANTONIO RIVER BASINS

SUBMITTED TO:
CITY OF VICTORIA

SUBMITTED BY:
CAMP DRESSER & McKEE, INC.
IN ASSOCIATION WITH
MICHAEL SULLIVAN & ASSOCIATES, INC.

6.1 LIMITED/NO ACTION ALTERNATIVE

The baseline for all planning studies is the no action alternative. The no action alternative assumes that all current and future water users in the Victoria service area will continue to rely on existing sources to support future development and demands. In conjunction with the no action alternative is the "limited action" alternative. This development alternative assumes that current supply sources will be developed to the maximum extent possible under engineering, legal, and economic constraints and that additional supplies for future needs are developed only to the extent necessary to make up the difference between current source supplies and future demands.

6.1.1 Victoria Remains Exclusively on Groundwater From Existing Sources

In Section 5.0 of this study, it was demonstrated through groundwater modeling and other means that current groundwater supplies will be sufficient to meet the demands for the City of Victoria and other municipal and industrial users in the region through the year 2040. However, the groundwater levels in the regional aquifer were lowered by an additional 170 feet while meeting this demand. As a result, wells may have to be extended much deeper as the groundwater levels in the aquifer drop in the future. Current groundwater users in the region are experiencing problems with high concentrations of barium, manganese, iron, and other metals. The concentrations of these metals appears to be increasing and is likely to require construction of sophisticated treatment process and facilities to reduce their concentrations below State and Federal drinking water standards.

6.1.2 Victoria's Future Demand Supplied Principally From Existing Groundwater Sources But Supplemented With Minimal Surface Water Supplies

The limited action alternative assumes that the City of Victoria and other participating municipalities will continue to rely on groundwater for their primary source of supply. But, that surface water supplies will either be purchased or developed to meet projected future municipal demands.

6.2 PURCHASE FUTURE SUPPLIES FROM OTHER PURVEYORS OR ENTITIES

There are three regional purveyors of surface water that may have supplies available for purchase by Victoria County users. Those entities are the Guadalupe-Blanco River Authority (GBRA), the Lavaca-Navidad River Authority (LNRA), San Antonio River Authority (SARA). In addition, there is the option for Victoria County users to purchase and convert local irrigation rights to municipal rights. Each of these options will be examined in detail.

6.2.1 Guadalupe-Blanco River Authority (GBRA)

The GBRA operates Canyon Reservoir, located on the Guadalupe River just upstream from the City of New Braunfels, plus six small hydropower projects between New Braunfels and Gonzalez. Canyon Reservoir was constructed by the U.S. Army Corp of Engineers and has a maximum design capacity of 1,129,300 ac-ft. The GBRA has a permit to sell 50,000 ac-ft/yr from Canyon Reservoir. Recent engineering studies indicate that the Firm Annual Yield (FAY) of Canyon Reservoir when honoring all senior downstream water rights is less than 50,000 ac-ft/yr. The latest study has suggested that the FAY of Canyon Reservoir is approximately 4,000 ac-ft/yr. GBRA has maintained a 10,000 ac-ft/yr yield buffer and has unofficially assumed a 40,000 ac-ft/yr firm yield for sale. To date, the GBRA has sold approximately 33,000 ac-ft/yr to downstream users ranging from New Braunfels to San Antonio Bay. The majority of the customers for Canyon water are in the lower Guadalupe Basin with some users in the San Antonio-Guadalupe and Guadalupe-Lavaca Navidad coastal basins.

The GBRA owns six small low-head hydropower dams on the Guadalupe between New Braunfels and Gonzales with permit priority dates from 1914. Those hydropower dams generate peaking power purchased by the Guadalupe Valley Electric Coop (GVEC). The GBRA has initiated a partial subordination of some of their own hydropower rights for the six projects. This will result in an increase in the firm annual yield of Canyon Reservoir. It is anticipated that the partial hydropower right subordination will increase the Canyon Reservoir yield by 9,000 ac-ft/yr. This water would then become available for sale to downstream customers such as the City of Victoria and Victoria County.

The GBRA has additional water rights that could be partially or totally subordinated if additional yield may be required. The GBRA partially subordinated some downstream water rights to free-up supplies for the Coleto Creek Power Generating Station cooling water project.

Recent offerings of Canyon Reservoir water to other regional entities have been at approximately $53.03/ac-ft. The Canyon Regional Water Authority (CRWA) recently contracted for 1,740 ac-ft/yr at that rate. The GBRA has structured contracts on a fixed take-or-pay basis but has also considered development of diversion and treatment facilities with the end user serving as a wholesale customer. Conceivably, both of these options would be available to Victoria.

6.2.2 Lavaca-Navidad River Authority (LNRA)

The LNRA operates Lake Texana on the Navidad River in Jackson County. Lake Texana, developed by the Bureau of Reclamation (BurRec) and the Texas Water Development Board (TWDB), which still owns a major share of the project, intercepts and impounds one of the two major rivers of the Lavaca-Navidad Basin. The Lavaca River currently remains uncontrolled and flows directly to Lavaca Bay. The permitted FAY of Lake Texana is 75,000 ac-ft/yr. Revised hydrologic studies have predicted a firm annual yield for Lake Texana in excess of 82,000 ac-ft/yr. Other studies have suggested that purchase of the Garwood Irrigation Company rights to Colorado River water, which were formerly used for rice irrigation, could also be used to greatly increase the yield of the project. However, it appears that this development option may draw significant opposition.

The LNRA has contractual obligations for approximately 35,000 to 40,000 ac-ft/yr to be used for industrial purposes, principally by Formosa Plastics, in the Point Comfort area. To take advantage of favorable bond rates, the pipeline which will carry the 35,000 to 40,000 ac-ft/yr of industrial supplies to Point Comfort was oversized by 25 percent, with the excess capacity reserved for municipal use. In addition, the LNRA and others have examined the feasibility of using the remainder of the Texana water for such diverse customers as the City of San Antonio, the City of Corpus Christi, and the Corpus Christi Port Authority. At various times, each of these entities has expressed a serious interest in purchasing the remainder of the Lake Texana yield. However, no contracts have been executed. The problems associated with long pumping distances plus crossing significant wetland areas to move water to the south and west may influence those decisions. A pipeline from Lake Texana to Victoria would be at least 28 miles long and may cross wetlands adjacent to the Lavaca River and Upper Lavaca Bay. These are not fatal flaws to the development of this resource but may pose some engineering and environmental concerns.

The amount of water available for sale to other entities is also somewhat clouded by an unresolved lawsuit brought by a 1983 Sierra Club and the Texas Parks and Wildlife Department (TP&WD) over required freshwater inflows to Lavaca Bay and the Lavaca Tres Palacios Estuary. Numerous studies have been performed to quantify the spatial and temporal freshwater inflow requirements of the bay and estuary system. These requirements will drive reservoir operation rules which will impact the FAY of the system. Resolution of this suit may have a significant impact on the amount of water available for sale to other users.

A Texana II project (originally called Palmetto Bend II) on the Lavaca River, which would be hydraulically connected to the existing Texana reservoir, has been federally authorized and permitted through the Texas Water commission (TWC). However, the future of this project is unknown at this time. Economic, hydrologic, and bay and estuary release issues need to be resolved. In addition, increased spillway capacity requirements for Texana I which may be necessitated by the revised river basin hydrologic and hydraulic evaluations may need to be incorporated into the Phase II project. Both of these issues may influence future development decisions.

6.2.3 San Antonio River Authority (SARA)

SARA does not own or operate any major reservoir projects that could be used as a firm supply for the Victoria study area. However, much of the wastewater from the City of San Antonio which flows down the San Antonio River remains unappropriated and could conceivable be used by Victoria County. The City of San Antonio is currently developing an extensive reuse/recycle plan which could alter future availability of water from this source. Cibolo Reservoir, located on Cibolo Creek in Wilson County, and Goliad Reservoir, located on San Antonio River in Goliad County, are two potential future SARA projects which produce a potential future source for Victoria.

6.2.4 Purchase and Conversion of Local Irrigation Water Rights

Due to recent changes in agricultural practices in south Texas, there may be a significant amount of local irrigation water rights available in the Lower Guadalupe and San Antonio River Basins as well as adjacent coastal basins. Those rights conceivably could be purchased and converted to municipal rights in Victoria County.

6.3 DEVELOP ADDITIONAL GROUNDWATER SOURCES

Most municipal entities in Victoria County currently derive all of their supplies from groundwater sources. Nearly all of the local wells are drilled into the Gulf Coast Aquifer. As discussed in Section 5.0, supplies appear to be adequate throughout the planning horizon; however, quality problems may preclude total reliance on this source. Other groundwater sources also may be feasible for development within the study area.

6.3.1 Shallow Wells Drilled into Local Formations

Shallow wells drilled into local perched lens formations are an inexpensive and readily available source of small quantities of water. These shallow perched lenses tend to follow the hydrologic cycle with respect to availability and are extremely sensitive to pollution potential and should be considered only as a possible limited short term supply.

6.3.2 Drill Additional Wells into the Gulf Coast Aquifer

Additional wells to supply future demands in the study area could be drilled into the Gulf Coast Aquifer. However, as the demand increases, groundwater levels will fall and it is likely that treatment for Barium, Manganese, Iron and other metals will be likely.

6.3.3 Drill Wells into the Carrizo-Wilcox Formation

The Carrizo-Wilcox Aquifer extends as far south as Wilson, Gonzalez and Lavaca Counties. The Carrizo-Wilcox Aquifer is a source of large quantities of relatively good quality water. However, portions of the Carrizo-Wilcox currently experience minor water quality problems similar to those of the Gulf Coast Aquifer. Long pumping distances plus potential future water quality problems limit the future development of this source.

6.4 SEEK CONJUNCTIVE USE OF THE EXISTING COLETO CREEK POWER PLANT COOLING RESERVOIR

The Coleto Creek Power Plant Cooling Reservoir is located in the Guadalupe Basin directly west of the City of Victoria. Coleto Creek Reservoir derives its water from natural inflows from Coleto Creek with make-up water pumped from the Guadalupe River. The reservoir contains approximately 35,000 ac-ft of storage at normal elevation. Off-channel storage of surface water is a major development option in the Victoria area. Conjunctive use of the Coleto Creek Cooling Reservoir, with or without raising of the impoundment levy, is an attractive option. Victoria could develop surface water sources dependent on run-of-the-river water during normal hydrologic periods and rely on stored water within Coleto Creek Reservoir during drought periods. Development of this option would, however, require the participation of both the GBRA and Central Power and Light (CP&L) and could pose some interesting engineering challenges.

6.5 APPROPRIATE AND DEVELOP LOCAL SURFACE WATER SOURCES WITHOUT CONSTRUCTION OF A STORAGE IMPOUNDMENT

San Antonio Bay currently receives of approximately 1.2 million ac-ft/yr, on average, of freshwater inflows from the San Antonio and Guadalupe River Basins. Studies of the freshwater inflow requirements of San Antonio Bay performed by the Texas Water

Development Board have indicated that approximately 800,000 ac-ft/yr is necessary to maintain the ecological health and integrity of that bay and estuary system. Thus, on average, there should be approximately 400,000 ac-ft/yr of excess water available for development from these two river basins. One means of developing this water source is simple appropriation through the Texas Water Commission. The reliability of appropriated water in the Lower Guadalupe and San Antonio Basins is the only constraint to development of this option as the future surface water source for the study area.

6.5.1 Guadalupe River Basin Local Sources

The Texas Water Commission has estimated through their adjudication process that there is between 14,000 and 260,000 ac-ft/yr of water available within Victoria County. The reliability of these flows as a future water supply source is questionable during periods of severe or prolonged drought. However, when used in conjunction with existing groundwater sources, this may be sufficient for future Victoria County demands. A detailed analysis of surface water supplies from the Guadalupe River is presented in Section 6.13.

6.5.2 San Antonio River Basin

The Texas Water Commission estimates that the unappropriated water available for diversion directly from the San Antonio River above its confluence with the Guadalupe River varies from zero to over 200,000 ac-ft/yr. Clearly, this will not suffice as the primary source of water available for Victoria County; however, it could be used conjunctively with other surface water sources and existing groundwater supplies.

6.6 APPROPRIATE AND DEVELOP LOCAL SURFACE WATER SOURCES WITH CONSTRUCTION OF EITHER AN IN-CHANNEL OR OFF-CHANNEL STORAGE IMPOUNDMENT

Development of firm surface water supplies in a region of irregular flows which range from near zero during drought periods to hurricane induced floods requires either the maintenance of an alternative source, such as groundwater, or construction of a storage impoundment capable of maintaining supplies, plus evaporative and seepage losses, sufficient to bridge the most severe drought of record. In-channel storage reservoirs require construction of an earthen or concrete dam across an existing stream. This option can be very expensive because a spillway must be constructed of concrete sufficient to pass the Probable Maximum Flood (PMF). Off-channel storage utilizes either a natural or man-made depression for water storage sufficient to maintain supplies, plus evaporative and seepage losses through the drought of record. Water is pumped from the primary stream source into the impoundments. The major advantages of off-channel storage over in-channel storage are that there is no requirement for a spillway other than what is necessary to pass the probable maximum precipitation (PMP) which falls directly on the impoundment surface and the impoundment(s) can be constructed in phases, which improves the efficiency of the system and reduces the cost to the local rate payers.

6.6.1 Guadalupe River Basin — In-Stream Impoundment

With the exceptions of the proposed Cuero and Lindenau Reservoir sites in DeWitt County on the Guadalupe River upstream of Victoria County, there are relatively few suitable sites for an in-stream impoundment of sufficient size to meet the future needs of Victoria.

6.6.2 Guadalupe River Basin — Off-Channel Impoundment

Within the proposed study area, there are a number of natural depressions which may be suitable for development of off-channel storage. A detailed siting evaluation for and off-channel reservoir would be necessary to adequately locate, size and cost this alternative.

6.6.3 San Antonio River Basin — In-Stream Impoundment

With the exception of the potential Goliad project on the San Antonio River, there are relatively few suitable sites for in-stream impoundment in the San Antonio River Basin. There is an unnamed creek which flows into the San Antonio River just south of the Coleto Creek Storage Reservoir that may have some sites suitable for in-stream storage. However, additional supplies may need to be appropriated and diverted into this reservoir from the San Antonio River.

6.6.4 San Antonio River Basin — Off-Channel Impoundment

The lower San Antonio River Basin is relatively flat and narrow. It is not likely that there will be suitable sites available for development of an off channel reservoir system.

6.7 VICTORIA PARTICIPATION IN OTHER EXISTING OR PROPOSED STATE OR FEDERAL PROJECTS

There are several potential water resource development projects that have been proposed for south Texas that could serve as a long-term future supply for Victoria study area. Cuero and Lindenau Reservoirs proposed just upstream from Victoria County in the Guadalupe Basin are candidate projects for future supply. The Goliad project on the San Antonio River is also a potential future supply source. The Cibolo Reservoir located on

Cibolo Creek in Wilson County is a federally authorized project that has not yet been constructed. It is doubtful, however, that there will be water available for the study area from this project.

6.7.1 Lindenau Reservoir

It is anticipated that construction of the Lindenau Reservoir will begin about the year 2005. A low flow diversion structure on the Guadalupe River near Cuero and pipeline facilities will pump excess flows from the Guadalupe River to Lindenau Reservoir. It is anticipated that the majority of water developed by the Lindenau project will be used by the City of San Antonio. Some water may be available to serve the Victoria regional study area but the time-frame and availability are presently unknown (TWDB, 1977).

6.7.2 Cuero Reservoir

Construction of the Cuero Reservoir adjacent to the Lindenau Reservoir on the Guadalupe River is not anticipated before the year 2020. Therefore, Cuero Reservoir is not a feasible short- or long-term supply alternative for the study area defined for this project (TWDB, 1977).

6.7.3 Goliad Reservoir

The major reservoir proposed for construction in the lower San Antonio Basin is Goliad Reservoir. The potential dam site is located on the San Antonio River several miles upstream form the City of Goliad in Goliad County. The Goliad site is proposed for development by the year 2020 to meet the needs of the City of San Antonio and to provide water to the Nueces Basin, particularly the City of Corpus Christi. The long time-line for this project, however, eliminates it from serious consideration as a short- or long-term supply option for this study (TWDB, 1977).

6.7.4 Cibolo Reservoir

Hydrologic studies have determined that the FAY of the Cibolo Reservoir project scheduled for construction in the early 2000's will yield approximately 22,000 ac-ft/yr. 20,000 ac-ft/yr of this yield is currently identified as a future water source for the City of San Antonio. Therefore, there will be insufficient water available for Victoria County's participation in the project at any level.

6.8 TRANSFER OF A PORTION OF LOWER GUADALUPE BASIN, GUADALUPE-LAVACA COASTAL BASIN AND SAN ANTONIO-GUADALUPE COASTAL BASIN CONTRACTS OR WATER RIGHTS CURRENTLY SERVED THROUGH RELEASES FROM CANYON RESERVOIR TO LAKE TEXANA AND REASSIGN THAT PORTION OF CANYON STORAGE TO VICTORIA

Approximately 12,000 ac-ft of the 30,053 present contractual GBRA water sales from Canyon Reservoir are in the lower Guadalupe or adjacent coastal basins. Release of water from Canyon Reservoir, which is several hundred miles from the potential users, represents a relatively inefficient use of the resource. Port Lavaca currently purchases its water supplies from the GBRA which owns and operates a water treatment plant near Port Lavaca. Conceivably, the demands of Port Lavaca and surrounding communities served by the GBRA could be converted to Lake Texana water as a source with GBRA maintaining treatment facilities and the original water from the Guadalupe Basin used in the Victoria study area. The transmission main between Lake Texana and Point Comfort has approximately 13,000 ac-ft/yr of excess capacity which can only be used to deliver municipal supplies. Construction of a pipeline across Lavaca Bay to the GBRA plant could accomplish such a switch.

6.9 IMPROVE EFFICIENCY OR PARTIAL SUBORDINATION OF THE GUADALUPE-LAVACA COASTAL BASIN AND SAN ANTONIO-GUADALUPE COASTAL BASIN CANAL SYSTEMS AND ASSIGN THE SAVED WATER TO VICTORIA

Most end users of water in the San Antonio-Guadalupe and Guadalupe-Lavaca Coastal Basins receive that water via an extensive canal system. Channel losses through such a system are often exceedingly high, especially in regions of sandy soils. Significant savings could be accrued through improved efficiency of canal operations or reductions to channel losses through lining of existing canals or conversion to a totally enclosed pipeline system. Theoretically, the savings could then become available for appropriation from the Water Commission by Victoria.

Beyond improving the efficiency of the system, the GBRA could agree to partial subordination of unused industrial or irrigation waters diverted into the canal system.

6.10 RECHARGE LOCAL GROUNDWATER FORMATIONS FROM SURFACE WATER SOURCES DURING ABUNDANT TIME AND RECOVER THE STORED WATER DURING DROUGHTS

Recharging local groundwater formations from surface water sources is popular in West Texas and New Mexico especially in the El Paso area. This technology is for storing water during abundant times and for retrieval during drought periods. This technology has not been practiced in south Texas. However, there may be geologic formation(s) within the study area appropriate for storage of water from the Guadalupe River during high flow periods for retrieval during droughts.

6.11 WASTEWATER REUSE/RECYCLE

Water Conservation is the simplest mechanism for accommodating the demands for future growth short of the development of additional supplies. Water reuse and recycling are two forms of conservation that attempt to view wastewater as a resource rather than a disposal problem. The requirements for a successful water reuse and recycling program are a relatively constant supply of easily treatable wastewater and a relatively constant demand for that product. Generally, water reuse and recycling is reserved for areas of intense development where large users, such as industries or golf courses, could use nearly all of the wastewater produced by a municipality thereby reducing the demand for new sources.

6.12 MATRIX EVALUATION OF WATER DEVELOPMENT SCENARIOS

A total of 23 projects are shown in Table 6-1. An economic analysis of each of these projects is beyond the scope of this study and is not justified. Many of the projects listed in Table 6-1 are obviously better than others. To determine which projects demand closer scrutiny, an elimination procedure has been used to lower the number of projects that need to be examined in detail from 23 to three. This elimination procedure takes the form of a matrix evaluation.

Matrix methods have long served as a means to reduce a large number of potential development options to a few of the most promising options which are examined in more detail. A fatal flaw analysis is, by definition, built into a matrix evaluation through application of large negative weighting factors to those options which contain a fatal flaw.

Matrix evaluation techniques attempt to, in a semi-rigorous manner, identify and assign a numerical weighting factor to each of the advantages and disadvantages associated with each future development option. A list of the advantages and disadvantages associated

Table 6-1
Future Victoria Regional Water Supply Option Advantages and Disadvantages

OPTION	ADVANTAGES	DISADVANTAGES
1. Remain on Groundwater Sources		
a. Remain on Groundwater	• Least expensive option for both long- and short-term. • Flexibility of operation is only slightly affected for both long- and short-term. • Little environmental impact.	• Uncertain future supply availability. • Uniform supply during drought conditions. • Loss of opportunity for surface supplies.
b. Limited Surface Water	• Short-term supply relatively adequate.	• Long-term response accentuates short-term impact. • Future costs higher, length of time to develop options long.
2. Purchase Supply From Others		
a. GBRA Supplies from Canyon Reservoir	• Firm supply, if available, for short- and long-term. • Contracted supply at known prices (currently Canyon Reservoir water is being sold to new customers at about $53.03/ac-ft). • Increased instream flow between Canyon Reservoir and Victoria for enhanced water quality and aquatic uses.	• Supply may not be available for purchase. 32,000/AF committed. • Contracted supply may be "take-or-pay" which can be expensive in the early years of the contract when there is a lower demand and rate base. • Expense of Surface Water treatment.
b. LNRA Supplies from Lake Texana	• GBRA financing. • GBRA offers several options. • Firm supply, if available, for short- and long-term; 30,000 ac-ft currently contracted.	• Other cities such as San Antonio and Corpus Christi may be competing for same supply. Texana II may not be built. • Will require construction of a relatively long pipeline.

OPTION	ADVANTAGES	DISADVANTAGES
	• Low cost contracted supply (currently Lake Texana water is being sold to new customers at about $17/ac-ft). • Could be purchased from TWDB if LNRA refuses first option on Boar's share.	• Must cross Navidad River. • Decreased freshwater inflows to Lavaca Bay.
c. SARA supplies from San Antonio River	• Firm supply, if available, for short- and long-term. • Victoria County could purchase all or part of Applewhite.	• Availability extremely doubtful.
d. Irrigation Permits	• Reasonable supply of available permits. • Almost no environmental impact.	• Viable short-term option only. • Need to upgrade permit status from TWC Category 3 to Category 1. • Monthly distribution may be the same as original agricultural distribution; may also be minimum flow restrictions and maximum diversion rates. • Must negotiate each individual right. • Cost more than run-of-river permit.
3. Wells a. Shallow Wells	• Easy to design and construct.	• Viable short-term option only. • Rapid well depletion. • More prone to Contamination/Pollution • Drought sensitive. • Unknown yield capacity.

OPTION	ADVANTAGES	DISADVANTAGES
b Gulf Coast Aquifer	• Extensive formation; good recharge capability; large supply. • No depletion of surface water supplies. • No negative environmental impacts.	• May require relatively large well field. • Salt water intrusion. • Subsidence. • No exclusivity.
4 Conjunctive Use of Coletto Creek Reservoir.	• Use of existing impoundment. Either contracted GBRA Canyon Reservoir releases or unappropriated flows may be captured. • Use of existing diversion structures. • Use of flood flows and unappropriated flows.	• Lake level may need to be raised to accommodate the additional yield requirements. This cold necessitate extensive construction. • Will require contractual agreements with GBRA and CP&L. Either party may choose to not participate. • Will require relatively long delivery pipeline. • GBRA has permit; CP&L has water right.
5 Appropriation of Surface Water Without Construction of an Impoundment a Guadalupe River - Local	• Low cost. • Short pumping distance. • No cost for impoundment.	• No firm supply or less than required during droughts. • Must store as much as can be pumped in wet-well. • Supply may vary inversely with demand. • Supply consists of return flows from San Antonio, therefore limited and not firm.

OPTION	ADVANTAGE	DISADVANTAGE
b San Antonio River	• Low cost. • Longer pumping distance. • No impoundment required.	• Will require construction of a long pipeline. • Water re-use in San Antonio will reduce supply. • Upstream development may capture supplies.
6 Appropriation of Surface Water With Construction of an Impoundment		
a Guadalupe River In-channal Reservoir	• Firm supply. • Appropriative water right.	• High cost of construction of full impound ment well in advance of demand and rate base. • Minimum Required spillway. • Inefficient use of storage in early years. • Environmental mitigation. • May not be suitable site(s) available
b Guadalupe River Off-channel Storage	• Firm supply. • Use unappropriated surface water flows. • Inexpensive construction. • Phased construction possible. • Multiple sites available. • Also captures natural supply.	

OPTION	ADVANTAGE	DISADVANTAGE
	• Can build anywhere. • Project construction can be phased with increased demand. • Efficient use of water; evaporation is minimized. • Supply, cost and rate base increase together.	
c San Antonio River In-channal Reservoir	• Firm supply. • Appropriative water right	• High cost of construction of full impoundment well in advance of demand and rate base. • May require spillway. • Inefficient use of storage in early years. • May not be suitable site(s) available.
d San Antonio River Off-channel Storage	• Firm supply. • Appropriative water right. • Project construction can be phased with increased demand. • Efficient use of water; evaporation is minimized. • Supply, cost and rate base increase together.	• May not be suitable site(s) available. • Long pumping distance.

OPTION	ADVANTAGE	DISADVANTAGE
7 Other State/Federal Projects		
a Cuero Reservoir	• Long-term Supply (construction estimated between 2020 - 2030).	• Not viable short-term option; (construction estimated between 2020 - 2030). • Water must be purchased from GBRA or unspecified local sponsor. • Doubtful project future. • Participation may be expensive. • Low flow mitigation.
b Lindenau Reservoir	• Long-term Supply.	• Not viable short-term option; (construction estimated between 2000 - 2010). • Water must be purchased from GBRA or local sponsor.
c Goliad Reservoir	• Firm Supply.	• Not viable short-term option; no anticipated construction date. • Water must be purchased from SARA or local sponsor. • Doubtful project future.
d Cibolo Reservoir	• Firm Supply.	• Not viable short-term option; no anticipated construction date. • Water must be purchased from SARA or local sponsor or participant in project. • Doubtful project future.

	OPTION	ADVANTAGE	DISADVANTAGE
8	Transfer of Coastal Basin Demands (availability 4,500/AF Port Lavaca and Indianolo, 5,934/AF Indianolo).	• Relatively Firm Supply.	• Requires concurrence of GBRA. • Requires TWC review and authorization. • May be expensive to implement; must build pipeline across Lavaca.
9	Improve Coastal Canal System Efficiency (Calhoun County canal would reduce permanent diversions).	• Reduced channel losses between river and major users. • Net increase in water availability.	• Construction difficulties. • Most saved water will have irrigation right distribution factors or minimum diversion requirements by TWC. • Requires TWC concurrence. • Expensive. • Could give water but not obligated.
10	Recharge Local Groundwater Formations from Surface Water Source	• Relatively firm yield.	• May not be suitable formation available. • Requires Pre-treatment. • Not complete control of resource; total control of surface acreage required. • Technology inefficient and expensive.
11	Water Reuse	• Adjunct supply. • Reduces future new supply requirements. • Can reduce irrigation demands of golf courses, parks and green areas.	• Viable as adjunct supply only. • Separated grey-water distribution required: may be suitable for major metropolitan areas only. • Growth in area is municipal use not industrial use.

with each future supply options for the Victoria study are contained in Table 6-1. This table attempts to weigh the feasibility, flexibility, and sufficiency of each option against known disadvantages. Matrix evaluation techniques apply positive weighting factors to advantages and negative weighting factors to disadvantages. Summation of the positive and negative factors associated with each development option will readily identify those options worthy of future consideration and those options which should be eliminated from consideration.

6.12.1 Evaluation Criteria

Before weighting factors can be applied to the advantages and disadvantages of each supply option, a set of evaluation criteria must be established and a numerical weighting scale applied to each criteria. For the purposes of this study, we have chosen to separate evaluation criteria for engineering/technical considerations from those associated with institutional/legal considerations. An example of the Victoria water supply evaluation matrix with source options and supply evaluation weighting criteria is shown in Table 6-2.

6.12.2 Engineering/Technical Criteria

Four engineering/technical criteria were selected for evaluation with respect to each one of the potential supply options for the Victoria study area. Those criteria are engineering feasibility, reliability of the supply, flexibility of implementation, and environmental impacts.

Engineering Feasibility

Engineering feasibility attempts to measure the technical reality of development of a particular supply option. If a project requires very little engineering of if the engineering associated with that project is very simple and straight forward, the project would receive

Table 6-2
City of Victoria Water Supply Options Evaluation Matrix
(Part 1)

	Engineering a/									
	Firm Supply		Engineering Feasibility		Flexibility		Environmental		Total Engineering	
Source Option	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
1. Limited/No Action										
a. Remain on Groundwater Supplies										
b. Limited Surface Water Use										
2. Purchase from Others										
a. Guad.-Blanco River Authority										
b. Lavaca-Navidad River Authority										
c. San Antonio River Authority										
d. Local Irrigation Permits										
3. Wells										
a. Local Shallow Wells										
b. Gulf Coast Aquifer										
c. Carrizo-Wilcox Formation										
4. Conjunctive Use/Subbordination of Coletto Creek Reservoir										
5. Appropriate S.W. w/o Impoundment										
a. Guadalupe River - Local										
b. Guadalupe River - Other										
c. San Antonio River										
6. Appropriate S.W. w/ Impoundment										
a. Guadalupe River - Instream										
b. Guadalupe River - Off-channel										
c. San Antonio River - Instream										
d. San Antonio River - Off Channel										
7. Other State and Federal Projects										
a. Cuero Reservoir										
b. Lindenau Reservoir										
c. Goliad Reservoir										
d. Cibolo Reservoir										
8. Trans. of Coastal Basin Demands										
9. Improve Coast Canal Sys. Efficiency										
10. Recharge Local Groundwater Form.										
a. Guadalupe River Source										
b. San Antonio River Source										
11. Wastewater Reuse										

a/

Supply Evaluation Weighting	Issues	Range	
Engineering Feasibility	Are there significant engineering challanges to this option?	-10	10
Firm Supply	Will this option carry CRWA through drought conditions? With/without augmentation?	-10	10
Flexibility	How well does this option fit in with implementation of other options?	-5	5
Environmental	Habitat Preservation/Creation and other possible environmental impacts.	-4	4

Table 6-2 (Continued)
City of Victoria Water Supply Options Evaluation Matrix
(Part 2)

	Institutional/Legal b/									
	Legal Considerations		Institutional Considerations		Public Acceptance		Total Intitutional		TOTAL	
Source Option	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
1. Limited/No Action										
a. Remain on Groundwater Supplies										
b. Limited Surface Water Use										
2. Purchase from Others										
a. Guad.-Blanco River Authority										
b. Lavaca-Navidad River Authority										
c. San Antonio River Authority										
d. Local Irrigation Permits										
3. Wells										
a. Local Shallow Wells										
b. Gulf Coast Aquifer										
c. Carrizo-Wilcox Formation										
4. Conjunctive Use/Subbordination of Coletto Creek Reservoir										
5. Appropriate S.W. w/o Impoundment										
a. Guadalupe River - Local										
b. Guadalupe River - Other										
c. San Antonio River										
6. Appropriate S.W. w/ Impoundment										
a. Guadalupe River - Instream										
b. Guadalupe River - Off-channel										
c. San Antonio River - Instream										
d. San Antonio River - Off Channel										
7. Other State and Federal Projects										
a. Cuero Reservoir										
b. Lindenau Reservoir										
c. Goliad Reservoir										
d. Cibolo Reservoir										
8. Trans. of Coastal Basin Demands										
9. Improve Coast Canal Sys. Efficiency										
10. Recharge Local Groundwater Form.										
a. Guadalupe River Source										
b. San Antonio River Source										
11. Wastewater Reuse										

b/

Supply Evaluation Weighting	Issues	Range	
Legal Restrictions	Are there any legal obstacles, impediments or restrictions to implementation of this option?	-10	0
Institutional Considerations	What institutional arrangements can/must be made to facilitate/allow development of this option?	-6	6
Public Acceptance	Will the CRWA members accept this option? Will other regional and state entities accept this option?	-4	4

a relatively high positive weighting factor. Because engineering feasibility tends to be one of the principal drivers of the supply development process, we have chosen to use a weighting factor range of -10 to +10.

Firm Supply

Second only to engineering feasibility in importance is evaluation of a potential water supply project's reliability as a sole source. The true measure of a supply source is the Firm Annual Yield (FAY) which is that yield which could be diverted continuously throughout the worst drought of the period of record. Sources with a FAY less than the amount required by the study area can still be favorably considered; however, an alternative source of supply is generally necessary to insure adequate supplies through the drought of record. The evaluation criteria placed on the reliability of supply ranges from -10 to +10.

Flexibility

In developing future water supplies, it is desirable that they be compatible with existing supplies, treatment processes and distribution systems. Often times the flexibility of a potential supply source and its compatibility with existing treatment and distribution systems can be a limiting factor in the selection of that source. However, flexibility is far less important than either engineering feasibility or reliability of supply. Flexibility has been given an evaluation criteria ranging from -5 to +5.

Environmental Impacts

Environmental impacts of proposed projects can either be glaring or very subtle. Large negative environmental impacts tend to be obvious. Positive impacts, however, are generally less discernable and often apparent only in a relative sense when compared to the impacts of competing options. Therefore environmental impacts were given an evaluation range of -4 to +4.

6.12.3 Institutional and Legal Criteria

Institutional and legal considerations encompass those softer issues such as governmental entity interaction, contractual relationships, legal conformance with regulatory requirements and public acceptance. Generally these are not issues that will make or break a project; however, ignoring any one of them can make completion of a project exceedingly difficult, time consuming or expensive.

Legal Considerations

Legal considerations that could affect a potential supply option would include requirements for legal formation of a type of political entity or subdivision prior to development of a particular supply option, legal prohibitions on development of a supply option or regulatory restriction. Legal considerations rarely have positive impacts on a project and generally only negatively impact feasibility. Therefore, a range of -10 to 0 is assigned to this criteria.

Institutional Considerations

Advantageous or disadvantageous contractual arrangements, intergovernmental agreements or regulatory agency restrictions can often make a project appear very good or very bad. An evaluation criteria range of -6 to +6 is applied to institutional considerations.

Public Acceptance

Public acceptance of a project is difficult to judge prior to selection of a desired alterative and exposure to public scrutiny. Public acceptance of a proposed project generally assures political support and a favorable review by regularity entities. Strong negative public opinion surrounding a project can certainly slow a project down, rob the project of political support and in some cases ensure failure of a particular development option. Generally, in water resource development projects, however, public acceptance ranges from mild discontent to mild acceptance. An evaluation criteria range of -4 to +4 was assigned to public acceptance.

6.13 MATRIX EVALUATION APPLICATION

Each of the identified supply options was subjected to the matrix evaluation criteria and a numerical score was applied to each option as it applies to satisfaction of short term demand and long term demand. Raw scores for engineering criteria and institutional/legal criteria were summed separately and long term and short term scores for each option were tabulated. Not all matrix evaluations for each option will be discussed in detail in this section as some of them are self evident. Others, however, require supporting information to facilitate evaluation of a particular option.

Reliability of a particular future supply option is pivotal to its future consideration. If a supply is firm, and all other issues score favorably, it should be considered as a serious option for future development. Purchasing water from an existing supply entity such as the Guadalupe Blanco River Authority generally results in a very firm supply. The supply quantity and purchase terms can be negotiated in a number of ways. The two most common terms are: (1) a take-or-pay contract between the supplier and the user where the demand entity contracts with a supplier into the future for a specified quantity of water at a specified rate regardless of whether that water is used and (2) a treated water supply contract where the supply entity absorbs the costs and risk of development and functions as a wholesale purveyor of water to the demand entity. When such options as appropriation are considered, considerably more information is necessary to allow an informed judgement.

6.13.1 Historical River Flows

The San Antonio and Guadalupe basin maps with USGS flow gages are shown in Figure 6-2. Note that Victoria County is located near the lower edge of the Guadalupe Basin. The stream flow gage at the City of Victoria is the lowest non-tidally influenced gage on the Guadalupe River. The lowest non-tidally influenced gage on the San Antonio River is near Goliad. Historical monthly flows for these two gages are shown in Tables 6-3 and 6-4. Note that the annual flows at the Victoria gage on the Guadalupe River range from a minimum of 47,500 ac-ft/yr in 1956 to a maximum in excess of 1.6 million ac-ft/yr in 1976. Much of the flow at the Victoria gage is either reserved for satisfaction of downstream water rights or includes contractual releases from Canyon Reservoir. Thus even during severe drought periods, significant quantities of water passed the Victoria gage because many of the downstream water rights are considered senior or superior to upstream users. San Antonio River flows at Goliad range from a minimum 29,000 ac-ft/yr in 1956 to a maximum 699,000 ac-ft/yr in 1973.

6.13.2 Lower Guadalupe and San Antonio River Basin and San Antonio-Guadalupe and Guadalupe Lavaca Coastal Basin Water Rights

For the purposes of location of water rights within a major river basin, the Texas Water Commission divides each of the river basins into a number of smaller sub-watersheds. Water rights are grouped within a watershed and compared with historical flows to determine the amount of water available for appropriation in downstream watersheds. The San Antonio and Guadalupe River Basins with sub-watersheds are shown in

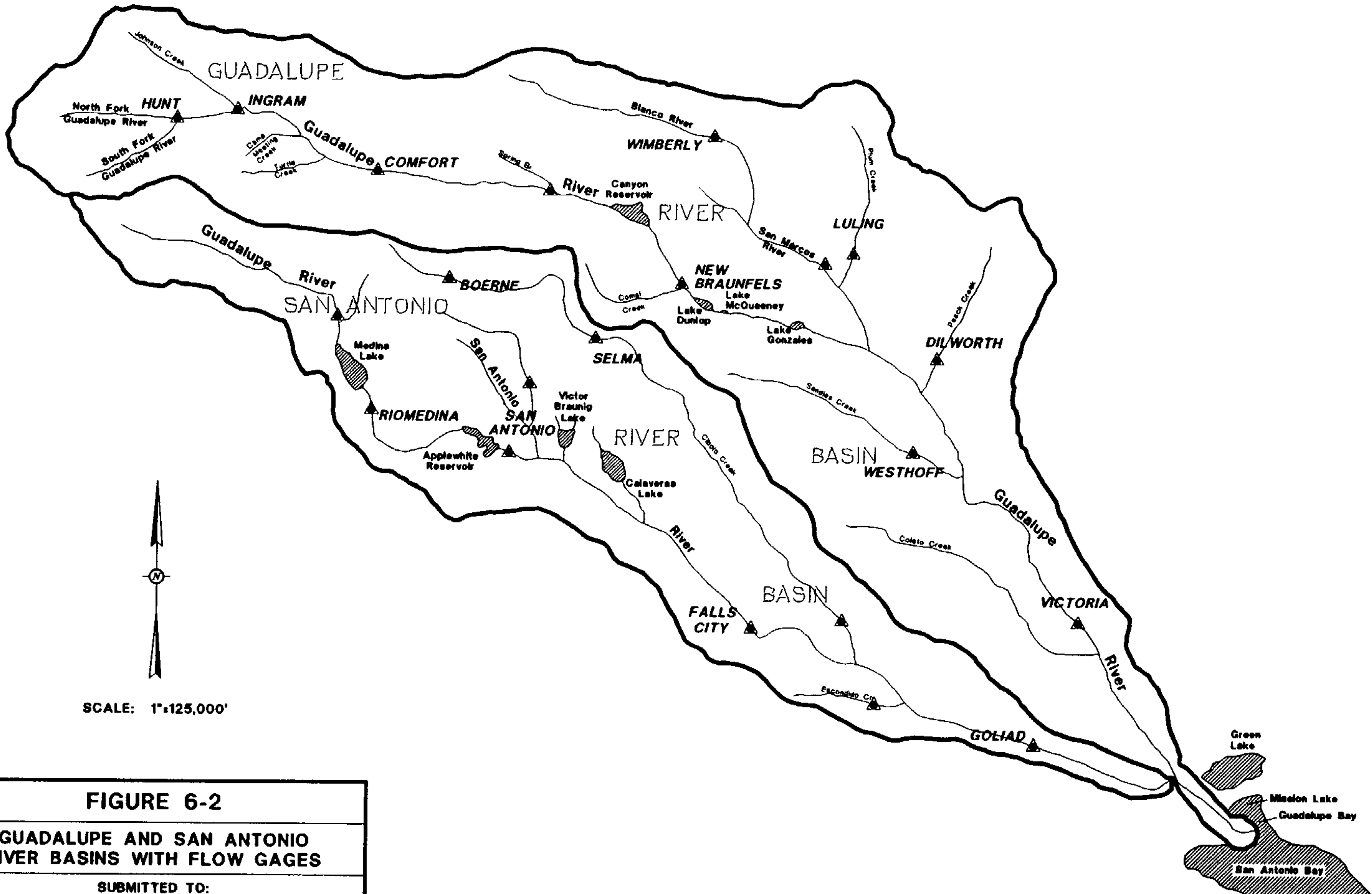


FIGURE 6-2

GUADALUPE AND SAN ANTONIO RIVER BASINS WITH FLOW GAGES

SUBMITTED TO:

CITY OF VICTORIA

SUBMITTED BY:

CAMP DRESSER & McKEE, INC.
IN ASSOCIATION WITH
MICHAEL SULLIVAN & ASSOCIATES, INC.

Table 6-3
Historical Guadalupe River Flows at Victoria a/

Year	January	February	March	April	May	June	July	August	September	October	November	December
1940	26138	25013	29213	30345	30135	24693	29520	2060	21123	23063	31130	48585
1941	56980	73815	118850	124950	135300	101885	89790	70725	55930	58425	56525	55350
1942	51660	41348	44280	49385	68765	50375	56965	51660	74375	102090	92225	84670
1943	78720	61050	60270	53550	49415	47005	43665	38745	36295	37515	34216	35478
1944	44995	58075	84870	79135	84255	82705	88265	47970	51170	46740	47005	60270
1945	83640	104340	118080	96390	79850	61680	50738	39975	32130	49815	44625	45510
1946	58425	61605	79950	74375	74415	65450	47355	36900	35105	46740	65450	97170
1947	116850	101785	98400	83895	71740	55335	44895	38130	35105	33518	34212	36980
1948	36901	34213	35055	28360	26138	22610	19988	16605	16660	19988	21716	24293
1949	24601	28640	33210	35700	50430	49980	41513	33210	24990	28290	38675	35670
1950	35870	33023	35363	30940	34133	31535	28445	20910	18148	18143	18743	20603
1951	20603	18593	20910	20230	19065	16363	13838	10455	8806	10148	11900	14760
1952	15990	196388	18143	16065	15068	12495	10086	7811	12495	30750	28263	37515
1953	47355	38850	35055	26775	21833	16660	13838	11378	19040	23063	27965	31365
1954	32595	27195	24293	18743	15375	11365	8303	6581	5772	5351	6248	8303
1955	10025	9879	11070	9520	8610	11127	9840	8795	6962	5904	5712	6765
1956	7872	7475	6981	3058	4151	2993	2614	1845	1577	1630	2380	3321
1957	5658	5439	8303	13685	23865	30940	28905	20295	16363	22448	36890	64575
1958	130245	101010	110700	98175	87330	71400	58425	45680	41650	69495	89250	83020
1959	75645	66600	69495	62475	60885	49385	48585	44280	34510	46125	58905	59963
1960	62730	60950	63345	56525	56888	42840	49815	52275	52955	48585	71995	113775
1961	141450	116550	104550	80325	65190	54145	73800	66420	54740	53813	54145	67810
1962	53013	45788	44895	36890	33210	21288	20910	16605	16065	21218	28560	38130
1963	38745	33300	32595	25288	20003	15470	12608	10025	6509	9287	10230	13223
1964	17935	21563	27368	24088	19060	15173	12300	10824	11484	19990	19040	22448
1965	29520	36630	53505	53550	50123	48195	43665	34440	30345	37515	44030	55350
1966	67650	70485	79950	66938	68880	54145	44890	36363	31238	34440	35403	36865
1967	34440	24975	22140	16958	14145	10710	8195	7380	13090	28905	46493	60210
1968	67650	82225	99015	107100	111315	88060	7257	48094	49385	49815	47005	59040
1969	52890	49950	65190	70805	72570	58905	48885	38130	35998	41820	47898	67035
1970	96291	87491	128209	110026	111407	130277	71319	51574	43850	48709	43397	41180
1971	41246	33927	34882	25042	22065	18304	14680	83231	86577	82913	84142	106739
1972	77098	84073	61223	44859	150502	145762	120195	79917	55378	51161	49778	51070
1973	62005	77338	99558	100319	112931	127187	233915	167028	109777	202794	171729	122221
1974	115798	102246	89950	70433	19276	79802	62723	50295	122842	87013	148082	125164
1975	126460	210089	136538	109028	172997	261661	172163	115458	85920	65265	68908	64415
1976	54854	49941	52145	80734	123467	1445080	123234	104104	83254	100371	157929	177570
1977	162869	167008	140767	238191	234198	138000	107147	71674	57199	55166	64795	57413
1978	14472	52899	52580	47821	46287	50909	38320	228954	139436	93363	80995	61665
1979	153820	168224	201277	205358	229271	217852	125341	121273	77611	50596	50881	47350

a/ USGS Gage No. 08176500, Period-of-Record 1940 to Present

Table 6-4
Historical San Antonio Flows at Juncture with Guadalupe River a/

Year	January	February	March	April	May	June	July	August	September	October	November	December
1940	7872	7418	7380	6605	6458	6684	7319	6355	6188	6888	9520	60122
1941	13830	1598	16605	16958	13499	21718	19680	15375	13983	13990	16660	19916
1942	18813	14663	13838	13090	18605	14280	15683	16298	20230	33825	33320	235205
1943	20838	21358	21218	18445	16913	13173	15069	14453	13388	13530	13388	203832
1944	15990	14375	15068	13983	14700	14280	14145	13530	13090	13530	13963	174267
1945	18758	18703	25215	24098	20945	16065	14145	11870	11008	1116	12793	200519
1946	15175	14708	15687	14578	15990	16065	13838	11685	15173	27060	23618	223293
1947	31365	28305	27368	22906	20003	17255	15683	15683	13983	13100	13685	235621
1948	15683	13800	12915	9937	8672	1962	7011	6642	7914	8426	7973	114545
1949	8733	8436	11070	10710	12300	12198	12300	10025	8985	11501	12793	133196
1950	12915	10934	10886	9282	9840	9223	7995	7442	6545	5535	4879	101196
1951	7211	1003	8487	8628	8241	7081	5904	4736	4879	6273	7438	84891
1952	7603	7360	8303	7259	8212	4820	4059	3260	4284	7319	7676	76788
1953	9410	8325	8057	6145	5412	4165	3506	3198	3808	4982	6950	70185
1954	6764	5273	4920	3808	3075	2380	2060	2153	2975	4059	3987	45638
1955	4367	3885	3690	2856	2491	2321	2183	2645	3511	3813	3749	40185
1956	4551	3623	3137	2410	1968	1012	1169	1046	1488	2522	3039	29282
1957	5843	4829	5843	6545	7626	7616	6888	5535	6069	9410	12995	93274
1958	15913	17205	20911	19040	19373	16958	14145	11070	13090	26445	34700	243059
1959	27983	22200	20910	17850	16298	12793	12054	11193	10710	12608	14875	197924
1960	20910	18400	15990	12198	9900	7795	10947	11747	9580	13530	25585	192869
1961	39363	25530	22448	17255	14145	17070	18758	17835	13173	19880	20230	239792
1962	18143	14708	13223	12198	11685	8925	7380	5996	3950	7380	8628	124733
1963	11255	9624	9225	7081	5863	3868	3629	2708	2737	3998	5772	74425
1964	11178	11500	11439	9401	7883	5950	4613	3998	4403	5535	6643	91604
1965	10763	13598	17523	15470	14451	14280	12300	9717	7914	7872	9104	149069
1966	10455	10878	14453	11484	10886	8628	7380	6827	6902	7688	7795	111679
1967	8603	7215	7380	6426	6625	3927	3444	3690	11008	21218	21618	120674
1968	23678	33350	36900	3094	30135	25286	20910	16298	13388	19068	16660	281065
1969	15375	11655	14452	14697	13487	10512	8610	6885	6634	8610	10591	135012
1970	21143	10059	27380	19577	17700	19731	13567	13240	11663	16093	11578	204760
1971	14131	11337	11474	9574	7022	6399	5906	25277	24139	51587	46382	251271
1972	22094	1917	21390	17061	6514	54165	29498	25781	19397	23751	24821	394470
1973	22154	24614	17470	29463	32867	40408	88006	79818	85369	112976	92434	699208
1974	42002	37145	35142	29300	34022	24021	13949	30662	56134	38186	48412	438747
1975	48142	70299	56031	48198	65177	68228	51448	32292	27739	24689	23399	526391
1976	22084	20192	20201	24102	55000	60779	50896	34540	32513	58880	86771	524296
1977	26795	71117	61790	73770	105148	63093	40579	25400	28090	25914	39174	651150
1978	21023	30999	21010	30175	24627	26743	11996	51194	54837	38859	35258	402586
1979	37707	57972	63464	80397	79880	76651	54466	41104	27550	22291	23090	620865

a/ USGS Gage No. 08188800

Figure 6-3. The Guadalupe basin is divided into 22 sub-watersheds, starting with watershed 1 in the upper terminus of the basin and culminating with watershed 22 at San Antonio Bay. The San Antonio Basin starts with sub-watershed 1 on the Median River at its upper extreme and ends with sub-watershed 15 at the confluence with the Guadalupe River Basin above sub-watershed 22. Water rights in Guadalupe Basin sub-watershed 21 and sub-watershed 22, which is fed by both the Guadalupe and San Antonio Rivers, are considered for the purposes of this study senior and superior to Victoria diversions. Table 6-5 shows all existing water rights in Guadalupe Basin sub-watersheds 21 and 22 including use code, authorized diversion amount, irrigation area, owner of water right, reservoir capacity, and priority date. Water use codes 1 through 4 identify municipal, industrial, irrigation, and mining and other uses respectively. Each of those uses have a monthly demand distribution around the annual quantities. Those monthly demand distribution factors are shown in Table 6-6.

6.13.3 Estimates of Surface Water Availability

Worst Case Scenario

In Chapter 3.0, year 2040 municipal water demands within the Victoria regional planning area were estimated at 16,000 ac-ft/yr. As a worst case, it may be necessary that all 16,000 ac-ft/yr be derived from surface water sources. Another plausible future development scenario is that approximately half (8,000 ac-ft/yr) will be needed from surface water sources while the remainder of the demand will continue to be satisfied from existing groundwater supplies.

One way to assess the availability of future supplies is to construct a plausible worst case scenario where extreme conditions prevail and that all traditional sources are exhausted. In this case, that extreme scenario is constructed by assuming no releases from Canyon Reservoir available for downstream appropriation and Comal Springs and San Marcos

FIGURE 6-3

GUADALUPE AND SAN ANTONIO RIVER BASINS WITH TWC SUBWATERSHEDS

SUBMITTED TO:

CITY OF VICTORIA

SUBMITTED BY:

CAMP DRESSER & McKEE, INC.
IN ASSOCIATION WITH
MICHAEL SULLIVAN & ASSOCIATES, INC.

Table 6-5
Existing Water Rights in Guadalupe Basin
Subwatersheds 21 and 22 a/ b/

Adjudication Certification or Application No.	Type Code	Tie Number	Basin Code	County Code	Permit Number	Stream Name	Use Code	Authorized Amount (ac-ft/yr)	Irrigation Area (acres)	Owner of Water Right	Reservoir Capacity (ac-ft)	Priority Date	Sub-watershed Number	River Order No.
1722	1	72	18	235	1596	Guadalupe R.	1	10		W.L. Lipscomb & Sons, et. al.		8/15/51	(21,1)S	1550000001
1722	1	71	18	235	1596	Guadalupe R.	3	250		W.L. Lipscomb & Sons, et.al.	155	8/15/51	(21,1)R	1550000000
1732A	1	71	18	235	1609A	Guadalupe R.	3	400		Big Rack Ltd.		12/12/51	(21,1)S	1500000000
1578B	1	72	18	235	1472B	Guadalupe R.	2			E.I. DuPont de Nemours Co.	1,056	2/14/63	(21,1)R	1451000000
1578D	1	71	18	235	1472B	Guadalupe R.	2	60,000		E.I. DuPont de Nemours Co.		6/16/48	(21,2)S	1450000000
3895	1	71	18	235	3606	Guadalupe R.	2	9,676		Gulf Oil Chemicals Co.	132	7/10/78	(21,2)R	1380000000
1672B	1	71	18	235	1562B	Guadalupe R.	3	32,000	2,000	J.A. McFaddin Estate		3/1/51	(21,3)S	1300000000
1736E	1	70	18	29	1614E	Guadalupe R.	2			Union Carbide	4,771	5/5/54	(22,1)R	1151000000
1736F	1	71	18	29	1614E	Guadalupe R.	1,2,3	106,000	25,000	Union Carbide		1/7/52	(22,1)S	1150000000
1469G	1	71	18	29	1375G	Guadalupe R.	1,2,3	32,615		GBRA, et. al.		1/3/44	(22,1)S	1000000000
16469G	1	72	1375G	29	1375G	Guadalupe R.	1,2,3	10,000		Union Carbide		1/3/44	(22,1)S	0999000000
2336	1	71	18	29	2120	Guadalupe R.	2			GBRA	600	5/15/64	(22,1)R	0751000000
1671	1	71	18	29	1564	Guadalupe R.	2,3,4,6	940		West S. Calhoun		2/13/51	(22,1)R	0750000000
1713	1	71	18	29	1592	Guadalupe R.	1,2,3	9,944		West S. Calhoun		6/21/51	(22,1)S	0700000000
8084	2	71	18	29		Hog Bayou	3	50	200	Stofer-McNeel Trusts		12/31/55	Coastal	0210000000
1410A	1	11	18	29	1319A	Guadalupe R.	2,3	2,500	1,000	West S. Calhoun		1/3/41	(22,1)R	0200000000
1455A	1	71	18	29	1362A	Smuggler	2,3	1,870	935	West S. Calhoun		6/15/44	(22,1)R	0150000000
1469B	1	71	18	29	1375B	Guadalupe R.	2,3	8,632		Union Carbide, et. al.		12/6/48	(22,1)R	0750000000
							Total	274,887						

a/ See Figure 6-3 for location of sub-watersheds.

b/ All permits considered senior and superior to Victoria Application for the purposes of this study.

Table 6-6
Monthly Distribution Factors for Guadalupe Basin
Water Uses by Class and Subwatershed

	January	February	March	April	May	June	July	August	September	October	November	December
Municipal												
Upper Guadalupe River Watershed (Sub-watersheds 1,1 thru 7,7)	0.05	0.06	0.08	0.08	0.09	0.12	0.13	0.12	0.08	0.08	0.06	0.05
Blanco-San Marcos Watershed (Sub-watershed 10,1 thru 13,3)	0.07	0.07	0.07	0.08	0.08	0.10	0.11	0.11	0.09	0.08	0.07	0.07
Lower Guadalupe River Watershed (Sub-watersheds 7,8 thru 9,21 and 14,1 thru 22,1)	0.07	0.07	0.08	0.08	0.09	0.10	0.11	0.10	0.08	0.08	0.07	0.07
Industrial												
Upper Guadalupe River Watershed (Sub-watersheds 1,1 thru 7,7)	0.06	0.06	0.07	0.07	0.08	0.09	0.10	0.11	0.09	0.11	0.08	0.08
Blanco-San Marcos Watershed (Sub-watershed 10,1 thru 13,3)	0.08	0.10	0.08	0.10	0.07	0.10	0.10	0.11	0.09	0.08	0.05	0.04
Lower Guadalupe River Watershed (Sub-watersheds 7,8 thru 9,21 and 14,1 thru 22,1)	0.06	0.07	0.08	0.09	0.08	0.09	0.10	0.10	0.10	0.08	0.07	0.08
Irrigation												
Upper Guadalupe River Watershed (Sub-watersheds 1,1 thru 7,7)	0.00	0.02	0.05	0.06	0.14	0.19	0.30	0.09	0.09	0.04	0.02	0.00
Blanco-San Marcos Watershed (Sub-watershed 10,1 thru 13,3)	0.00	0.00	0.06	0.12	0.21	0.17	0.25	0.05	0.09	0.05	0.00	0.00
Lower Guadalupe River Watershed (Sub-watersheds 7,8 thru 9,21 and 14,1 thru 22,1)	0.00	0.00	0.00	0.06	0.15	0.21	0.31	0.19	0.05	0.03	0.00	0.00
Mining												
Upper Guadalupe River Watershed, Blanco-San Marcos Watershed, and Lower Guadalupe River Watershed	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08

Springs dry. Under this scenario the only water available for diversion at Victoria would be quantities contributed through intervening incremental runoff from the region bounded at the upper end by Canyon Reservoir and Comal and San Marcos Springs and at the lower end by the Victoria diversion point. In addition, it is assumed that all downstream water rights are considered senior and superior and will be diverting to the maximum extent allowable under the conditions of their existing permit. Satisfaction of those downstream water rights can either come entirely from Guadalupe Basin incremental flows or a combination of Guadalupe Basin and San Antonio Basin Flows. The Guadalupe Basin map showing the incremental flow area is shown in Figure 6-4.

For the purpose of this study, four incremental flow scenarios were developed and evaluated. Water available for diversion at Victoria immediately downstream of the existing CP&L cooling water discharge was estimated for each of the incremental flow scenarios (CP&L has a 206,000 ac-ft/yr nonconsumptive use water right used for cooling water which essentially insures a constant supply of water at a convenient location). The following outline demonstrates the incremental flow evaluation scenarios.

- 8,000 ac-ft/yr Victoria diversion with the remainder of year 2040 projected demand supplied from existing groundwater sources and all downstream water rights satisfied from Guadalupe Basin incremental flows.

- 8,000 ac-ft/yr Victoria diversion with the remainder of projected year 2040 demand supplied from existing groundwater sources and all downstream water rights satisfied at 50% by Guadalupe Basin incremental flows and 50% by San Antonio Basin flows.

- 16,000 ac-ft/yr Victoria diversion with no contributions from groundwater and all downstream water rights satisfied through Guadalupe Basin incremental flows.

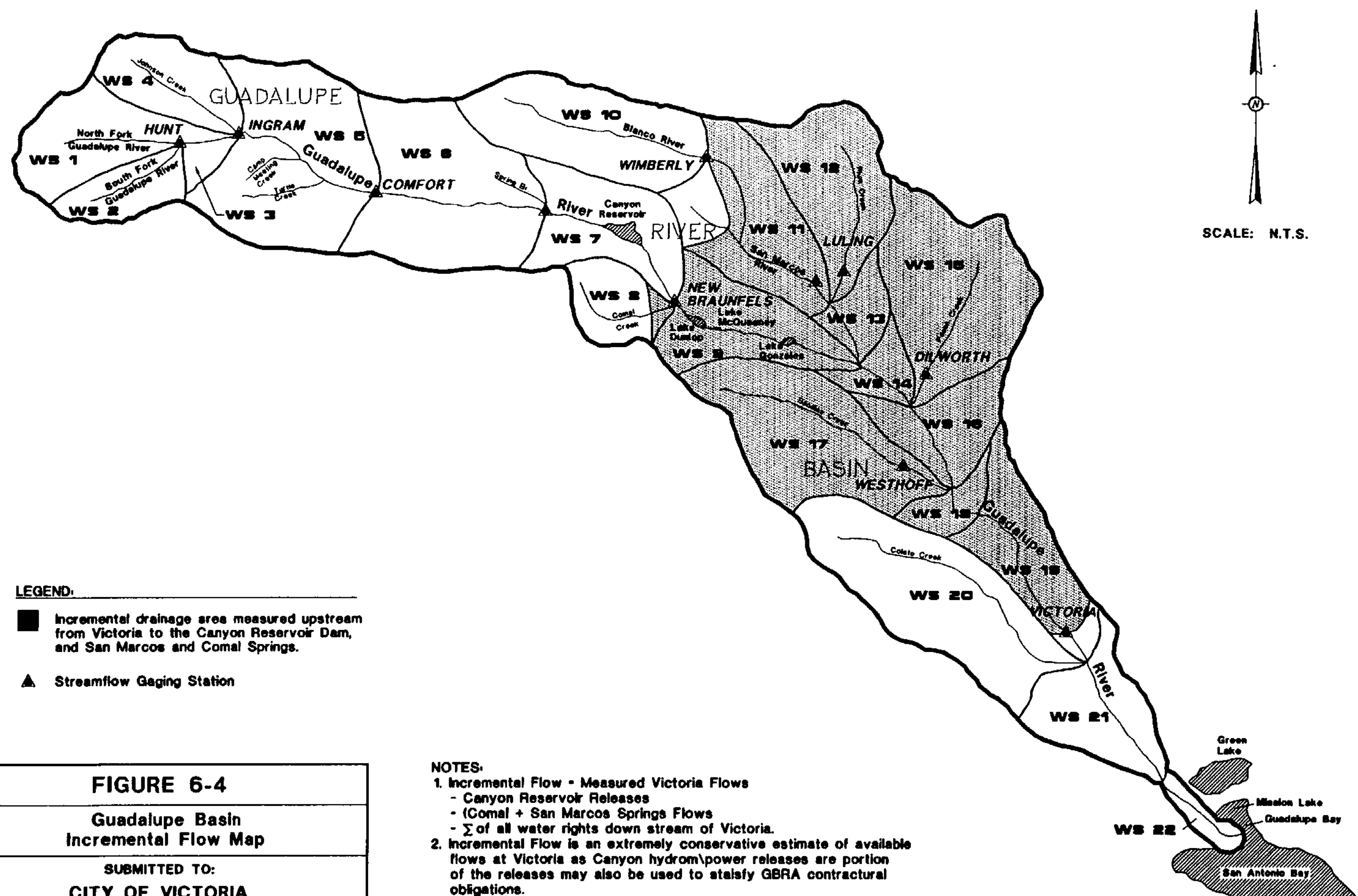


FIGURE 6-4

Guadalupe Basin
Incremental Flow Map

SUBMITTED TO:
CITY OF VICTORIA

SUBMITTED BY:
CAMP DRESSER & McKEE, INC.
IN ASSOCIATION WITH
MICHAEL SULLIVAN & ASSOCIATES, INC.

- 16,000 ac-ft/yr Victoria diversion with no contributions from groundwater and all downstream water rights satisfied at 50% by Guadalupe Basin incremental flows and 50% by San Antonio Basin flows.

Diversions available from the Guadalupe River for the Victoria regional study area are shown in Tables 6-7 through 6-10 and Figures 6-5 through 6-8. Note that the gray areas in the figures represents water available for diversion under the conditions of that particular development scenario, and the white portion of the plot areas show when sufficient water is not available for diversion. At a diversion rate of 8,000 ac-ft/yr (738 ac-ft/mo) and all downstream water rights satisfied from Guadalupe Basin incremental flows, there is insufficient water available to unconditionally satisfy Victoria's demands. However, when a portion of the downstream water rights are satisfied through dedicated flows from the San Antonio Basin, the amount of time that there is sufficient water available to serve as a reliable supply for the Victoria service area is considerably higher. Examination of diversion tables and plots assuming a 16,000 ac-ft/yr (1,353 ac-ft/mo) demand with downstream water rights satisfied from the Guadalupe Basin, and from both the Guadalupe and San Antonio Basins, present almost identical circumstances as were shown with the 8,000 ac-ft/yr diversion. This is not totally unexpected as in the lower portion of these basins, water is generally flowing at either very high or very low rates.

6.13.4 TWC San Antonio-Guadalupe River Basins Water Rights Adjudication Model

As part of the adjudication process, the TWC relies on a computer Water Rights Adjudication (WRADJ) model designed to predict unappropriated flows within each sub-watershed of each major river basin. The TWC has created separate models for the Guadalupe and San Antonio River Basins with both models being driven by partial satisfaction of water rights in Guadalupe sub-watershed 22 which lies between their confluence and San Antonio Bay. The sub-watersheds of particular interest in this study are Guadalupe Basin WS-19, WS-20 and WS-21 (Figure 6-9). The City of Victoria is

Table 6-7

Diversions From Guadalupe River by the City of Victoria Assuming an 8,000 ac-ft/yr (738 ac-ft/mo)
Surface Water Demand Supplied by Incremental Flows from Guadalupe River Basin a/ b/ c/

Year	January	February	March	April	May	June	July	August	September	October	November	December
1940	738	627	48	357	190	369	738	0	0	95	714	738
1941	738	666	738	714	738	714	738	561	660	738	714	738
1942	738	202	167	714	738	214	738	48	714	738	714	738
1943	738	666	738	607	85	405	0	0	24	0	99	736
1944	738	690	738	714	738	714	48	24	714	167	714	738
1945	738	666	738	714	500	198	24	0	0	631	99	405
1946	738	666	738	714	738	714	0	48	714	738	714	738
1947	738	666	738	714	738	167	143	222	0	0	0	476
1948	657	690	738	0	629	0	24	71	0	0	0	0
1949	0	151	738	714	738	264	48	0	0	738	714	738
1950	738	666	18	714	190	690	0	0	0	0	0	0
1951	0	0	0	0	0	476	0	0	0	0	0	0
1952	0	135	0	145	119	381	0	0	309	448	714	738
1953	738	666	97	119	738	0	0	48	633	738	714	738
1954	615	0	0	95	143	0	0	0	0	0	0	0
1955	0	643	48	0	238	214	0	0	0	0	0	0
1956	0	6	0	0	71	0	0	0	0	71	0	260
1957	0	226	555	476	738	714	0	0	290	738	714	738
1958	738	666	738	714	738	476	238	0	555	738	714	738
1959	738	666	738	714	738	119	337	0	24	666	714	738
1960	738	690	738	714	738	540	738	381	274	738	714	738
1961	738	666	738	714	238	714	738	432	714	738	714	738
1962	738	666	714	690	42	119	0	0	198	95	696	738
1963	738	666	357	79	0	0	0	0	0	0	619	24
1964	30	690	738	103	0	24	0	0	238	95	714	0
1965	738	666	738	714	738	714	95	0	0	738	714	738
1966	738	666	738	714	738	119	0	286	238	107	0	48
1967	242	24	0	0	0	0	0	0	676	738	714	738
1968	738	690	738	714	738	714	643	0	714	738	714	738
1969	738	666	738	714	738	452	0	0	294	619	657	738
1970	738	666	738	714	738	714	0	0	48	738	0	0
1971	0	0	24	0	0	24	0	405	714	738	714	738
1972	738	690	738	119	738	714	95	309	95	738	714	726
1973	738	666	738	714	738	714	738	738	714	738	714	738
1974	738	666	738	714	738	641	0	143	714	738	714	738
1975	738	666	738	714	738	714	738	738	714	738	714	738
1976	738	690	738	714	738	714	738	238	714	738	714	738
1977	738	666	738	714	738	714	95	95	714	736	714	738
1978	738	666	738	714	0	621	0	690	714	738	714	738
1979	738	666	738	714	738	714	738	736	714	698	714	722
1980	738	690	71	71	738	0	0	0	524	619	236	214
1981	738	659	670	714	738	714	738	298	714	738	714	738
1982	738	666	738	714	738	518	0	0	0	71	714	623
1983	401	666	738	714	738	514	143	0	147	528	714	0
1984	738	643	738	0	0	0	0	0	0	357	234	738
1985	738	666	738	714	738	714	714	0	0	381	714	738
1986	738	666	738	282	738	714	167	0	452	738	714	738
1987	738	666	738	714	738	714	738	738	561	738	714	738

a/ Incremental flow computed from Canyon Reservoir Dam (USGS #08168500), San Marcos Springs (USGS #0817000) and Comal Springs (USGS #0816900) to Victoria (USGS #08176500).

b/ Option assumes all senior and superior downstream rights must be satisfied from only Guadalupe Basin flows.

c/ Assumes an additional 8,000 ac-ft/yr of year 2020 demand satisfied from groundwater sources.

Table 6-8

Diversions From Guadalupe River by the City of Victoria Assuming an 8,000 ac-ft/yr (738 ac-ft/mo) Surface Water Demand Supplied by Incremental Flows From Guadalupe and San Antonio Rivers a/ b/ c/

Year	January	February	March	April	May	June	July	August	September	October	November	December
1940	738	690	633	551	242	428	738	0	0	738	714	738
1941	738	666	738	714	738	714	738	738	714	738	714	738
1942	738	666	738	714	738	296	738	738	714	738	714	738
1943	738	666	738	714	738	714	143	24	698	738	714	738
1944	738	690	738	714	738	714	321	24	714	190	714	738
1945	738	666	738	714	738	714	24	0	0	738	714	738
1946	738	666	738	714	738	714	0	71	714	738	714	738
1947	738	666	738	714	738	167	143	738	303	0	688	738
1948	738	690	738	0	738	0	204	103	0	24	0	0
1949	58	666	738	714	738	714	276	0	24	738	714	738
1950	738	666	738	714	738	714	0	0	0	0	0	0
1951	0	0	0	2	24	714	0	0	167	0	0	0
1952	0	655	0	448	543	643	95	0	309	738	714	738
1953	738	666	738	714	738	0	0	119	714	738	714	738
1954	738	666	95	490	639	0	0	0	0	0	0	0
1955	0	666	230	95	262	379	0	0	0	0	0	0
1956	0	60	0	24	109	0	0	0	0	119	0	329
1957	0	627	738	714	738	714	0	0	714	738	714	738
1958	738	666	738	714	738	714	500	0	714	738	714	738
1959	738	666	738	714	738	119	738	264	714	738	714	738
1960	738	690	738	714	738	714	738	428	714	738	714	738
1961	738	666	738	714	738	714	738	738	714	738	714	738
1962	738	666	738	714	365	405	0	0	690	738	714	738
1963	738	666	738	651	0	0	0	0	0	0	714	738
1964	732	690	738	714	0	79	0	0	492	710	714	615
1965	738	666	738	714	738	714	286	0	99	738	714	738
1966	738	666	738	714	738	714	0	286	559	738	714	738
1967	738	666	534	0	0	0	0	0	714	738	714	738
1968	738	690	738	714	738	714	738	738	714	738	714	738
1969	738	666	738	714	738	714	0	71	714	690	714	738
1970	738	666	738	714	738	714	0	0	714	738	714	738
1971	738	666	738	0	0	48	0	405	714	738	714	738
1972	738	690	738	119	738	714	738	738	714	738	714	738
1973	738	666	738	714	738	714	738	738	714	738	714	738
1974	738	666	738	714	738	714	0	738	714	738	714	738
1975	738	666	738	714	738	714	738	738	714	738	714	738
1976	738	690	738	714	738	714	738	738	714	738	714	738
1977	738	666	738	714	738	714	738	738	714	738	714	738
1978	738	666	738	714	738	714	0	690	714	738	714	738
1979	738	666	738	714	738	714	738	738	714	738	714	738
1980	738	690	738	121	738	670	0	0	714	738	714	738
1981	738	666	738	714	738	714	738	738	714	738	714	738
1982	738	666	738	714	738	714	0	0	0	738	714	738
1983	738	666	738	714	738	714	738	0	714	738	714	609
1984	738	690	738	325	0	0	0	0	0	476	714	738
1985	738	666	738	714	738	714	738	0	24	738	714	738
1986	738	666	738	714	738	714	167	0	571	738	714	738
1987	738	666	738	714	738	714	738	738	714	738	714	738

a/ Incremental flow computed from Canyon Reservoir Dam (USGS #08168500), San Marcos Springs (USGS #0817000) and Comal Springs (USGS #0816900) to Victoria (USGS #08176500).

b/ Option assumes all senior and superior downstream rights must be satisfied from only Guadalupe Basin flows at 52% and San Antonio Basin flows at 48%.

c/ Assumes an additional 8,000 ac-ft/yr of demand satisfied from groundwater sources.

Table 6-9
Diversions From Guadalupe River by the City of Victoria Assuming a 16,000 ac-ft/yr (1,353 ac-ft/mo)
Surface Water Demand Supplied by Incremental Flows from Guadalupe River a/ b/ c/

	January	February	March	April	May	June	July	August	September	October	November	December
1940	1,353	1,135	87	655	349	666	1,339	0	0	175	1,309	1,353
1941	1,353	1,222	1,353	1,309	1,353	1,309	1,353	938	1,152	1,347	1,309	1,333
1942	1,353	309	232	1,309	1,353	393	1,353	87	1,309	1,353	1,309	1,353
1943	1,353	1,222	1,353	1,012	145	742	0	0	44	0	101	1,271
1944	1,353	1,265	1,353	1,309	1,353	1,309	87	44	1,309	305	1,309	1,353
1945	1,353	1,222	1,353	1,309	893	337	44	0	0	1,109	179	742
1946	1,353	1,222	1,353	1,309	1,353	1,309	0	87	1,309	1,353	1,309	1,353
1947	1,353	1,222	1,353	1,309	1,353	305	262	371	0	0	0	746
1948	972	1,265	1,353	0	1,089	0	44	131	0	0	0	0
1949	0	250	1,353	1,309	1,353	482	87	0	0	1,353	1,309	1,353
1950	1,353	1,222	18	1,309	337	1,260	0	0	0	0	0	0
1951	0	0	0	0	0	873	0	0	0	0	0	0
1952	0	198	0	252	218	678	0	0	567	776	1,309	1,353
1953	1,353	1,222	127	218	1,353	0	0	87	1,148	1,353	1,261	1,353
1954	912	0	0	169	262	0	0	0	0	0	0	0
1955	0	1,168	85	0	436	393	0	0	0	0	0	0
1956	0	6	0	0	131	0	0	0	0	131	0	456
1957	0	365	1,000	873	1,353	1,309	0	0	510	1,353	1,309	1,353
1958	1,353	1,222	1,353	1,309	1,353	873	436	0	1,012	1,353	1,309	1,353
1959	1,353	1,222	1,353	1,309	1,353	218	605	0	44	1,222	1,309	1,353
1960	1,353	1,265	1,353	1,309	1,353	968	1,353	698	480	1,353	1,309	1,353
1961	1,353	1,222	1,353	1,309	415	1,309	1,353	750	1,309	1,353	1,309	1,353
1962	1,353	1,222	1,285	1,194	61	218	0	0	357	159	1,216	1,353
1963	1,353	1,222	547	139	0	0	0	0	0	0	1,133	34
1964	50	1,265	1,353	182	0	44	0	0	436	175	1,305	0
1965	1,353	1,222	1,353	1,309	1,353	1,309	175	0	0	1,353	1,309	1,353
1966	1,353	1,222	1,353	1,309	1,353	218	0	524	436	167	0	87
1967	262	44	0	0	0	0	0	0	1,232	1,353	1,309	1,353
1968	1,353	1,265	1,353	1,309	1,353	1,309	1,158	0	1,309	1,353	1,309	1,353
1969	1,353	1,222	1,353	1,309	1,353	817	0	0	474	1,135	1,192	1,353
1970	1,353	1,222	1,353	1,309	1,353	1,309	0	0	87	1,353	0	0
1971	0	0	26	0	0	44	0	742	1,309	1,353	1,309	1,353
1972	1,353	1,265	1,345	218	1,353	1,309	175	567	175	1,325	1,309	1,166
1973	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1974	1,353	1,222	1,353	1,309	1,353	1,156	0	262	1,309	1,353	1,309	1,353
1975	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1976	1,353	1,265	1,353	1,309	1,353	1,309	1,353	436	1,309	1,353	1,309	1,353
1977	1,353	1,222	1,353	1,309	1,353	1,309	175	175	1,309	1,194	1,309	1,353
1978	1,353	1,222	1,353	1,309	0	1,101	0	1,265	1,309	1,353	1,309	1,353
1979	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,331	1,309	992	1,309	1,265
1980	1,353	1,265	131	131	1,353	0	0	0	960	1,135	415	393
1981	1,353	1,140	1,226	1,309	1,353	1,309	1,353	536	1,309	1,353	1,309	1,353
1982	1,353	1,222	1,353	1,309	1,353	928	0	0	0	131	1,309	875
1983	649	1,222	1,353	1,295	1,353	926	262	0	266	853	1,309	0
1984	1,353	1,150	1,353	0	0	0	0	0	0	655	385	1,258
1985	1,353	1,222	1,353	1,309	1,353	1,309	1,283	0	0	698	1,309	1,353
1986	1,353	1,222	1,353	436	1,353	1,309	305	0	829	1,353	1,309	1,353
1987	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,353	1,018	1,353	1,309	1,353

a/ Incremental flow computed from Canyon Reservoir Dam (USGS #08168500), San Marcos Springs (USGS #0817000) and Comal Springs (USGS #0816900) to Victoria (USGS #08176500).
b/ Option assumes all senior and superior downstream rights must be satisfied from only Guadalupe Basin flows.
c/ Assumes no future demands satisfied from groundwater sources.

Table 6-10
Diversions From Guadalupe River by the City of Victoria Assuming a 16,000 ac-ft/yr (1,353 ac-ft/mo) Surface Water Demand Supplied by Incremental Flows from Guadalupe and San Antonio Rivers a/ b/ c/

	January	February	March	April	May	June	July	August	September	October	November	December
1940	1,353	1,265	918	924	426	785	1,353	0	0	1,353	1,309	1,353
1941	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1942	1,353	1,222	1,353	1,309	1,353	534	1,353	1,353	1,309	1,353	1,309	1,353
1943	1,353	1,222	1,353	1,309	1,353	1,309	260	44	1,204	1,341	1,309	1,353
1944	1,353	1,265	1,353	1,309	1,353	1,309	559	44	1,309	349	1,309	1,353
1945	1,353	1,222	1,353	1,309	1,353	1,309	44	0	0	1,353	1,309	1,353
1946	1,353	1,222	1,353	1,309	1,353	1,309	0	131	1,309	1,353	1,309	1,353
1947	1,353	1,222	1,353	1,309	1,353	305	262	1,353	504	0	1,236	1,353
1948	1,353	1,265	1,353	0	1,353	0	355	163	0	44	0	0
1949	58	1,222	1,353	1,309	1,353	1,309	476	0	42	1,353	1,309	1,353
1950	1,353	1,222	1,353	1,309	1,353	1,309	0	0	0	0	0	0
1951	0	0	0	2	28	1,309	0	0	305	0	0	0
1952	0	1,047	0	746	904	1,162	175	0	567	1,353	1,309	1,353
1953	1,353	1,222	1,353	1,309	1,353	0	0	218	1,309	1,353	1,309	1,353
1954	1,353	1,222	105	791	1,121	0	0	0	0	0	0	0
1955	0	1,222	300	175	480	676	0	0	0	0	0	0
1956	0	99	0	44	188	0	0	0	0	218	0	587
1957	0	1,023	1,353	1,299	1,353	1,309	0	0	1,309	1,353	1,309	1,353
1958	1,353	1,222	1,353	1,309	1,353	1,309	916	0	1,309	1,353	1,309	1,353
1959	1,353	1,222	1,353	1,309	1,353	218	1,353	359	1,289	1,353	1,309	1,353
1960	1,353	1,265	1,353	1,309	1,353	1,309	1,353	772	1,309	1,353	1,309	1,353
1961	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1962	1,353	1,222	1,353	1,309	611	742	0	0	1,230	1,353	1,309	1,353
1963	1,353	1,222	1,353	1,081	0	0	0	0	0	0	1,309	1,347
1964	1,307	1,265	1,353	1,309	0	139	0	0	847	1,164	1,309	976
1965	1,353	1,222	1,353	1,309	1,353	1,309	484	0	179	1,353	1,309	1,353
1966	1,353	1,222	1,353	1,309	1,353	1,309	0	524	948	1,353	1,309	1,353
1967	1,353	1,222	629	0	0	0	0	0	1,309	1,353	1,309	1,353
1968	1,353	1,265	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1969	1,353	1,222	1,353	1,309	1,353	1,309	0	131	1,309	1,222	1,309	1,353
1970	1,353	1,222	1,353	1,309	1,353	1,309	0	0	1,309	1,353	1,309	1,333
1971	1,353	1,222	1,353	0	0	81	0	742	1,309	1,353	1,309	1,353
1972	1,353	1,265	1,353	218	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1973	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1974	1,353	1,222	1,353	1,309	1,353	1,309	0	1,353	1,309	1,353	1,309	1,353
1975	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1976	1,353	1,265	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1977	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1978	1,353	1,222	1,353	1,309	1,353	1,309	0	1,265	1,309	1,353	1,309	1,353
1979	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1980	1,353	1,265	1,353	190	1,353	1,180	0	0	1,309	1,261	1,309	1,353
1981	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353
1982	1,353	1,222	1,353	1,309	1,353	1,309	0	0	0	1,353	1,309	1,353
1983	1,353	1,222	1,353	1,309	1,353	1,309	1,347	0	1,309	1,353	1,309	708
1984	1,353	1,265	1,353	434	0	0	0	0	0	873	1,309	1,353
1985	1,353	1,222	1,353	1,309	1,353	1,309	1,353	0	44	1,353	1,309	1,353
1986	1,353	1,222	1,353	1,309	1,353	1,309	305	0	1,047	1,353	1,309	1,353
1987	1,353	1,222	1,353	1,309	1,353	1,309	1,353	1,353	1,309	1,353	1,309	1,353

a/ Incremental flow computed from Canyon Reservoir Dam (USGS #08168500), San Marcos Springs (USGS #0817000) and Comal Springs (USGS #0816900) to Victoria (USGS #08176500).
b/ Option assumes all senior and superior downstream rights must be satisfied from Guadalupe Basin flows at 52% and from San Antonio Basin flows at 48%.
c/ Assumes no future demands satisfied from groundwater sources.

Figure 6-5
Guadalupe River Direct Diversions at 738 ac-ft/mo for Incremental Flow
Data Set With All Senior and Superior Permits in Guadalupe Basin
Subwatersheds 21 and 22 Supplied from Guadalupe River

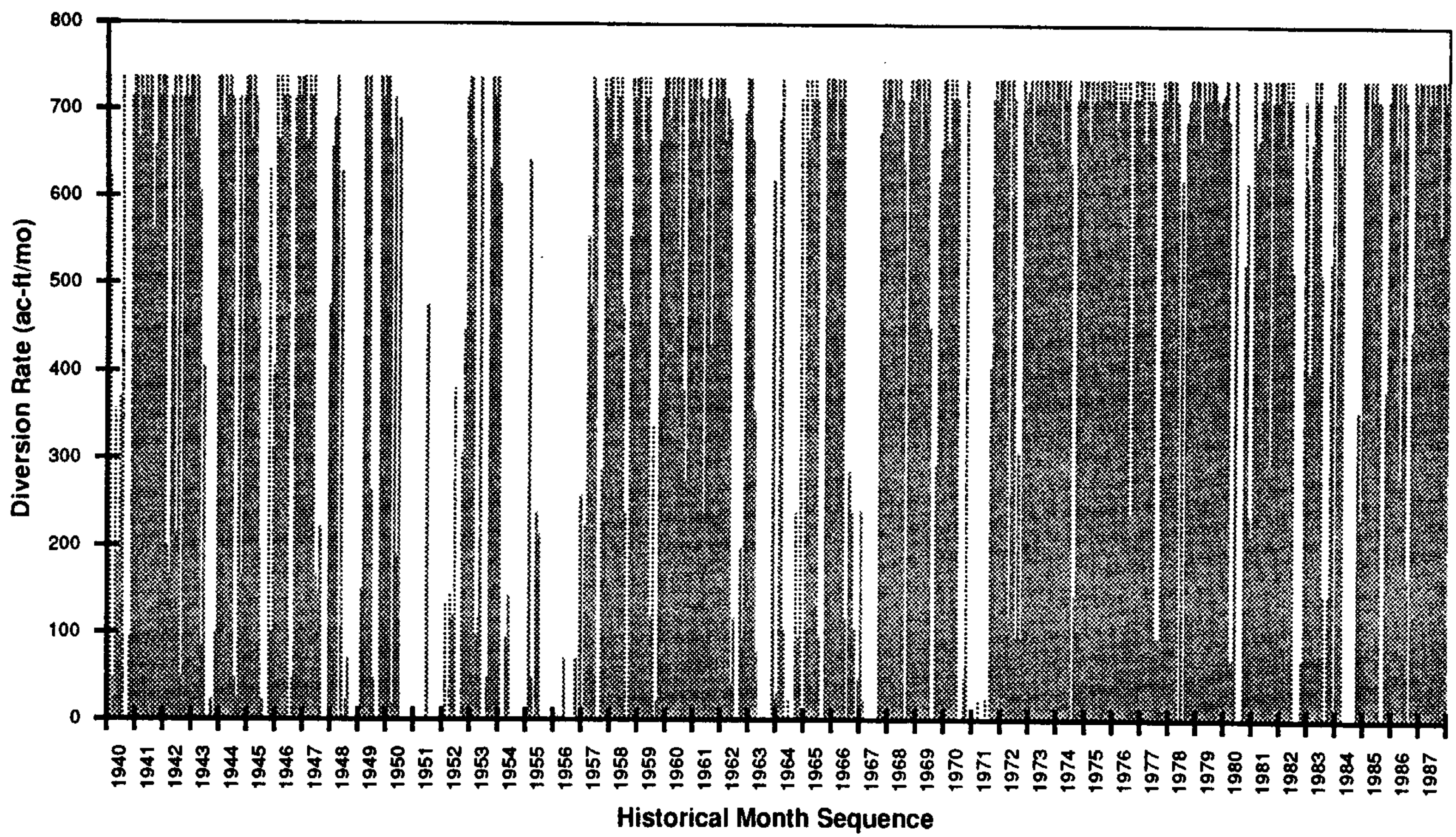


Figure 6-6
Guadalupe River Direct Diversions at 738 ac-ft/mo for Incremental Flow
Data Set With All Senior and Superior Permits in Guadalupe Basin
Subwatersheds 21 and 22 Supplied from Guadalupe and San Antonio Rivers

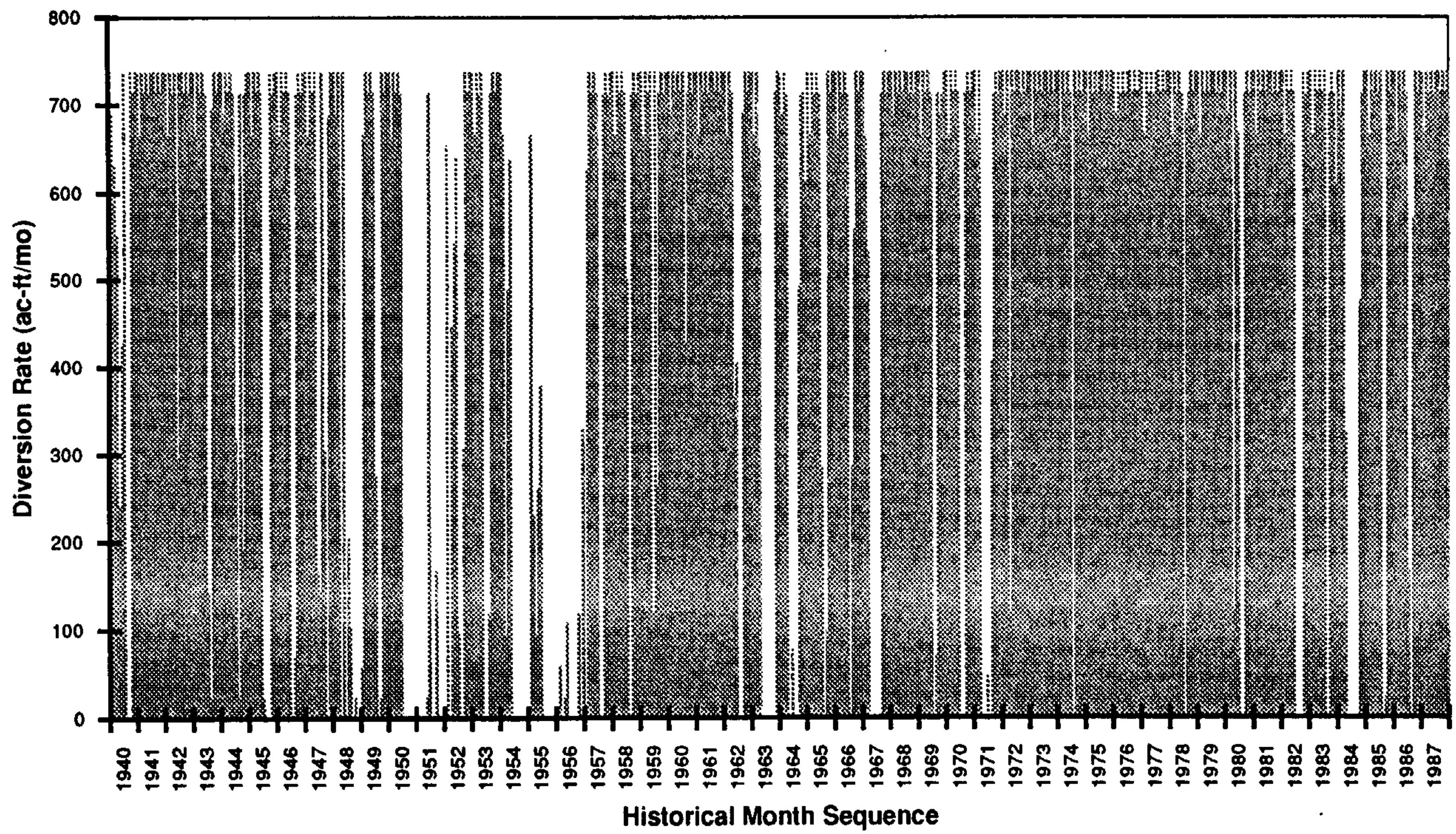


Figure 6-7
Guadalupe River Direct Diversions at 1,353 ac-ft/mo for Incremental Flow
Data Set With All Senior and Superior Permits in Guadalupe Basin
Subwatersheds 21and 22 Supplied from Guadalupe River

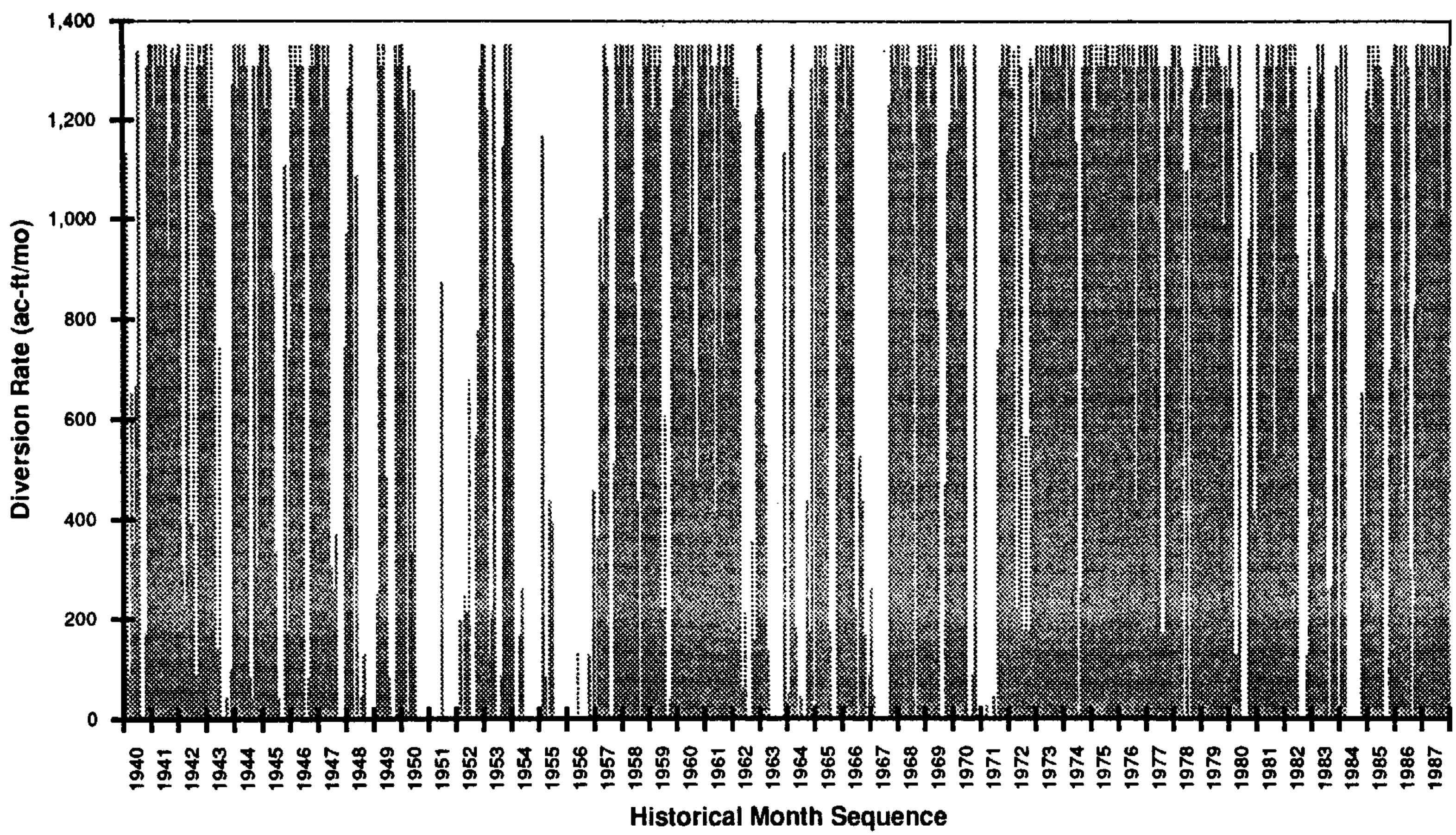
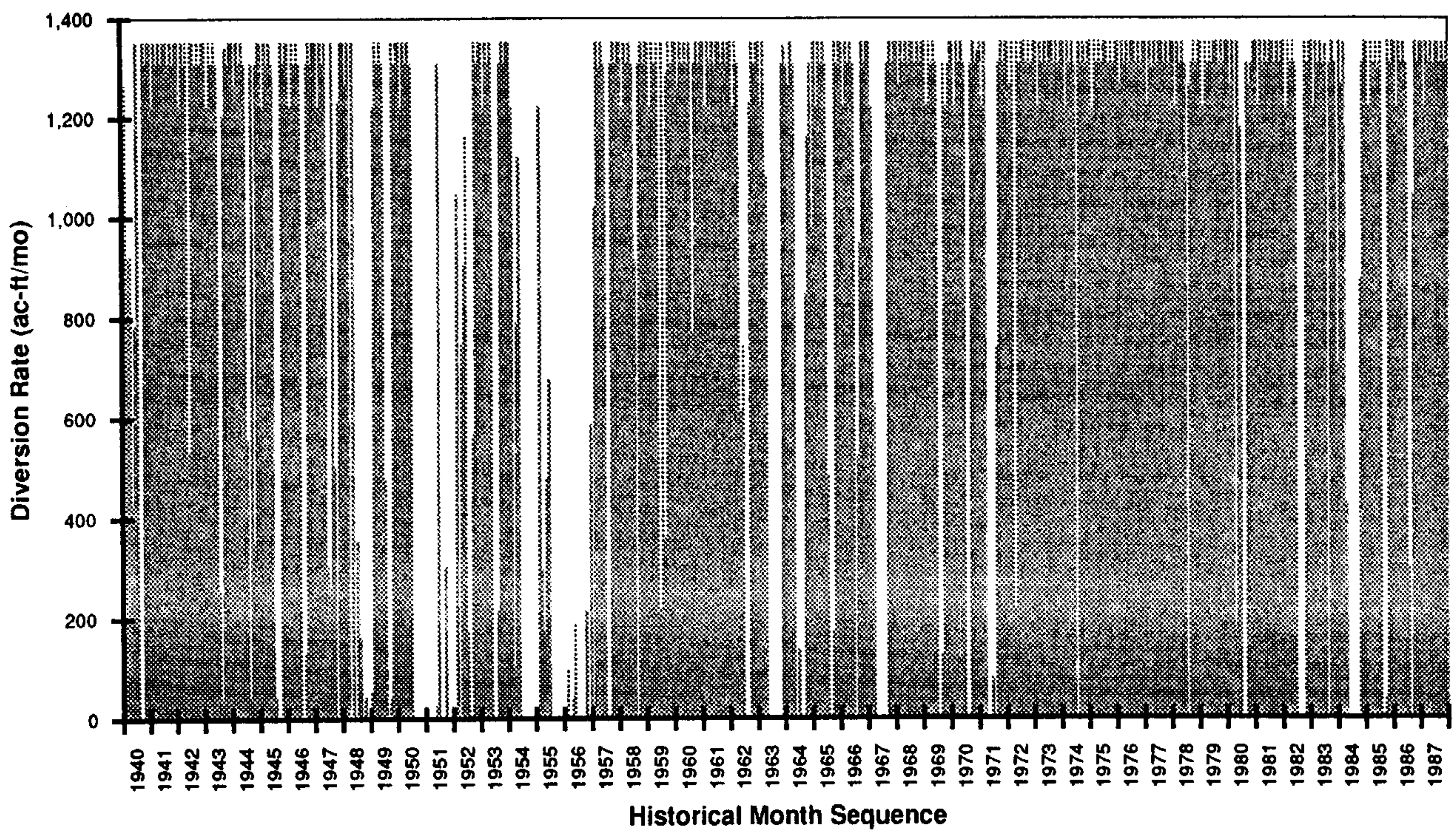


Figure 6-8
Guadalupe River Direct Diversions at 1,353 ac-ft/mo for Incremental Flow
Data Set With All Senior and Superior Permits in Guadalupe Basin
Subwatersheds 21 and 22 Supplied from Guadalupe and San Antonio Rivers



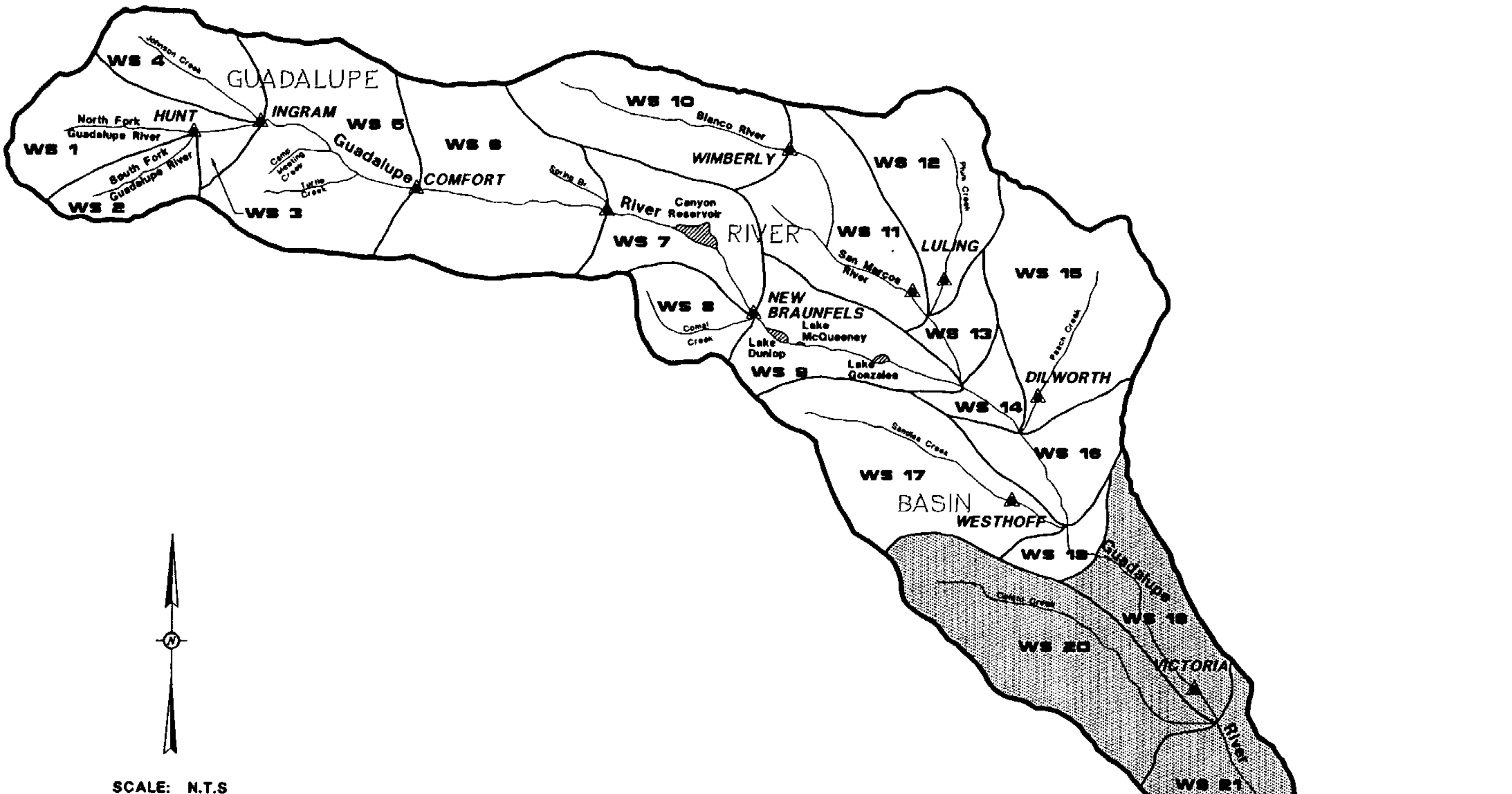


FIGURE 6-9
Guadalupe Subwatersheds 19, 20, and 21
SUBMITTED TO: CITY OF VICTORIA
SUBMITTED BY: CAMP DRESSER & McKEE, INC. IN ASSOCIATION WITH MICHAEL SULLIVAN & ASSOCIATES, INC.

located near the lower end of WS-19. The water available for appropriation within WS-19 is actually unappropriated water leaving WS-18. Concomitantly, the water available for appropriation in WS-21 is the sum of unappropriated waters leaving WS-19 and WS-20. The farthest downstream permit in WS-19 is the 60,000 ac-ft/yr nonconsumptive use cooling water permit of CP&L. The location of this permit is nearly at the confluence of the Guadalupe River and Coleto Creek. Therefore, the water available for appropriation in WS-21 is essentially that water which passes from the CP&L discharge plus any other unappropriated flows form the Guadalupe River and Coleto Creek. Total monthly simulated diversions for all downstream water users in WS-21 and WS-22 are shown in Table 6-11. The maximum annual simulated diversion for those permit holders is 246,000 ac-ft/yr; the maximum monthly diversion is 27,000 ac-ft/yr. These are the downstream water rights which must be protected prior to any potential Victoria diversions.

TWC Guadalupe River Unappropriated Flows at Victoria

Figure 6-10 is an expanded view of Guadalupe Basin, WS-19, showing the location of the City of Victoria and the CP&L cooling water diversion (Permit A1723). The CP&L cooling water diversion represents the upstream terminus of WS-21. Table 6-12 and Figure 6-11 show the estimated quantities of unappropriated water in WS-19 as predicted by the TWC water rights adjudication model. The majority of the entries in both this table and plot are zero because of the CP&L 60,000 ac-ft/yr cooling water demand. Figure 6-12 shows WS-20 with relatively few water right permit holders in the basin. The TWC water adjudication model estimated quantities of unappropriated surface water in WS-20 are show in Table 6-13 and Figure 6-13. Again, there is very little surface water available for diversion within this sub-watershed.

An enlarged view of WS-21 is shown in Figure 6-14. WS-21 receives flow from both WS-20 and WS-19 at nearly the same location. Therefore, for all intents and purposes,

Table 6-11
Guadalupe River Basin (Run I - Revised 3/83)
Total Monthly Simulated Diversions in Subwatersheds 21 and 22 a/ b/

Year	January	February	March	April	May	June	July	August	September	October	November	Devember	Annual
1940	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1941	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1942	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1943	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1944	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1945	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1946	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1947	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1948	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1949	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1950	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1951	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1952	16,118	16,952	19,375	20,443	21,538	24,192	26,029	24,528	21,239	19,491	16,953	17,789	244,647
1953	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,188	21,239	19,491	16,953	17,789	245,275
1954	16,118	16,952	19,375	20,443	21,538	24,192	25,052	24,950	21,239	19,491	16,953	17,789	244,092
1955	16,118	16,952	19,375	20,443	21,538	23,452	17,226	15,507	15,174	19,491	16,953	17,789	220,018
1956	16,118	16,952	18,572	18,898	21,538	24,192	21,185	24,240	21,239	14,978	15,125	17,789	233,174
1957	16,118	16,952	19,375	20,443	21,538	9,329	9,643	11,539	18,973	19,491	16,953	17,789	195,795
1958	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1959	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1960	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1961	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1962	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1963	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1964	16,118	16,952	19,375	20,443	21,538	24,192	26,151	22,609	21,239	19,491	16,953	17,789	242,850
1965	16,118	16,952	19,375	20,443	21,538	24,192	26,817	24,950	21,239	19,491	16,953	17,789	245,857
1966	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1967	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1968	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1969	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1970	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1971	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1972	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1973	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1974	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1975	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1976	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1977	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1978	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
1979	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
Max. (ac-ft/mo)	16,118	16,952	19,375	20,443	21,538	24,192	26,997	24,950	21,239	19,491	16,953	17,789	246,037
Max. (cfs)	271	285	326	344	362	407	454	419	357	328	285	299	4,136
Max. (mgd)	175	184	210	222	234	263	293	271	231	212	184	193	2,672

a/ Source: Texas Water Commission

b/ Assumes all permitted diverters in WS-21 and WS-22 diverting to the maximum extent allowed under the conditions of their permit, constrained by the availability of water.

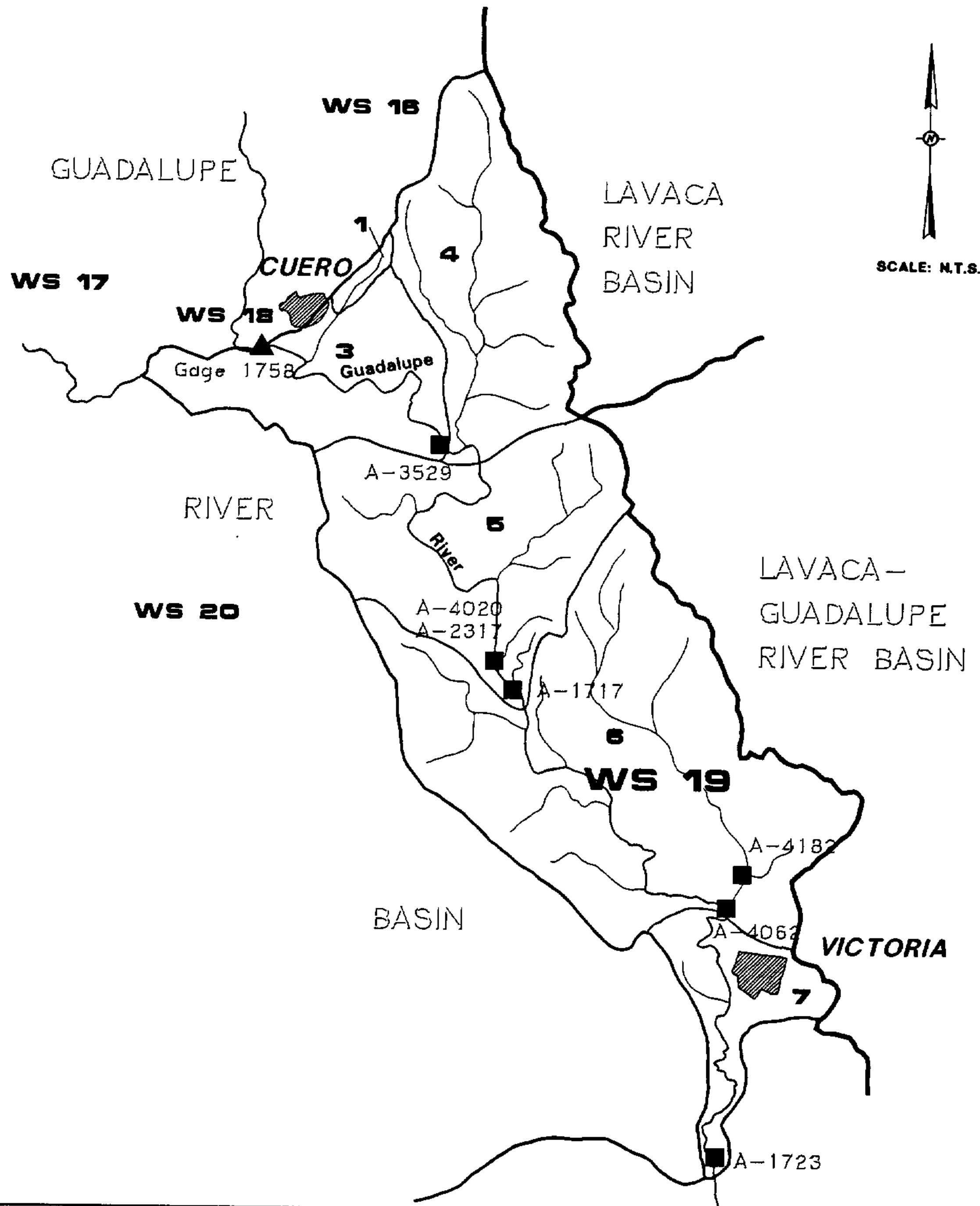


FIGURE 6-10

GUADALUPE BASIN SUBWATERSHED 19

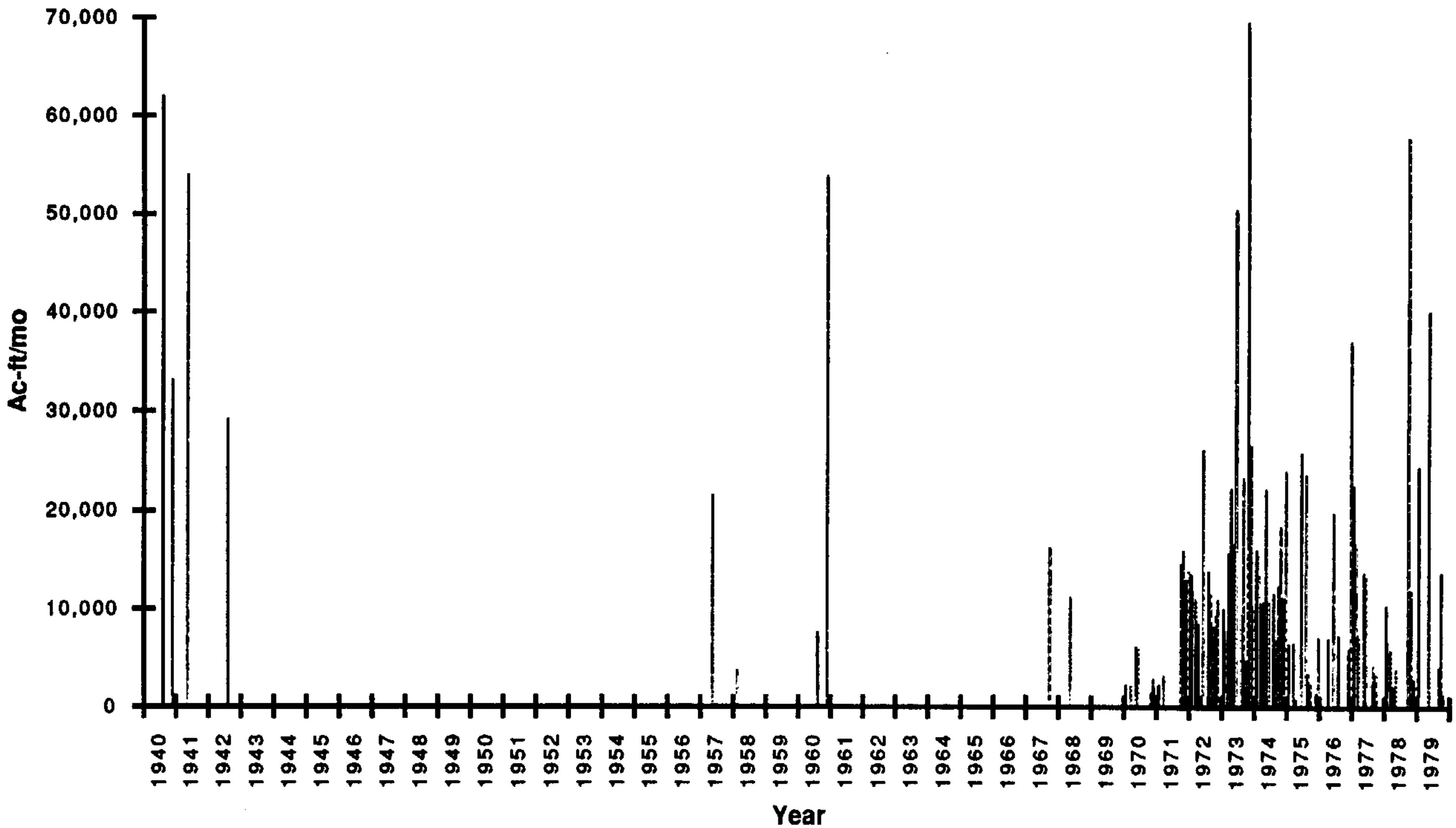
SUBMITTED TO:
CITY OF VICTORIA

SUBMITTED BY:
CAMP DRESSER & McKEE, INC.
IN ASSOCIATION WITH
MICHAEL SULLIVAN & ASSOCIATES, INC.

Table 6-12
Guadalupe River Basin (Run 1 - Revised 3/83)
Estimated Quantities of Unappropriated Surface Water in Acre-Feet
in Watershed 19

	January	February	March	April	May	June	July	August	September	October	November	December	Total
1940	0	0	0	0	0	0	62,149	0	0	0	33,280	61	95,490
1941	38	25	47	9	54,165	26	15	0	0	0	0	0	54,325
1942	0	0	0	4	0	0	29,309	0	0	0	0	0	29,313
1943	0	0	0	0	0	0	0	0	0	0	0	0	0
1944	0	0	0	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	0	0	0	18	0	0	0	0	0	0	0	18
1948	0	0	0	0	0	0	0	0	0	0	0	0	0
1949	0	0	0	0	12	0	0	0	0	0	0	0	12
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	0	0	0	0	0	0	0	0	0	0
1952	0	0	0	0	0	0	0	0	0	0	0	0	0
1953	0	0	0	0	1	0	0	0	0	0	0	0	1
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0
1957	0	0	0	0	21,724	93	0	0	20	0	61	0	21,898
1958	37	3,895	28	0	0	0	0	0	0	0	0	0	3,960
1959	0	0	0	4	8	0	0	0	0	0	0	0	12
1960	0	0	0	0	98	0	7,818	0	0	0	54,160	16	62,092
1961	15	3	0	0	0	46	35	0	0	0	1	0	100
1962	0	0	0	0	0	0	0	0	0	0	0	0	0
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	0
1967	0	0	0	0	0	0	0	0	16,418	57	0	0	16,475
1968	23	8	0	0	11,365	63	5	0	0	0	0	0	11,464
1969	0	168	60	79	35	0	0	0	0	0	0	0	342
1970	2,428	0	2,245	0	6,355	6,118	0	0	0	1,611	3,013	2,067	23,837
1971	2,416	0	3,328	0	0	0	0	0	14,771	16,103	13,188	13,954	63,760
1972	13,725	12,038	11,201	8,725	1,375	26,334	14,021	11,674	8,418	9,577	11,179	394	128,661
1973	10,263	7,941	15,894	22,437	16,762	50,764	9,675	23,539	4,923	69,903	26,733	10,517	269,351
1974	16,261	15,636	10,832	10,927	22,367	10,867	11,818	6,980	12,574	18,551	11,405	24,252	172,470
1975	6,642	0	6,682	983	0	25,979	23,861	3,593	2,512	0	1,585	7,334	79,171
1976	0	0	0	7,159	1	19,993	7,472	0	0	0	6,120	37,276	78,021
1977	22,727	16,883	7,612	0	13,880	13,375	2,391	4,362	3,437	0	0	0	84,667
1978	10,560	6,792	5,964	2,361	4,036	0	0	0	58,103	12,084	2,998	3,036	105,934
1979	24,649	0	0	0	40,389	0	0	4,262	13,874	1,451	0	0	84,625
Maximum	24,649	16,883	15,894	22,437	54,165	50,764	62,149	23,539	58,103	69,903	54,160	37,276	269,351
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	2,745	1,585	1,597	1,317	4,815	3,841	4,214	1,360	3,376	3,233	4,093	2,473	34,650
Std. Dev.	6,301	4,232	3,747	4,198	11,626	10,240	11,472	4,282	9,963	11,673	10,828	7,348	57,967
Median	0	0	0	0	0	0	0	0	0	0	0	0	59

Figure 6-11
Guadalupe River Basin (Run 1 - Revised 3/83)
Estimated Quantities of Unappropriated Surface Water in Acre-Feet
in Watershed 19



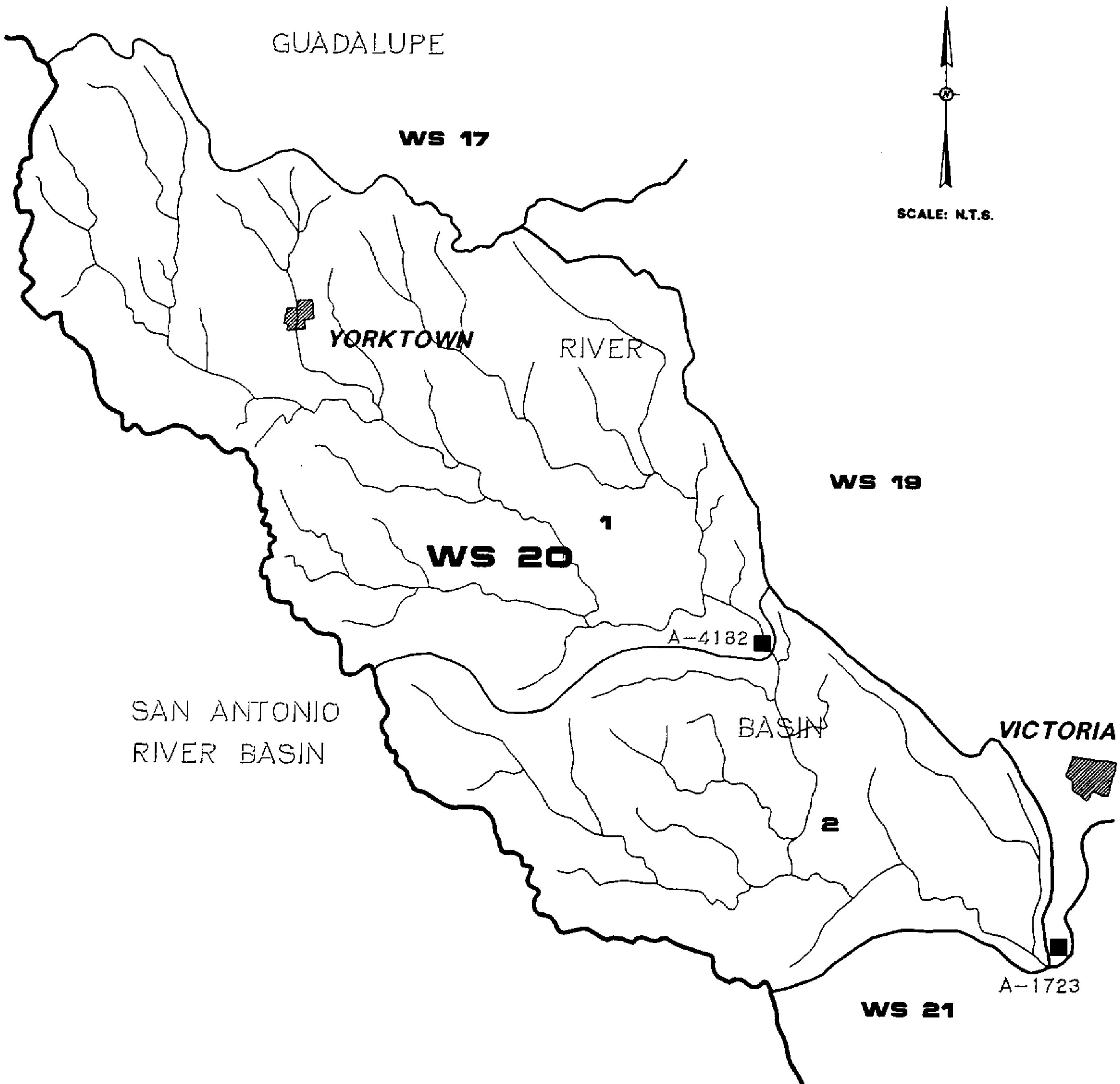


FIGURE 6-12

GUADALUPE BASIN SUBWATERSHED 20

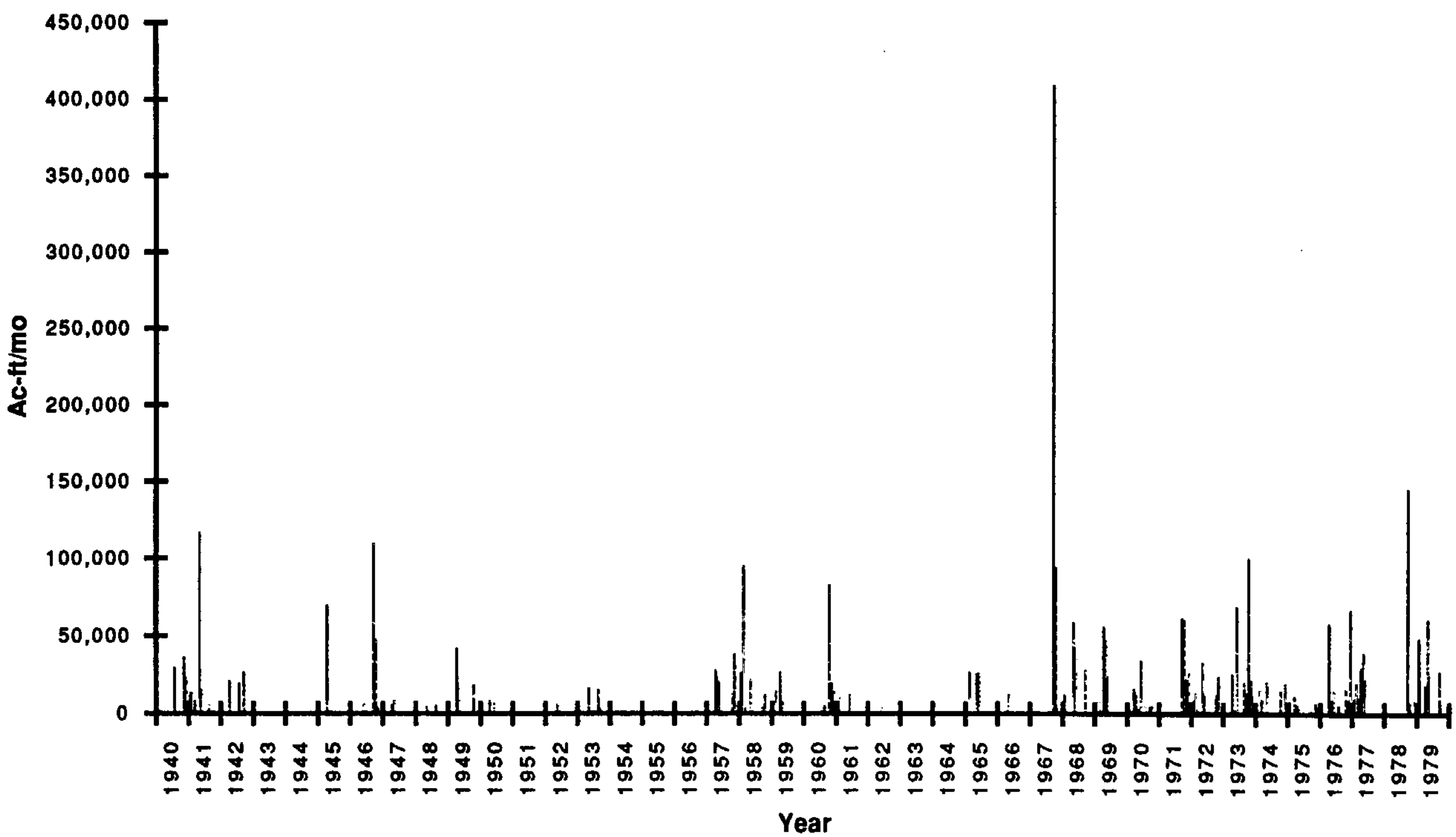
SUBMITTED TO:
CITY OF VICTORIA

SUBMITTED BY:
CAMP DRESSER & McKEE, INC.
IN ASSOCIATION WITH
MICHAEL SULLIVAN & ASSOCIATES, INC.

Table 6-13
Guadalupe River Basin (Run 1 - Revised 3/83)
Estimated Quantities of Unappropriated Surface Water in Acre-Feet
In Watershed 20

	January	February	March	April	May	June	July	August	September	October	November	December	Total
1940	0	2,799	0	0	0	0	30,284	0	0	2,036	37,354	23,611	96,084
1941	14,103	13,905	9,108	0	117,541	16,052	994	6,464	1,642	0	0	0	179,809
1942	0	0	0	21,925	0	0	20,019	0	27,280	0	0	0	69,224
1943	0	0	0	0	0	0	0	0	0	0	0	0	0
1944	0	0	0	0	0	0	0	0	1,441	0	0	0	1,441
1945	2,711	1,253	0	70,445	0	0	0	0	0	0	0	0	74,409
1946	0	0	0	0	0	6,797	0	0	110,441	48,265	4,176	0	169,679
1947	1,755	0	0	6,421	9,221	0	0	0	0	0	0	0	17,397
1948	0	0	0	0	5,340	0	0	5,946	1,321	0	0	0	12,607
1949	0	0	396	42,869	19,106	0	0	0	0	19,534	0	2,335	84,240
1950	155	987	0	8,897	0	7,439	0	0	0	0	0	0	17,478
1951	0	0	0	0	0	1,473	0	0	0	0	0	0	1,473
1952	0	0	0	0	6,639	5,687	0	0	0	0	0	3,827	16,153
1953	0	0	0	0	17,073	0	0	16,119	3,493	1,748	0	0	38,433
1954	0	0	0	0	0	0	0	0	0	0	0	0	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0
1956	0	0	0	0.	0	0	0	0	0	0	0	0	0
1957	0	0	0	28,770	23,984	20,415	0	0	12	13,365	39,281	0	125,827
1958	26,766	95,794	4,090	522	22,654	0	0	0	4,905	12,627	727	1,037	169,122
1959	104	15,194	212	27,131	8,347	0	0	0	0	0	0	0	50,988
1960	0	0	0	0	0	0	2,442	5,643	0	83,457	20,666	14,897	127,105
1961	8,633	11,133	847	28	0	12,901	1,245	0	0	0	79	0	34,866
1962	0	0	0	373	0	4,742	0	0	0	0	0	0	5,115
1963	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	27,889	0	0	26,577	26,816	0	0	0	0	0	0	81,282
1966	0	0	0	2,896	13,105	89	1,972	0	0	0	0	0	18,062
1967	0	0	0	0	0	0	0	0	411,011	94,828	4,477	756	511,072
1968	13,201	3,245	1,915	114	60,003	43,394	1,968	0	28,737	0	0	79	152,656
1969	0	8,817	3,086	57,068	48,149	25,053	0	0	0	0	0	0	142,173
1970	3,906	2,390	17,029	13,992	4,168	35,133	5,556	0	5,052	6,146	0	0	93,372
1971	0	0	0	0	0	5	1,054	0	62,357	61,316	22,989	26,992	174,713
1972	9,006	14,283	4,229	728	34,058	12,633	0	0	0	13,078	24,800	0	112,815
1973	156	984	18	26,388	3,704	69,818	0	21,132	14,764	100,970	22,595	12,349	272,878
1974	1,125	16,319	10,010	0	21,229	0	0	0	0	15,498	0	20,667	84,848
1975	8,893	0	12,321	7,717	6,447	0	0	0	2,428	0	7,472	4,659	49,937
1976	6,375	0	0	58,740	9,761	17,126	6,344	0	0	19,279	9,792	68,027	195,444
1977	10,508	20,709	10,886	30,576	39,976	23,011	0	0	0	0	381	0	136,047
1978	0	0	0	0	0	0	0	0	146,430	8,133	0	11,162	165,725
1979	49,313	21,673	0	19,328	61,707	25,229	0	0	28,091	2,038	0	0	207,379
Maximum	49,313	95,794	17,029	70,445	117,541	69,818	30,284	21,132	411,011	100,970	39,281	68,027	511,072
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	3,918	6,434	1,854	10,623	13,970	8,845	1,797	1,383	21,235	12,558	4,870	4,760	92,246
Std. Dev.	9,227	16,267	4,097	18,555	23,731	15,045	5,723	4,353	69,995	26,579	10,452	12,380	99,909
Median	0	0	0	14	3,936	0	0	0	0	0	0	0	77,846

Figure 6-13
Guadalupe River Basin (Run 1 - Revised 3/83)
Estimated Quantities of Unappropriated Surface Water in Acre-Feet
in Watershed 20



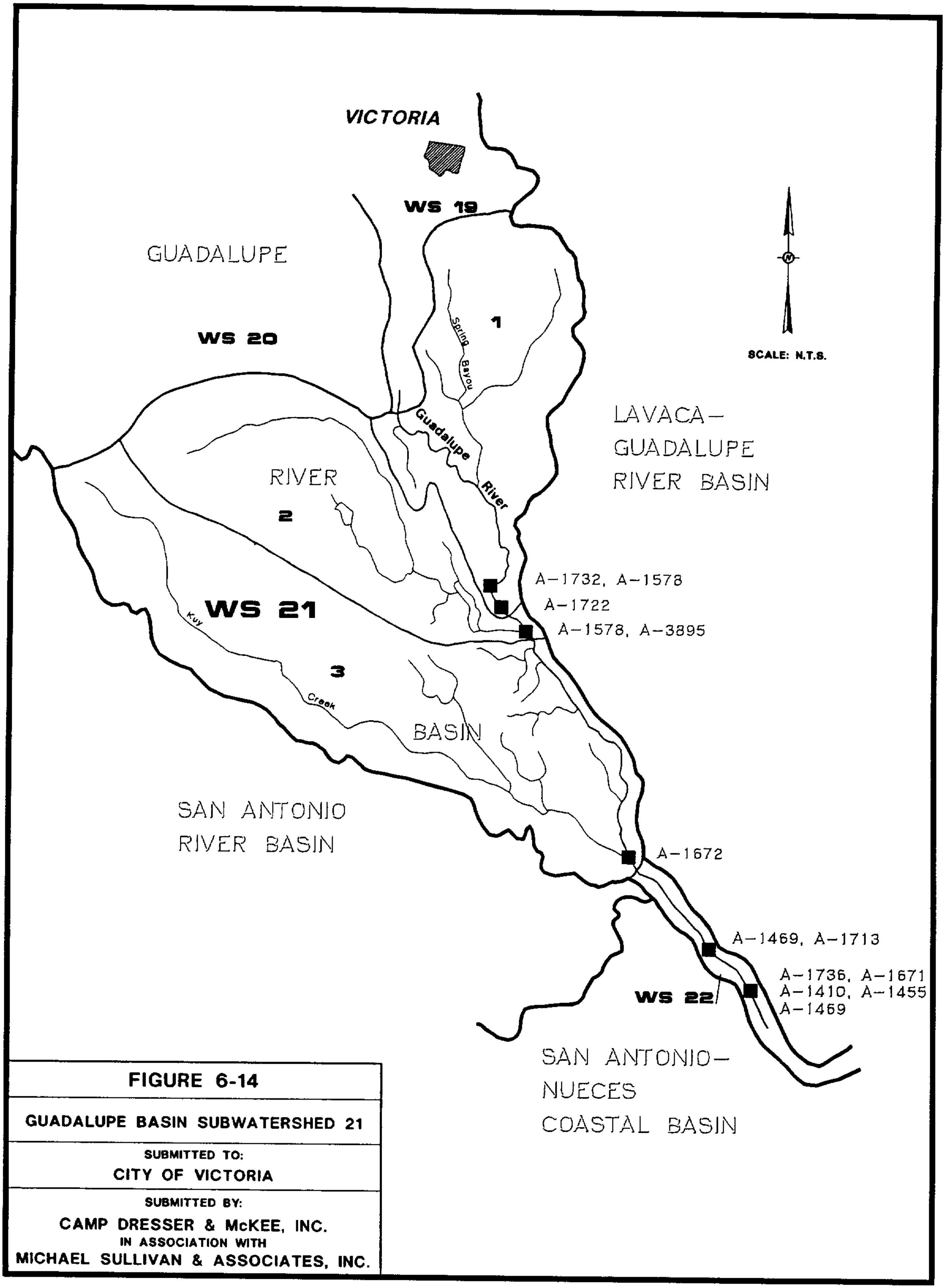


FIGURE 6-14

GUADALUPE BASIN SUBWATERSHED 21

SUBMITTED TO:
CITY OF VICTORIA

SUBMITTED BY:
CAMP DRESSER & McKEE, INC.
IN ASSOCIATION WITH
MICHAEL SULLIVAN & ASSOCIATES, INC.

water available for appropriation in watershed 21 is the sum of unappropriated water leaving WS-19 and WS-20. Those flows are shown in Table 6-14 and Figure 6-15. While individual monthly minimums of zero still occur, the frequency and duration of low flow periods is considerably diminished. It appears that the critical period, i.e. the duration during which available water remains below the 1,353 ac-ft/month demand is approximately six months. Thus, if off-channel storage is considered, required storage capacities will be relatively small. The minimum annual quantity of water available for diversion is 13,000 ac-ft the maximum quantity available for diversion 260,000 ac-ft/yr. Note that Figure 6-15 shows that since the late 1960's the Guadalupe Basin has experienced a significant wet period when compared to the antecedent period of record.

Estimates of annual quantities of unappropriated surface water available in WS-21 are shown in Figure 6-16. The wetter than normal trend of the 1970 to 1980 period is accentuated when examining annual unappropriated flows. Estimated annual quantities of unappropriated surface water in all three watersheds (WS-19, WS-20 and WS-21) are shown in Figure 6-17.

Victoria Diversion Based on WRADJ Flows

Diversions from the Guadalupe River assuming an 8,000 ac-ft/yr Victoria demand are shown in Table 6-15 and Figure 6-18. Note that there is nearly a constant supply of water available for diversion at this rate with gaps in availability generally lasting less than four months. Diversions from the Guadalupe River assuming a 16,000 ac-ft/yr demand (Table 6-16 and Figure 6-19) again are almost identical to the 8,000 ac-ft/yr demand scenario. Thus, if Victoria wishes to appropriate water from the Guadalupe River below the CP&L discharge point, it is within their best interest to request the largest demand anticipated and supportable by the TWC.

Table 6-14
Guadalupe River Basin (Run 1 - Revised 3/83)
Estimated Quantities of Unappropriated Surface Water in Acre-Feet
In Watershed 21

	January	February	March	April	May	June	July	August	September	October	November	December	Total
1940	0	2,353	914	3,633	0	955	40,265	4,941	4,411	2,302	30,122	10,608	100,504
1941	4,018	5,828	9,583	7,400	39,978	7,153	6,721	3,787	9,109	4,899	5,039	5,099	108,614
1942	1,568	3,105	2,987	6,234	2,677	645	27,965	5,557	12,966	8,181	4,669	6,071	82,625
1943	2,445	3,531	4,412	5,233	2,581	5,301	2,555	3,392	6,250	2,814	2,982	4,531	46,027
1944	863	1,903	2,668	3,265	5,719	2,378	0	2,190	6,622	1,645	1,697	3,788	32,738
1945	686	4,186	4,059	11,437	1,420	637	0	909	3,766	2,751	1,572	2,838	34,261
1946	579	2,473	3,175	6,269	6,421	4,217	0	3,237	11,225	10,130	3,115	3,781	54,622
1947	953	3,215	3,936	5,085	5,405	0	0	598	5,020	1,842	2,157	3,916	32,127
1948	1,641	3,209	3,437	4,511	2,978	0	3,497	7,260	8,363	5,221	3,035	4,844	47,996
1949	1,729	1,718	5,151	6,815	8,271	4,747	8,326	3,887	5,864	3,740	4,753	6,129	61,130
1950	775	1,644	1,955	2,565	0	158	0	2,721	4,932	1,592	1,254	3,069	20,665
1951	1,493	3,649	2,487	5,258	3,262	3,965	0	0	12,121	2,769	2,972	4,301	42,277
1952	816	3,252	4,294	5,863	3,190	0	0	0	11,530	1,931	2,357	5,175	38,408
1953	2,441	2,310	2,197	2,278	10,970	0	0	2,346	9,000	1,643	1,839	3,167	38,191
1954	325	1,675	1,549	3,441	987	0	0	0	0	590	2,107	2,927	13,601
1955	820	3,161	3,166	2,833	1,386	631	0	0	910	0	0	2,726	15,633
1956	921	2,128	0	0	2,418	0	0	0	0	6,227	986	7,228	19,908
1957	230	1,736	3,081	5,988	24,066	12,002	1,106	2,621	13,604	1,119	8,600	4,084	78,237
1958	7,501	13,025	6,715	3,977	2,817	3,352	511	1,182	6,507	6,553	7,251	5,229	64,620
1959	1,760	3,561	5,269	7,404	3,350	0	769	1,388	4,119	2,887	2,855	3,791	37,153
1960	525	1,632	2,518	2,581	7,835	0	13,556	4,731	5,645	2,692	41,524	5,698	88,937
1961	4,897	4,966	4,534	4,420	0	8,019	9,036	5,332	6,074	5,152	6,742	5,429	64,601
1962	2,082	3,329	2,658	4,650	781	5,173	0	0	5,899	1,174	2,622	8,631	36,999
1963	1,236	3,356	2,776	3,899	0	0	0	0	1,539	1,717	4,364	5,753	24,640
1964	1,186	5,099	3,337	3,608	0	503	0	8,564	4,551	2,138	4,012	4,075	37,073
1965	1,694	5,833	2,710	4,343	3,074	7,347	0	1,017	3,922	4,111	2,616	4,424	41,091
1966	986	3,260	3,942	5,119	3,483	59	0	1,516	6,043	1,333	1,267	3,200	30,208
1967	645	2,108	2,482	4,510	1,862	839	214	8,931	29,772	10,972	5,237	6,386	73,958
1968	8,677	6,802	6,566	8,443	18,665	10,028	6,394	5,980	9,284	5,664	4,607	7,520	98,630
1969	3,937	11,589	11,843	14,285	9,266	4,411	1,134	2,714	9,255	7,777	5,816	8,702	90,729
1970	11,904	4,662	16,540	21,328	6,210	39,602	16,229	12,172	19,937	14,740	5,437	6,956	175,717
1971	1,599	2,394	6,650	16,593	17,622	13,693	14,926	13,556	40,801	53,101	27,413	30,747	239,095
1972	7,794	15,310	9,542	14,411	11,575	34,683	12,397	16,962	18,640	24,831	28,995	6,853	201,993
1973	6,679	7,652	8,528	12,190	20,127	17,727	14,601	43,512	25,125	26,852	32,103	19,556	234,652
1974	7,819	23,764	16,992	15,391	24,483	20,101	14,848	14,191	23,808	28,543	4,942	33,130	228,012
1975	17,445	10,074	24,724	22,730	13,443	22,116	10,694	9,731	26,103	6,489	16,821	8,653	189,023
1976	11,057	6,126	5,976	40,412	8,458	38,770	16,473	10,026	17,033	6,799	16,888	57,631	235,649
1977	13,774	18,889	20,601	28,259	47,164	35,522	16,097	13,585	17,713	7,712	13,041	7,669	240,026
1978	3,785	8,836	7,146	11,860	14,621	15,278	10,942	10,210	122,492	21,549	9,180	17,417	253,316
1979	36,293	19,223	6,521	25,201	42,499	34,130	12,345	15,700	38,536	14,106	6,988	7,806	259,348
Maximum	36,293	23,764	24,724	40,412	47,164	39,602	40,265	43,512	122,492	53,101	41,524	57,631	259,348
Minimum	0	1,632	0	0	0	0	0	0	0	0	0	2,726	13,601
Mean	4,389	5,814	5,941	9,093	9,477	8,854	6,540	6,111	14,212	7,907	8,249	8,738	95,326
Std. Dev.	6,636	5,380	5,372	8,420	11,828	12,151	8,953	7,828	20,123	10,308	10,004	10,347	80,857
Median	1,668	3,444	4,001	5,561	4,444	4,091	1,120	3,590	8,682	4,505	4,638	5,564	62,866

Figure 6-15
Guadalupe River Basin (Run 1 - Revised 3/83)
Estimated Quantities of Unappropriated Surface Water in Acre-Feet
in Watershed 21

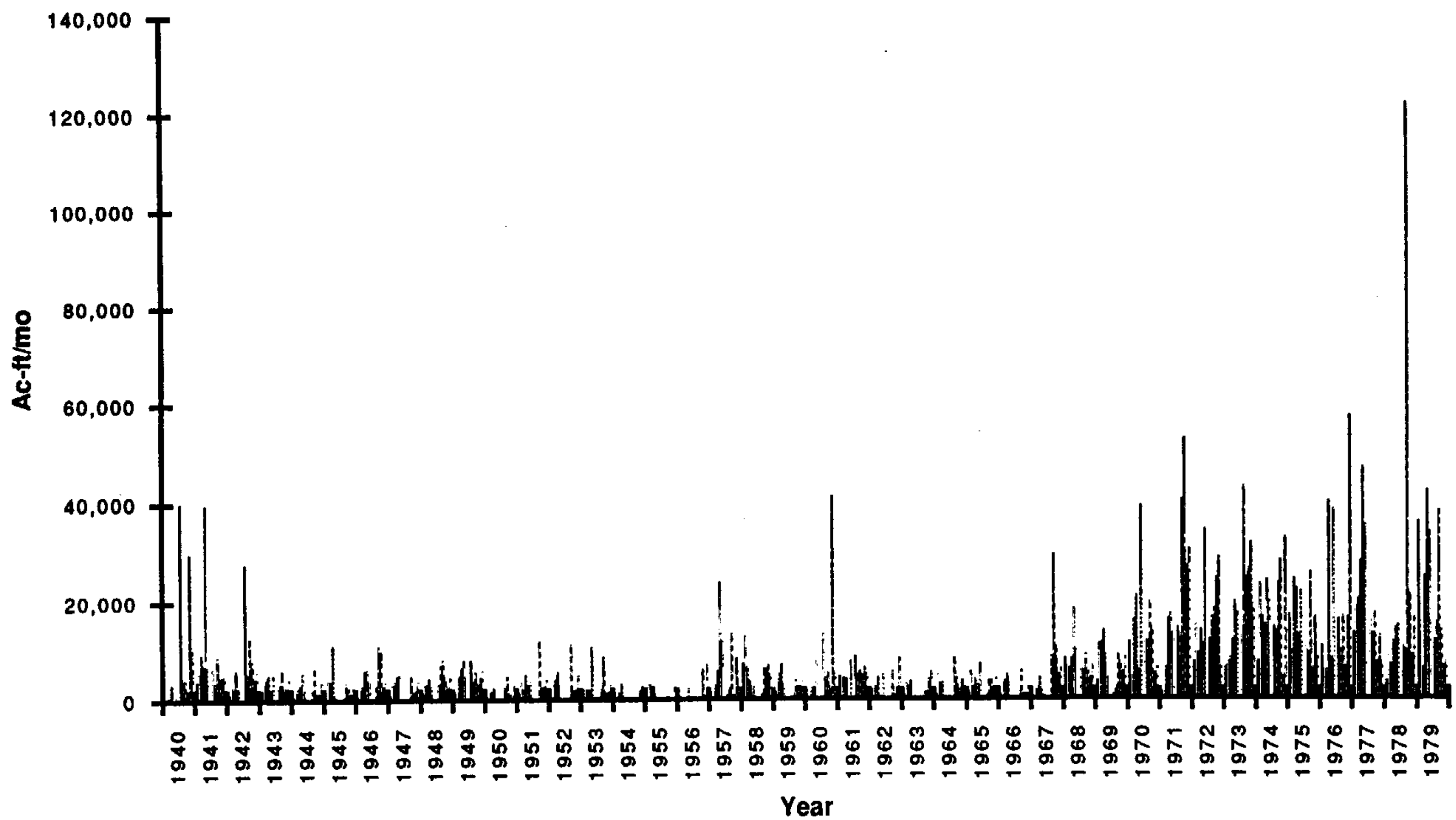


Figure 6-16
Guadalupe River Basin (Run 1 - Revised 3/83)
Estimated Annual Quantities of Unappropriated Surface Water in Acre-Feet
in Watershed 21

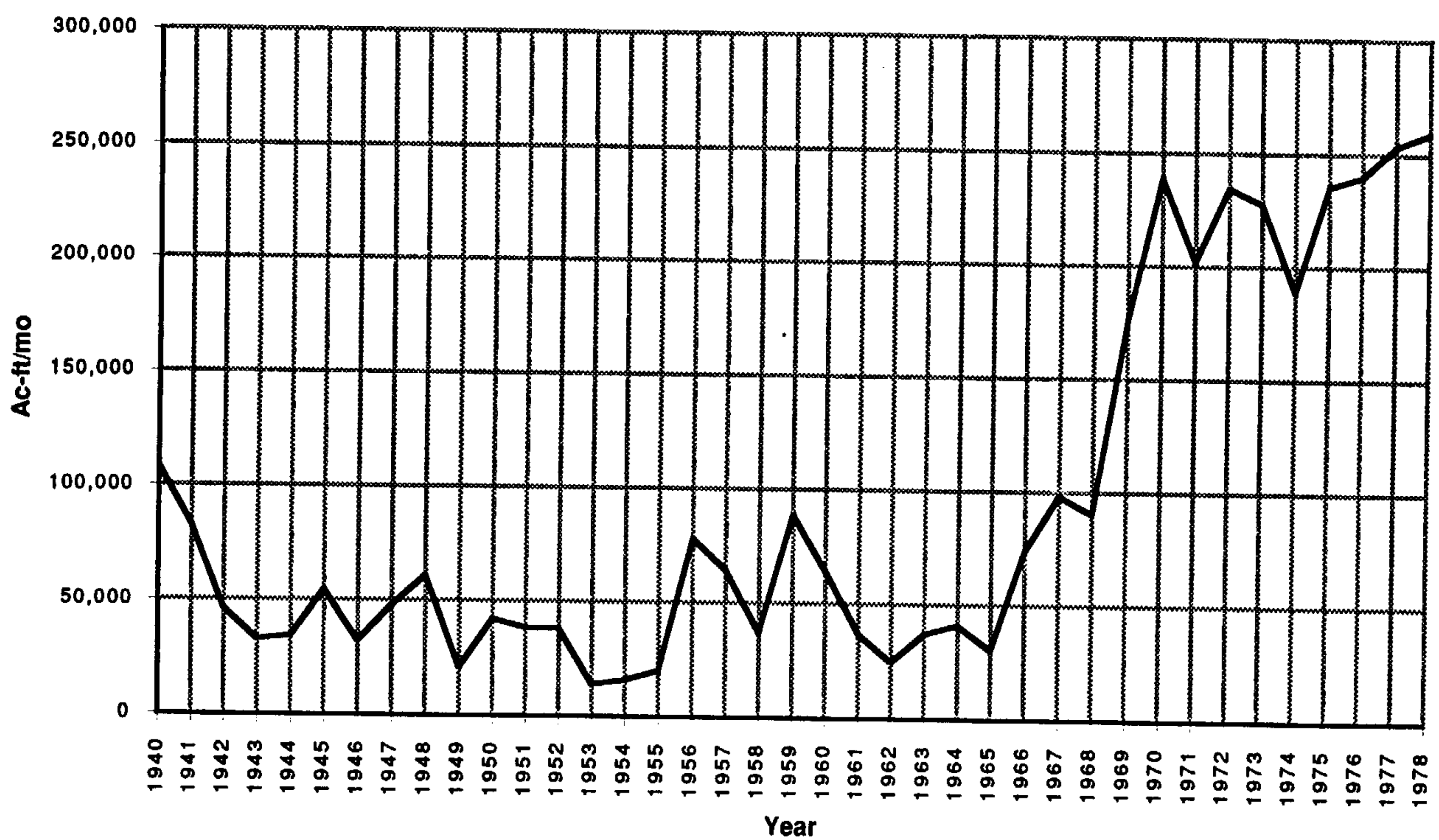


Figure 6-17
Guadalupe River Basin (Run 1 - Revised 3/83)
Estimated Annual Quantities of Unappropriated Surface Water in Acre-Feet
in Watersheds 19, 20 and 21

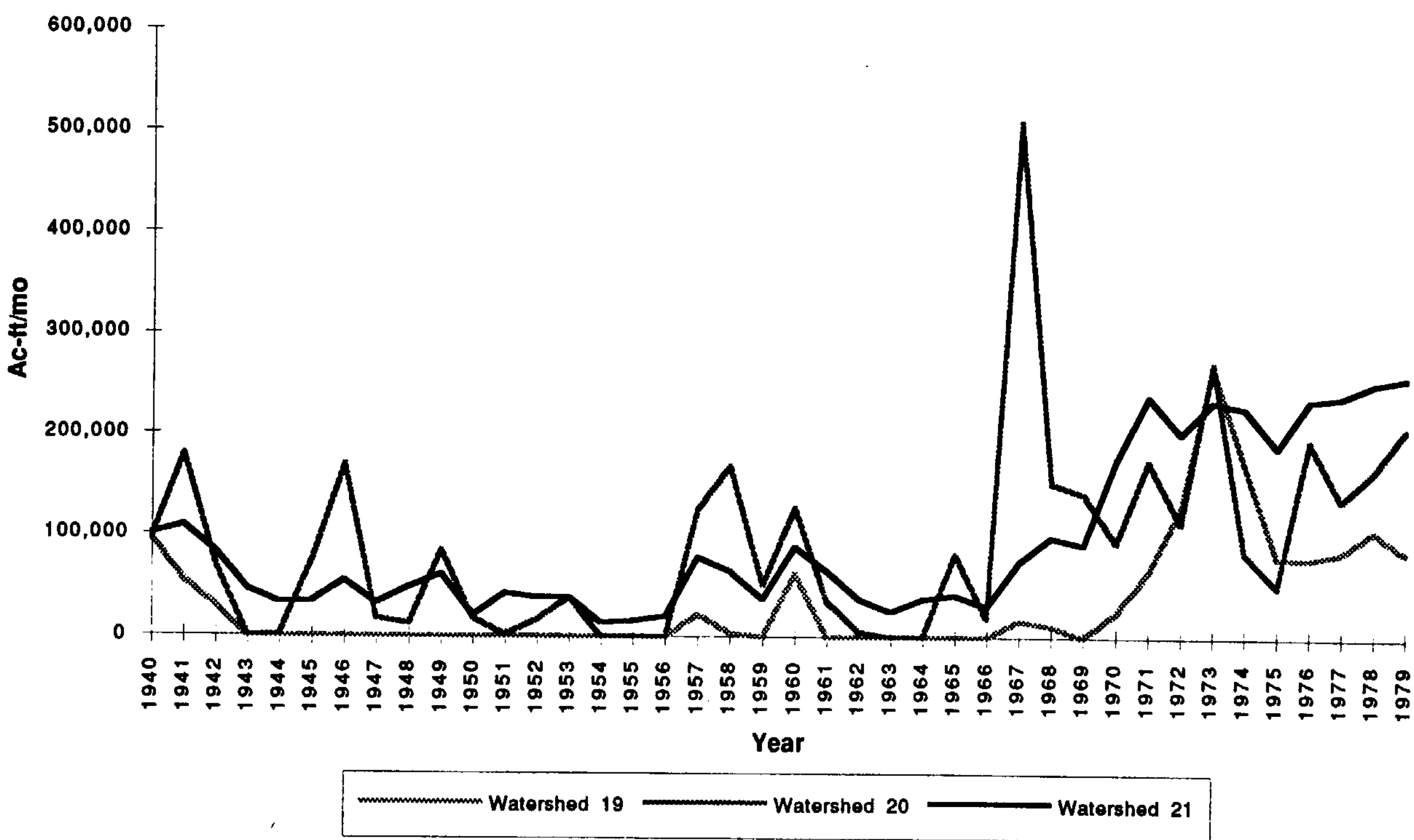


Table 6-15
Diversions From Guadalupe River by the City of Victoria Assuming an 8,000 ac-ft/yr
TWC Unappropriated Flow at the CPL Cooling Water Discharge Point a/ b/

Year	January	February	March	April	May	June	July	August	September	October	November	December
1940	738	690	736	714	0	591	738	738	714	738	714	738
1941	738	666	738	714	738	714	738	738	714	738	714	738
1942	738	666	738	714	738	621	738	738	714	738	714	738
1943	738	666	738	714	738	714	738	738	714	738	714	738
1944	700	690	738	714	738	714	0	738	714	738	714	738
1945	468	666	738	714	738	585	0	738	714	738	714	738
1946	516	666	738	714	738	714	0	738	714	738	714	738
1947	672	666	738	714	738	0	0	383	714	738	714	738
1948	738	690	738	714	738	0	738	738	714	738	714	738
1949	738	666	738	714	738	714	738	738	714	720	714	738
1950	726	666	738	714	0	159	0	738	714	738	714	738
1951	738	666	738	714	738	714	0	0	714	738	714	738
1952	732	690	738	714	730	0	0	0	613	738	714	738
1953	738	666	738	714	738	0	0	736	714	512	714	738
1954	325	666	738	714	660	0	0	0	0	575	714	738
1955	714	666	738	714	456	383	0	0	694	0	0	738
1956	730	690	0	0	738	0	0	0	0	738	704	732
1957	230	611	720	666	738	714	736	738	714	488	714	738
1958	738	666	738	714	738	714	514	738	714	738	714	738
1959	738	666	738	714	738	0	645	738	714	738	714	738
1960	522	690	738	714	738	0	738	738	714	488	714	738
1961	738	666	738	714	0	714	738	738	714	738	714	738
1962	738	666	738	714	676	714	0	0	714	738	714	738
1963	738	666	738	714	0	0	0	0	714	738	714	738
1964	738	690	738	714	0	415	0	738	714	738	714	738
1965	613	666	738	714	728	714	0	736	714	738	714	738
1966	738	666	738	714	738	63	0	738	714	738	714	738
1967	643	666	738	714	738	625	214	738	714	738	714	738
1968	738	690	738	714	738	714	738	738	714	738	714	738
1969	738	666	738	714	738	714	738	738	714	738	714	738
1970	738	666	738	714	738	714	738	738	714	738	714	738
1971	738	666	738	714	738	714	738	738	714	738	714	738
1972	738	690	738	714	730	714	738	738	714	738	714	738
1973	738	666	738	714	738	714	738	738	714	738	714	738
1974	738	666	738	714	738	714	738	738	714	738	714	738
1975	738	666	738	714	738	714	738	738	714	738	714	738
1976	738	690	738	714	738	714	738	738	714	738	714	738
1977	738	666	738	714	738	714	738	738	714	738	714	738
1978	738	666	738	714	738	714	738	738	714	738	714	738
1979	738	666	738	714	738	714	738	738	714	738	714	738

a/ TWC Unappropriated Flow data set distributed daily according to Victoria gage.
b/ Assume an additional 8,000 ac-ft/yr of demand satisfied from groundwater sources.

Figure 6-18
Guadalupe River Direct Diversions at 738 ac-ft/mo for TWC Unappropriated Flow
Data Set With All Senior and Superior Permits in Guadalupe Basin
Subwatersheds 21 and 22 Supplied from Guadalupe River

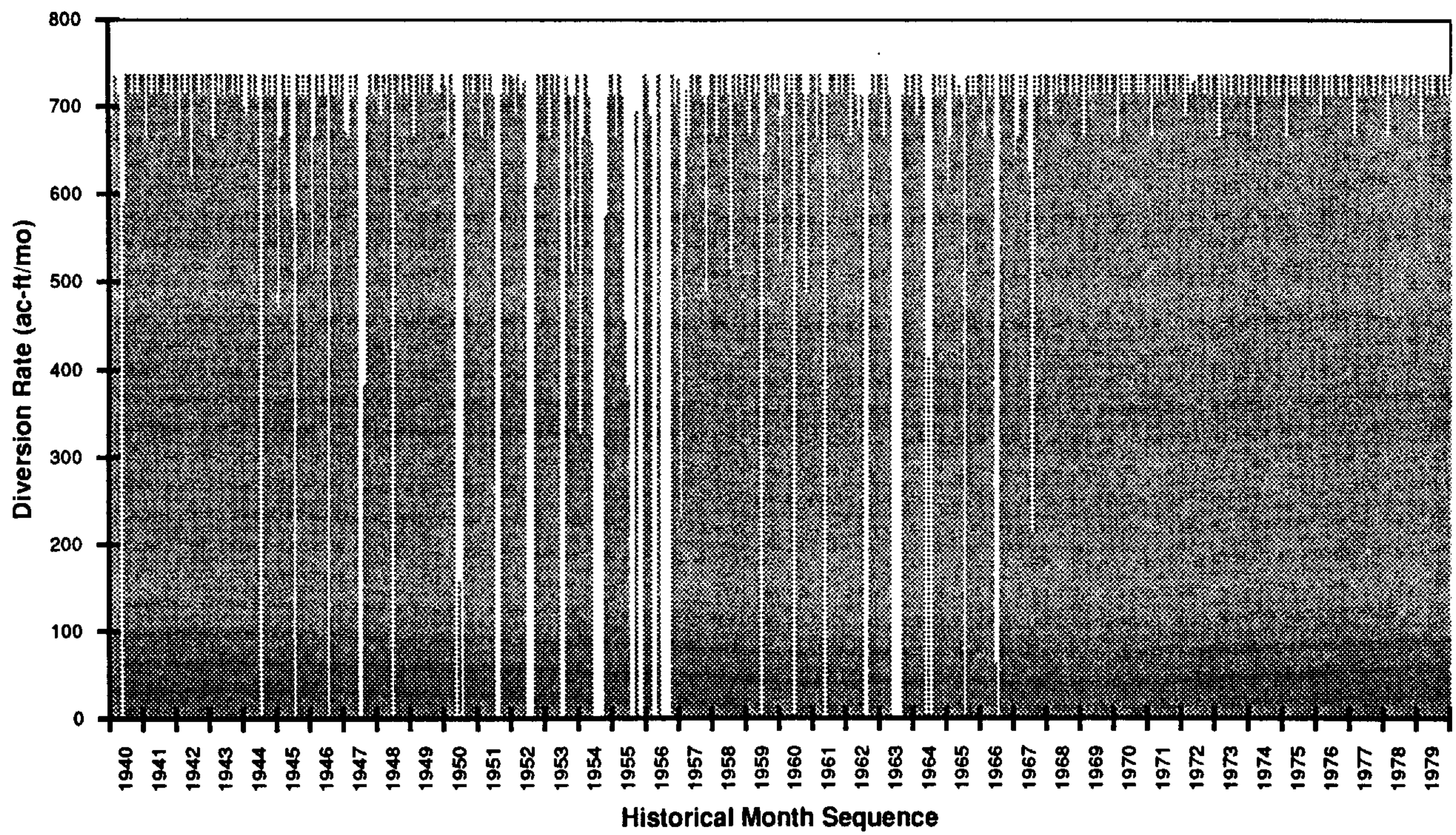
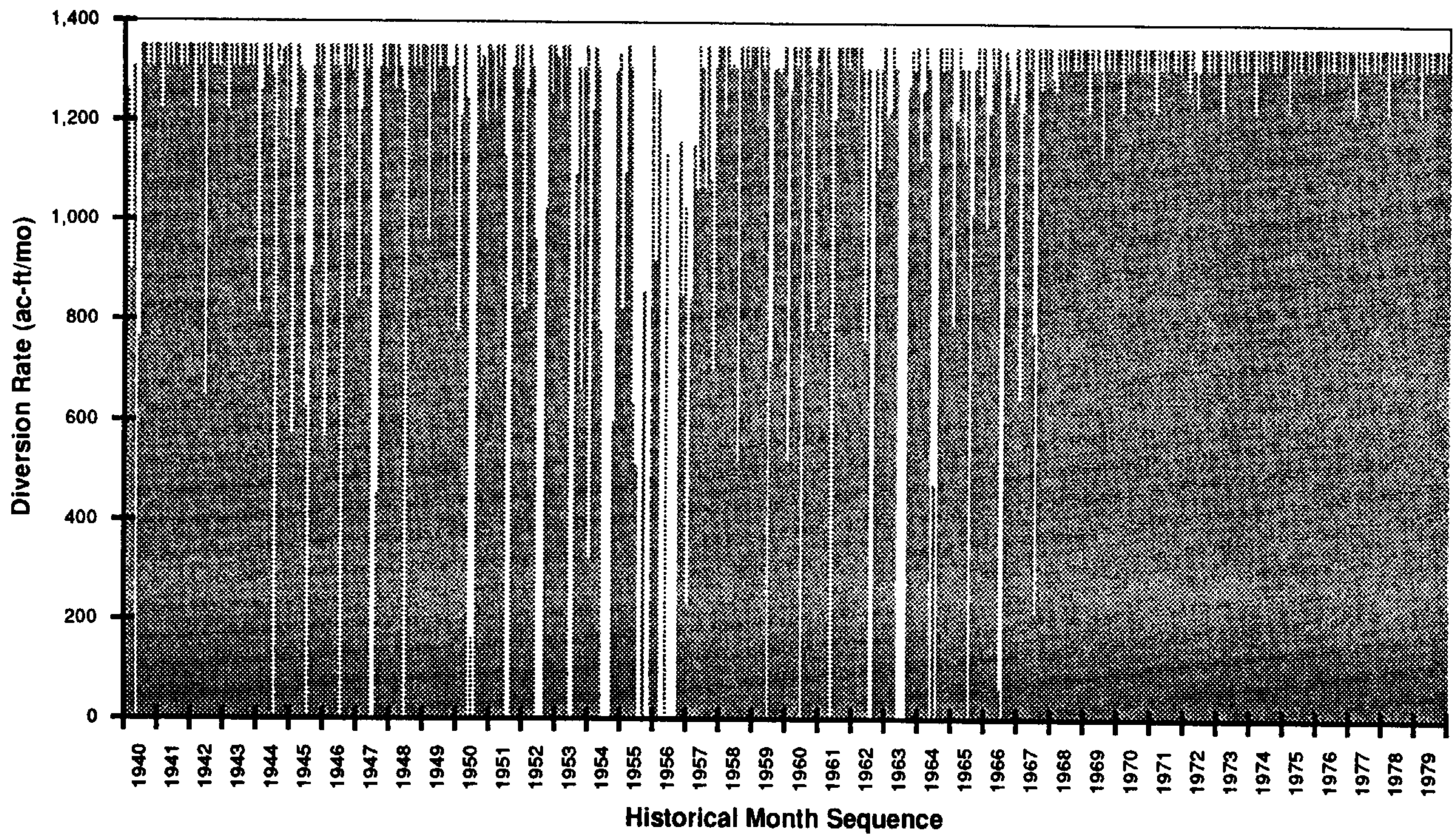


Table 6-16
Diversions From Guadalupe River by the City of Victoria Assuming an 16,000 ac-ft/yr
TWC Unappropriated Flow at the CPL Cooling Water Discharge Point a/

Year	January	February	March	April	May	June	July	August	September	October	November	December
1940	1353	1265	897	1309	0	768	1353	1353	1309	1353	1309	1353
1941	1353	1222	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353
1942	1353	1222	1353	1309	1353	649	1353	1353	1309	1353	1309	1353
1943	1353	1222	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353
1944	813	1263	1353	1309	1353	1291	0	1353	1309	1345	1166	1353
1945	573	1222	1353	1309	1299	631	0	904	1309	1353	1309	1353
1946	567	1222	1353	1309	1353	1309	0	1353	1309	1353	1301	1353
1947	841	1222	1353	1309	1353	0	0	452	1309	1353	1307	1353
1948	1353	1265	1353	1309	1258	0	1353	1353	1309	1353	1309	1353
1949	1351	960	1353	1256	1353	1309	1353	1353	1309	1035	1309	1353
1950	778	1212	1353	1248	0	163	0	1353	1309	1331	1198	1353
1951	1343	1222	1353	1309	1353	1133	0	0	1309	1353	1309	1353
1952	819	1265	1353	1309	962	0	0	0	1025	1353	1256	1353
1953	1329	1222	1353	1309	1353	0	0	1093	1309	660	1309	1353
1954	325	1222	1349	1309	778	0	0	0	0	597	1301	1337
1955	823	1097	1353	1309	635	512	0	0	857	0	0	1353
1956	920	1265	0	0	1139	0	0	0	0	1160	855	1033
1957	230	847	1154	1065	1353	1309	1067	1353	1085	698	1309	1353
1958	1353	1222	1353	1309	1317	1309	518	1353	1309	1353	1309	1353
1959	1353	1222	1353	1309	1353	0	720	1307	1309	1297	1309	1353
1960	522	1265	1353	1309	1353	0	1353	1353	1309	776	1309	1353
1961	1353	1222	1353	1309	0	1208	1353	1353	1309	1353	1309	1353
1962	1353	1222	1353	1309	760	1309	0	0	1309	1105	1309	1353
1963	1210	1222	1353	1309	0	0	0	0	1275	1347	1303	1353
1964	1123	1265	1353	1309	0	472	0	1353	1307	1353	1309	1353
1965	791	1206	1353	1309	1123	1309	0	1018	1309	1353	1256	1353
1966	990	1222	1353	1309	1353	63	0	1345	1309	1244	1261	1353
1967	643	1222	1353	1309	1353	778	214	1353	1269	1353	1309	1353
1968	1291	1265	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353
1969	1353	1222	1353	1309	1353	1309	1131	1353	1309	1353	1309	1353
1970	1353	1222	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353
1971	1353	1222	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353
1972	1353	1265	1353	1309	1232	1309	1353	1353	1309	1353	1309	1353
1973	1353	1222	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353
1974	1353	1222	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353
1975	1353	1222	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353
1976	1353	1265	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353
1977	1353	1222	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353
1978	1353	1222	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353
1979	1353	1222	1353	1309	1353	1309	1353	1353	1309	1353	1309	1353

a/ TWC Unappropriated Flow data set distributed daily according to Victoria gage.

Figure 6-19
Guadalupe River Direct Diversions at 1,353 ac-ft/mo for TWC Unappropriated Flow
Data Set With All Senior and Superior Permits in Guadalupe Basin
Subwatersheds 21 and 22 Supplied from Guadalupe River



Guadalupe Unappropriated Flow Frequency Distributions

Flow frequency distributions are often the best tool water system managers have to assess the reliability of the potential water supply sources. The flow frequency distributions of TWC unappropriated water below the CP&L discharge for non-irrigation months are shown in Figure 6-20. Diversion rates of 8,000 ac-ft/yr and 16,000 ac-ft/yr are roughly equivalent to 22 cfs and 44 cfs, respectively. Note that in nearly all cases, these flows are exceeded well in excess of 90% of the time. A similar set of curves derived for the irrigation months, April through September, are shown in Figure 6-21. In April and May, a 44 cfs flow is maintained in the river nearly 100% of the time. However, during the high irrigation months of June through September, the percent of time that unappropriated flows are greater than or equal to 44 cfs drops to approximately 70% of the time. On an annual basis, unappropriated flows form the Guadalupe River below the CP&L discharge are greater than 44 cfs approximately 86% of the time (Figure 6-22). Thus, the Guadalupe River as a future supply source without impoundment for the Victoria service area will be adequate approximately 86% of the time with the other 14% of the time requiring partial or total supplementation from existing groundwater sources.

6.14 MATRIX EVALUATION RESULTS

6.14.1 Engineering/Technical Considerations

Firm Supply

The GBRA and LNRA certainly offer the most secure supplies to meet future Victoria demands. With the GBRA, that supply is available within the limits of the City of Victoria. With LNRA, Lake Texana supply will require construction of a 28 mile pipeline from the lake to the City of Victoria. The cost of water from both projects are

Figure 6-20
TWC Unappropriated Flow Frequency Distribution at CPL Discharge
for Non-irrigation Months, October-March (1940-1979)

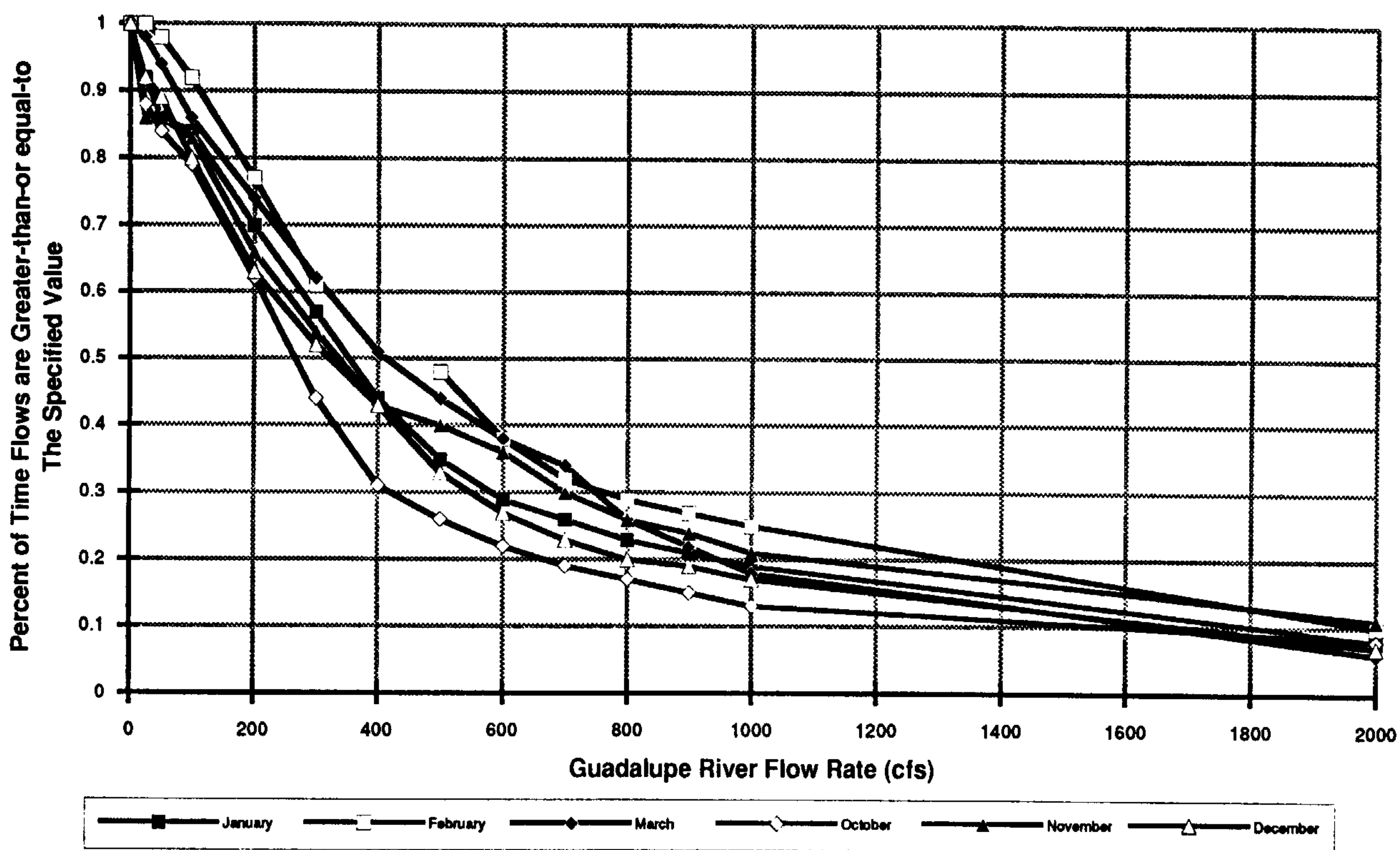


Figure 6-21
TWC Unappropriated Flow Frequency Distribution at CPL Discharge for Irrigation Months, April-September (1940-1979)

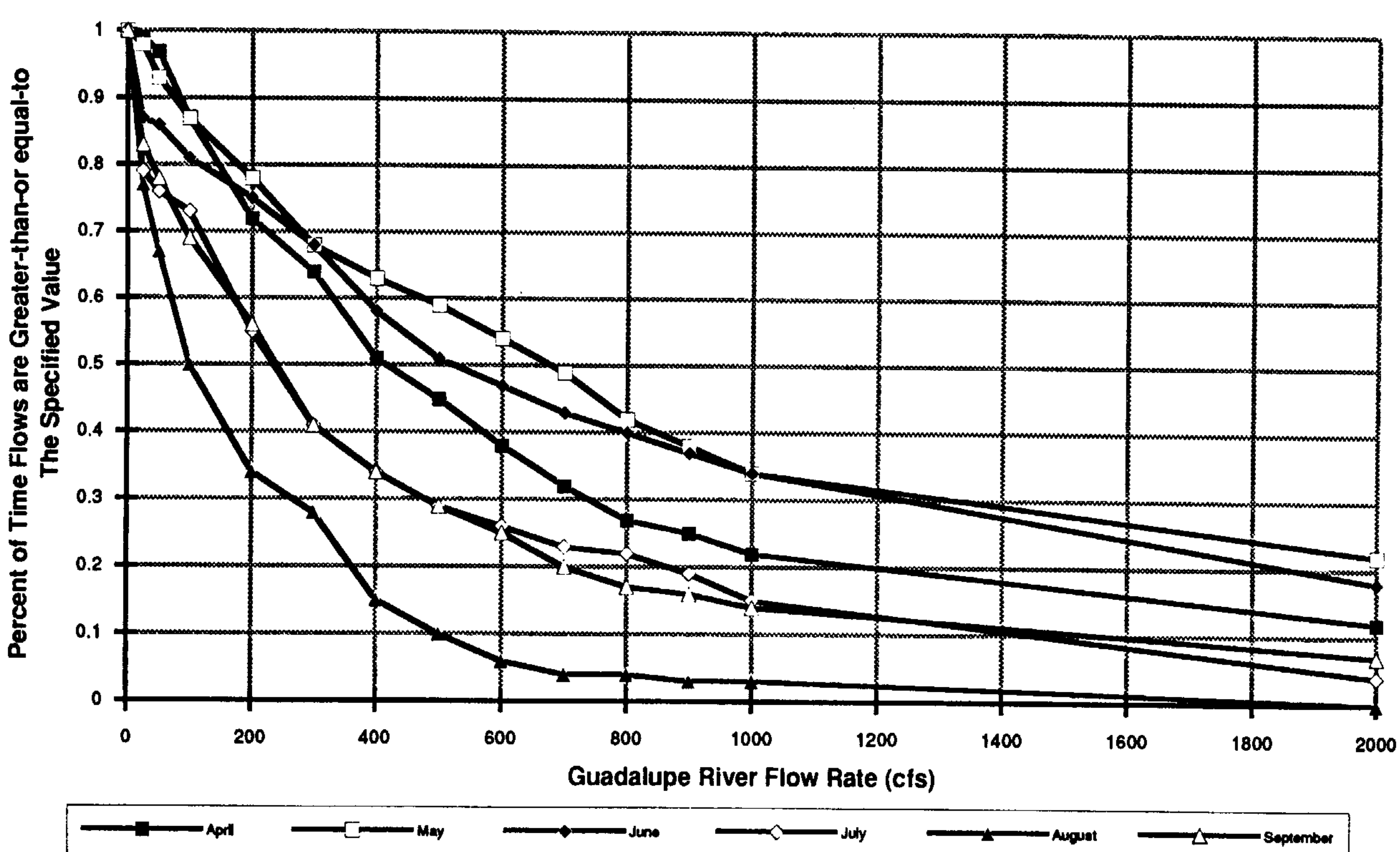
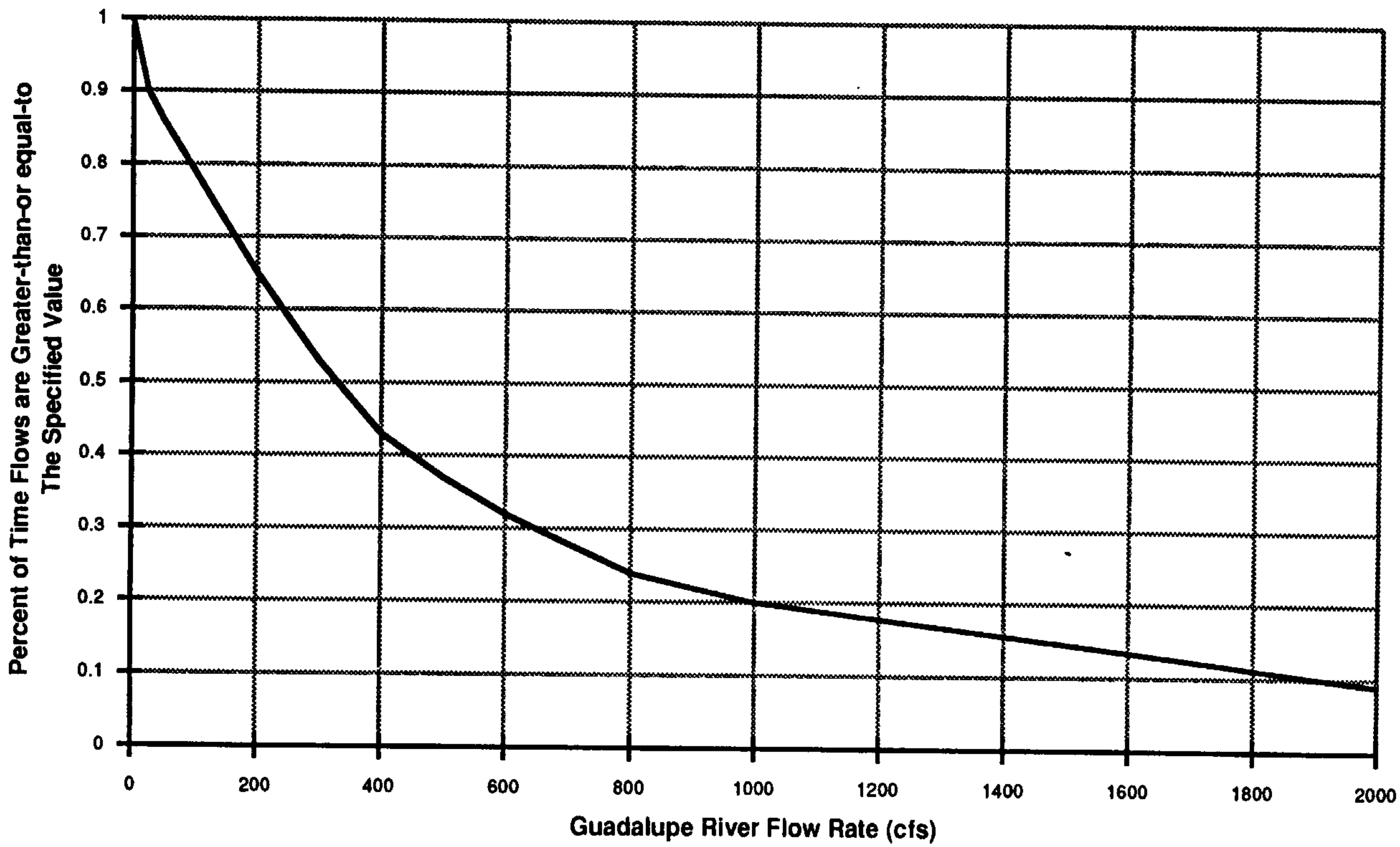


Figure 6-22
TWC Unappropriated Flow Frequency Distribution at CPL Discharge
for Annual Flowsr (1940-1979)



about the same, approximately $55-56/ac-ft. The difference between the two options will be the cost of pipeline construction.

Appropriation of future water supplies from the Guadalupe River is a relatively firm option. Based on daily flows, a 16,000 ac-ft/yr firm supply is available at least 86% of the time. This option will, however, require maintenance of Victoria's existing well capacity to supplement surface water supplies during periods of severe or prolonged drought.

Engineering Feasibility

Appropriation of Guadalupe River flows and purchase of water from GBRA will only require construction of a diversion and pumping facilities at Victoria. Certainly construction of a diversion facility from the Guadalupe River poses fewer engineering challenges than construction of a pipeline from Lake Texana to Victoria. Neither option, however, presents significantly complicated engineering challenges.

Flexibility

Appropriation of Guadalupe River unappropriated supplies is the most flexible of the proposed supply options. Diversion facilities will be sized and constructed to handle year 2040 demands and a surface water treatment plant can be constructed to process any blend of surface and groundwater. Purchase of water from either the GBRA or the LNRA is likely to be under a take-or-pay contract which will necessitate maximum utilization of that source from the beginning which may place a financial burden on the rate payers of Victoria. A pipeline from Lake Texana to Victoria would be sized to accommodate the maximum year 2040 supply which would further increase the cost of that option.

Environmental

Construction of diversion and pumping facilities from the Guadalupe River will not present any measurable negative or positive environmental impacts. Construction, operation and maintenance of a pipeline from Lake Texana to Victoria is likely to present initial and periodic negative impacts associated with construction and maintenance of the system.

6.14.2 Institutional/Legal Considerations

Legal Considerations

There do not appear to be any fatal legal constraints to any of the most desirable or feasible Victoria supply options. Construction of a pipeline from Lake Texana to Victoria will require acquisition of right-of-ways which may lead to condemnations against unwilling participants. Construction of in-stream or off-channel impoundments will require a permanent taking of property which can result in litigation and project delays.

Institutional Considerations

Each of the proposed supply options has an attendant set of institutional considerations which range from permitting to supply purchase contracts to conjunctive use agreements. Again, none of these issues, at the planning level, will preclude any of the proposed options. However, they can be an impediment to actual project implementation.

Public Acceptance

Future public acceptance of a particular supply option is difficult to gage. However non of the proposed options is likely to stir a particular set of public opinions.

6.14.3 Best Short-Term Options

The completed Victoria water supply options evaluation matrix is shown in Table 6-17. The highest scoring short-term option appears to be nearly a tie between the "no action alternative" which assumes continued reliance on groundwater sources and the appropriation of surface water without impoundment form the Guadalupe River. Both of these options requires the maintenance of a portion of Victoria's well capacity, treatment and distribution systems. As a second option, there is water available for purchase from the GBRA a reasonable price. The only major problem with this option is cost associated with the requirement to immediately develop the entire supply. Purchase of water from Lake Texana is the third most attractive option. However, it scored considerably lower than the other two options because of pipeline costs and environmental considerations.

6.14.4 Best Long-Term Options

The highest scoring long term option is appropriation of surface water from the Guadalupe River without impoundment with continued reliance on existing groundwater sources as a drought contingency back up source. This option is both reliable and cost effective. The next highest scoring long term option is to purchase surface water from the GBRA either on a take or pay contract or as a wholesale treated water customer.

Table 6-17
City of Victoria Water Supply Options Evaluation Matrix
(Part 1)

Source Option	Engineering a/ Firm Supply Short-term	Firm Supply Long-term	Engineering Feasibility Short-term	Engineering Feasibility Long-term	Flexibility Short-term	Flexibility Long-term	Environmental Short-term	Environmental Long-term	Total Engineering Short-term	Total Engineering Long-term
1. Limited/No Action										
a. Remain on Groundwater Supplies	10	8	10	8	5	0	4	4	29	20
b. Limited Surface Water Use	8	6	10	6	5	3	3	3	26	18
2. Purchase from Others										
a. Guad.-Blanco River Authority	10	10	10	10	5	5	3	3	28	28
b. Lavaca-Navidad River Authority	10	10	5	8	2	2	0	0	17	20
c. San Antonio River Authority	4	0	6	8	5	0	3	3	18	11
d. Local Irrigation Permits	2	0	4	4	0	-5	4	4	10	3
3. Wells										
a. Local Shallow Wells	0	-10	6	6	-5	-5	-4	-4	-3	-13
b. Gulf Coast Aquifer	5	5	10	8	5	0	0	-2	20	11
c. Carrizo-Wilcox Formation	5	5	4	4	0	0	0	-2	9	7
4. Conjunctive Use/Subordination of Coletto Creek Reservoir	5	0	3	0	0	-5	2	2	10	-3
5. Appropriate S.W. w/o Impoundment										
a. Guadalupe River - Local	10	8	10	10	5	5	4	4	29	27
b. Guadalupe River - Other	0	0	6	6	0	5	2	2	8	13
c. San Antonio River	5	0	4	0	-5	0	2	2	6	2
6. Appropriate S.W. w/ Impoundment										
a. Guadalupe River - Instream	10	10	-10	-10	2	5	-4	-4	-2	1
b. Guadalupe River - Off-channel	10	10	0	5	5	5	2	2	17	22
c. San Antonio River - Instream	8	6	-10	-10	-5	-5	-4	-4	-11	-13
d. San Antonio River - Off Channel	8	6	-5	0	0	0	2	2	5	8
7. Other State and Federal Projects										
a. Cuero Reservoir	-10	0	-10	10	5	5	0	0	-15	15
b. Lindenau Reservoir	-10	0	-10	10	5	5	0	0	-15	15
c. Goliad Reservoir	-10	0	-10	0	2	2	0	0	-18	2
d. Cibolo Reservoir	-10	0	-10	0	2	2	0	0	-18	2
8. Trans. of Coastal Basin Demands	0	-5	0	5	-5	-5	4	4	-1	-1
9. Improve Coast Canal Sys. Efficiency	-5	-10	0	0	-5	-5	4	4	-6	-11
10. Recharge Local Groundwater Form.										
a. Guadalupe River Source	0	-5	-5	0	-5	-5	2	0	-8	-10
b. San Antonio River Source	0	-5	-5	0	-5	-5	2	0	-8	-10
11. Wastewater Reuse	2	2	5	5	5	3	4	4	16	14

a/

Supply Evaluation Weighting	Issues	Range	
Engineering Feasibility	Are there significant engineering challanges to this option?	-10	10
Firm Supply	Will this option carry CRWA through drought conditions? With/without augmentation?	-10	10
Flexibility	How well does this option fit in with implementation of other options?	-5	5
Environmental	Habitat Preservation/Creation and other possible environmental impacts.	-4	4

Table 6-17 (Continued)
City of Victoria Water Supply Options Evaluation Matrix
(Part 2)

	Institutional/Legal b/									
	Legal Considerations		Institutional Considerations		Public Acceptance		Total Intitutional		TOTAL	
Source Option	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
1. Limited/No Action										
a. Remain on Groundwater Supplies	0	0	6	2	3	3	9	5	38	25
b. Limited Surface Water Use	0	0	0	3	3	3	3	6	29	24
2. Purchase from Others										
a. Guad.-Blanco River Authority	-2	-2	2	2	2	2	2	2	30	30
b. Lavaca-Navidad River Authority	-2	-5	-2	-2	2	2	-2	-5	15	15
c. San Antonio River Authority	-2	-5	-2	-2	-2	-2	-6	-9	12	2
d. Local Irrigation Permits	-8	-10	-6	-6	-4	-4	-18	-20	-8	-17
3. Wells										
a. Local Shallow Wells	0	-5	0	0	2	2	2	-3	-1	-16
b. Gulf Coast Aquifer	0	-5	0	0	2	2	2	-3	22	8
c. Carrizo-Wilcox Formation	-5	-5	0	0	0	0	-5	-5	4	2
4. Conjunctive Use/Subbordination of Coletto Creek Reservoir	-10	-10	0	0	0	0	-10	-10	0	-13
5. Appropriate S.W. w/o Impoundment										
a. Guadalupe River - Local	-2	-2	6	4	4	4	8	6	37	33
b. Guadalupe River - Other	-3	-3	4	3	4	4	5	4	13	17
c. San Antonio River	-5	-5	2	2	2	2	-1	-1	5	1
6. Appropriate S.W. w/ Impoundment										
a. Guadalupe River - Instream	-10	-10	-6	-4	-2	-2	-18	-16	-20	-15
b. Guadalupe River - Off-channel	-5	-5	-3	0	0	0	-8	-5	9	17
c. San Antonio River - Instream	-10	-10	-6	-4	-2	-2	-18	-16	-29	-29
d. San Antonio River - Off Channel	-5	-5	-3	-3	-2	-2	-10	-10	-5	-2
7. Other State and Federal Projects										
a. Cuero Reservoir	-5	0	0	2	0	0	-5	2	-20	17
b. Lindenau Reservoir	-5	0	0	2	0	0	-5	2	-20	17
c. Goliad Reservoir	-5	0	0	2	0	0	-5	2	-23	4
d. Cibolo Reservoir	-5	0	0	2	0	0	-5	2	-23	4
8. Trans. of Coastal Basin Demands	-10	-10	-6	-6	-4	-4	-20	-20	-21	-21
9. Improve Coast Canal Sys. Efficiency	-10	-10	-6	-6	-4	-4	-20	-20	-26	-31
10. Recharge Local Groundwater Form.										
a. Guadalupe River Source	-10	-10	-6	-6	-4	-4	-20	-20	-28	-30
b. San Antonio River Source	-10	-10	-6	-6	-4	-4	-20	-20	-28	-30
11. Wastewater Reuse	-2	-2	2	2	4	4	4	4	20	18

b/

Supply Evaluation Weighting	Issues	Range	
Legal Restrictions	Are there any legal obstacles, impediments or restrictions to implementation of this option?	-10	0
Institutional Considerations	What institutional arrangements can/must be made to facilitate/allow development of this option?	-6	6
Public Acceptance	Will the CRWA members accept this option? Will other regional and state entities accept this option?	-4	4

7.0 WATER SUPPLY SCENARIO FACILITIES PLAN

Section 5.0 of this report demonstrated that the existing groundwater source can meet the future demands of the study area, but not without water quality degradation or land surface subsidence. Section 6.0 examined water development scenarios, including groundwater and surface water scenarios, and it was determined that the best short-term alternatives were continued use of groundwater, appropriation of surface water from the Guadalupe River and buying surface water from either GBRA or LNRA. The best long-term alternative was use of appropriated water from the Guadalupe River with continued reliance on existing groundwater sources as a drought contingency back-up and buying surface water from GBRA. The groundwater sources must be maintained as a back-up source with the appropriation scenario because the surface water supply analysis in Section 6.0 shows that surface water is available only 86 percent of the time. Thus, groundwater supplies need to be maintained to supplement this surface water source.

In this section a layout of facilities will be developed for each of the above options, as well as a preliminary cost estimate for those facilities. Additionally, present worths of each alternative are developed. Present worth is an economic analysis concept that allows the comparison of a number of alternatives with different capital and annual costs occurring at different times. The present worth takes into account the time value of money. In this study, the present worths are computed using a seven percent interest rate during the 50-year study period. In clearer terms, the present worth is the amount of capital required to be invested initially to pay for all the capital and operating costs of an option during the study period. Strict economic analysis also requires that all costs, present and future, be used in current dollars.

7.1 GROUNDWATER SUPPLIES

As shown in Section 5.0, the Gulf Coast Aquifer can meet the water quantity needs of the municipalities in the region and also meet the growing water quantity needs of manufacturing in the region (Case B). If all these water needs are met solely by groundwater, the water levels in the Gulf Coast Aquifer in Victoria County are predicted to fall by 170 feet during the period from 1990 to 2040. As a result of this decline in water levels, it was predicted in Section 5.0 that Victoria County would experience a maximum land surface subsidence of an additional 1.3 feet. This maximum land surface subsidence would occur at the point of maximum decline in water levels which is in the vicinity of the City of Victoria. This amount of land surface subsidence may cause problems with building foundations, underground utilities and surface water flooding patterns. If the problems related to land surface subsidence can be tolerated or overcome, then the use of groundwater to meet all the future needs is only constrained by water quality and economics.

Economics of groundwater use will be dependent upon the number of new wells that must be developed to meet the growing demand and the increased energy costs associated with pumping larger volumes from increasingly greater depths. The economics of groundwater use is also related to water quality. The groundwater in Victoria County has high concentrations of iron, manganese and barium. Continued use of these waters as a municipal drinking water source will require treatment of some kind. Presently the City of Victoria treats its drinking water by adding phosphates to sequester the iron and manganese. This treatment impacts the economics of using groundwater. In the future if iron and manganese concentrations continue to increase it will become necessary to use a more elaborate treatment scheme to remove the iron and manganese. Currently the City of Victoria is not treating for barium. The new Safe Drinking Water Act (SDWA) proposed Maximum Contaminant Level (MCL) for barium is 2.0 mg/L. When this new MCL goes into effect the water in the region will meet the requirements of the SDWA for barium. If, however, barium levels increase in the future, then treatment to remove the barium will be required.

The quality of the water for use by manufacturing facilities will depend on the type of manufacturing facilities and their use of the water in the manufacturing process. It is probable that many manufacturers will need to treat the area groundwater to remove the iron and manganese before using the water in their processes.

These water treatment options will affect the economics of groundwater use as much, if not more, than the development and pumping costs.

Since the water quality needs of individual manufacturers are variable and are unknown at this time, and the size and number of wells each manufacturer will develop is also unknown, the economics of continued use of groundwater will be developed for the City of Victoria. The City of Victoria is one of the major water users in the county and the economics of groundwater use for the City of Victoria will be indicative of the groundwater economics of other large users. Also, if a regional system is developed in Victoria County it is probable that the City of Victoria will be the water supplier to the regional customers.

7.1.1 Groundwater Without Treatment

Facilities Plan

For the City of Victoria, other municipalities in Victoria County, and existing and future manufacturing facilities to use groundwater from the Evangeline or Chicot Aquifer without treatment the facilities required for development of this source are the same as the facilities currently used in the county to develop the existing groundwater resources. Therefore, to develop additional supplies the following facilities will be required:

- Groundwater well with pump;
- Transmission line from well to ground storage reservoir;
- High service pumping; and
- Chlorination and other minor treatment as required.

The exact location of these facilities to meet future needs will depend on the location of the demand and detailed hydrologic studies at the time the well is drilled.

Preliminary Cost Estimate

Water development costs will include development of new wells to meet the growing water needs of the region and new wells to replace existing wells that have reached the end of their useful life. Based upon discussions with City of Victoria, Department of Water/Wastewater staff members the useful life of a well is assumed to be 30 years. Based upon bids received by the City of Victoria in 1990 for a new well, the cost to develop a new well is assumed to be $440,000, and the cost of water transmission piping from the well to the storage facilities is assumed to be $210,000. Finally, based upon the yield of individual wells in the City of Victoria, it is assumed that each well will have a yield of 2 MGD. Table 7-1 presents a list of the City of Victoria's existing wells, the year they were constructed, and the capacity of each well.

Other than wells, there are no capital costs associated with the groundwater without treatment option. The present worth of this option, as well as each of the other options considered, was computed using a spreadsheet and estimating capital and operation and maintenance cost for the option at five-year intervals. The spreadsheets are detailed and extensive, but graphically portray the economics of each alternative. Table 7-2 is the spreadsheet prepared for the groundwater without treatment option.

TABLE 7-1

EXISTING WATER WELL DATA

Well Number	Completion Date	Installed Capacity (gpm)
12	1946	1,089
14	1953	1,560
15	1953	1,670
16	1958	1,557
17	1964	1,543
18	1968	1,529
19	1970	1,520
20	1970	1,529
21	1974	2,124
22	1975	1,767
23	1977	1,830
24	1981	1,900
25	1984	1,900
26	1987	1,700
27	1989	1,700

TABLE 7-2

CITY OF VICTORIA AND VICTORIA COUNTY
REGIONAL WATER SUPPLY STUDY
GROUNDWATER ONLY SCENARIO

	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
NUMBER OF CONNECTIONS	17903	19040	20158	20909	21661	22624	23588	24821	26035	26999	27963
AVERAGE DAY DEMAND, MGD	9.29	9.88	10.46	10.85	11.24	11.74	12.24	12.88	13.51	14.01	14.51
WELL CAPACITY REQUIRED, MGD	15.5	16.5	17.4	18.1	18.7	19.5	20.4	21.4	22.5	23.3	24.2
NUMBER OF EXISTING WELLS	11	10	7	7	9	8	8	11	9	9	11
NUMBER OF WELLS REQUIRED	8	9	9	10	10	10	11	11	12	12	13
NUMBER OF WELLS TO BE DEVELOPED	0	0	2	3	1	2	3	0	3	3	2
ESTIMATED WELL LEVEL	-70	-75	-90	-105	-120	-135	-150	-165	-175	-190	-210
PUMPING HEAD	170	175	190	205	220	235	250	265	275	290	310
ANNUAL ELECTRICITY CONSUMPTION (KW-HR)	2267640	2482587	2853611	3193692	3550573	3961370	4393705	4900848	5334547	5833721	6458603
ANNUAL ELECTRIC COST	$158,735	$173,781	$199,753	$223,558	$248,540	$277,296	$307,559	$343,059	$373,418	$408,360	$452,102
ANNUAL CHLORINE DIOXIDE CONSUMPTION	82577	87821	92977	96443	99910	104354	108799	114487	120087	124532	128976
ANNUAL CHLORINE DIOXIDE COST	$99,918	$106,263	$112,502	$116,696	$120,891	$126,269	$131,646	$138,530	$145,306	$150,683	$156,061
ANNUAL PHOSPHATE CONSUMPTION	28280	33475	38978	42899	46997	52511	58317	66173	74373	81211	88340
ANNUAL PHOSPHATE COST	$51,752	$61,259	$71,330	$78,505	$86,005	$96,095	$106,719	$121,096	$136,103	$148,615	$161,662
ANNUAL CHLORINE CONSUMPTION	155538	165416	175127	181657	188186	196558	204929	215644	226192	234563	242934
ANNUAL CHLORINE COST	$46,661	$49,625	$52,538	$54,497	$56,456	$58,967	$61,479	$64,693	$67,858	$70,369	$72,880
CAPITAL COST FOR NEW WELLS REQUIRED	$0	$0	$1,300,000	$1,950,000	$650,000	$1,300,000	$1,950,000	$0	$1,950,000	$1,950,000	$1,300,000
ANNUAL COST FOR WELLS BUILT IN 1995		$0	$0	$0	$0						
ANNUAL COST FOR WELLS BUILT IN 2000			$122,707	$122,707	$122,707	$122,707					
ANNUAL COST FOR WELLS BUILT IN 2005				$184,061	$184,061	$184,061	$184,061				
ANNUAL COST FOR WELLS BUILT IN 2010					$61,354	$61,354	$61,354	$61,354			
ANNUAL COST FOR WELLS BUILT IN 2015						$122,707	$122,707	$122,707	$122,707		
ANNUAL COST FOR WELLS BUILT IN 2020							$184,061	$184,061	$184,061	$184,061	
ANNUAL COST FOR WELLS BUILT IN 2025								$0	$0	$0	$0
ANNUAL COST FOR WELLS BUILT IN 2030									$184,061	$184,061	$184,061
ANNUAL COST FOR WELLS BUILT IN 2035										$184,061	$184,061
ANNUAL COST FOR WELLS BUILT IN 2040											$122,707
TOTAL ANNUAL OPERATING AND CAPITAL COST	$357,066	$390,929	$558,830	$780,025	$880,013	$1,049,455	$1,159,585	$1,035,500	$1,213,512	$1,330,210	$1,333,533
WATER PRODUCTION COST ($/1000 GALLON)	$0.11	$0.11	$0.15	$0.20	$0.21	$0.24	$0.26	$0.22	$0.25	$0.26	$0.25
PRESENT WORTH OF THIS OPTION	$8,314,962										

Below is a short description of each item included in the economic analysis shown on Table 7-2.

- Number of Connections. The 1990 value was taken from the 1990 Sanitary Survey contained in Appendix A. The values were increased based upon population growth rates established in Section 3.0.

- Average Day Demand. The values were taken from the information presented in Section 3.0.

- Well Capacity Required. Based upon Texas Health Department requirement of 0.6 gallons per minute per connection.

- Number of Existing Wells. In 1990, this number is the number of wells in place that had a service life less than 30 years. In years beyond 1990, it was existing wells plus wells added that had service lines less than 30 years.

- Number of Wells Required. This was calculated as the Well Capacity Required divided by an average well yield of 2 MGD/well.

- Number of Wells to be Developed. This value is equal to the Number of Wells Required less Number of Existing Wells.

- Estimated Well Level. Water level elevations shown were taken from Case B in Section 5.0.

- Pumping Head. This was calculated using an estimated land surface elevation of 100 feet and the Estimated Well Level.

- Annual Electricity Consumption. Calculated value based upon the Average Day Demand and Pumping Head.

- Annual Electric Cost. Calculated based upon Annual Electricity Consumption and an electrical unit cost of $0.07/kw-hr.

- Annual Chlorine Dioxide Consumption. The City uses Chlorine Dioxide to help control hydrogen sulfide in the groundwater and oxidize any bacteria in the groundwater. The amount consumed is calculated using the Average Day Demand and a Chlorine Dioxide feed rate of approximately 3 mg/L. It is assumed that the Chlorine Dioxide feed rate will not change during the analysis.

- Annual Chlorine Dioxide Cost. This value is calculated based upon the Annual Chlorine Dioxide Consumption and a unit cost for Chlorine Dioxide of $1.21/pound.

- Annual Phosphate Consumption. The City uses phosphate (both sodium hexa-metaphosphate and polyphosphate) to sequester the iron and manganese. The amount consumed is calculated using the Average Day Demand and a phosphate feed rate of 1 mg/L. It is assumed that as the groundwater levels fall that the iron and manganese concentrations will rise, and hence, the phosphate feed rate will also increase. The feed rate is assumed to increase to 2 mg/L in year 2040.

- Annual Phosphate Cost. This value is calculated based upon Annual Phosphate Consumption and a unit cost for phosphates of $1.83/pound.

- Annual Chlorine Consumption. Chlorine is used as a final disinfectant. The Annual Consumption Value is calculated using the Average Day Demand and a chlorine feed rate of 5.5 mg/L.

- Annual Chlorine Cost. This value is calculated based upon Annual Chlorine Consumption and a unit cost for chlorine of $600/ton.

- Capital Cost for New Wells Required. As existing wells reach the end of their useful life, they must be replaced. Also, new wells are required to meet the growing demand. The number of new wells required was computed earlier in the spreadsheet. The Capital Cost for New Wells uses the number of wells required and a unit cost per well of $650,000.

- Annual Cost of New Wells. There are several rows showing the annual payment to finance the new wells required. It is assumed that the wells are financed with 20-year bonds with a seven percent interest rate.

- Total Annual Operating and Capital Cost. This value is the sum of the electrical, chlorine dioxide, phosphate, chlorine and new well annual costs.

- Water Production Cost. This value is the Total Annual Operating and Capital Cost divided by the Annual Demand (based on the Average Day Demand).

One major assumption included in the cost analysis presented in Table 7-2 is that sequestering the iron and manganese in the drinking water will be adequate and that the barium concentration does not exceed 2.0 mg/L. If the combination of iron and manganese exceed 1.0 mg/L it is our opinion that sequestering will no longer be effective. If the iron and manganese exceed 1.0 mg/L the City of Victoria should consider treating the water to remove, or reduce, the iron and manganese concentrations. Also if the barium concentration in the drinking water exceeds 2.0 mg/L, water treatment will be required to remove, or reduce, the barium concentrations.

Also shown in Table 7-2 is the present worth of this option. The present worth of continuing to use groundwater with only limited treatment is $8,314,962.

7.1.2 Groundwater With Treatment

Facilities Plan

The future concentrations of iron, manganese and barium in the county's groundwater is difficult to predict. In Section 5.0 it was asserted that the iron and manganese is originating in the formations that overlie the Evangeline Aquifer. Therefore, as the water levels in the Evangeline Aquifer are lowered the opportunity for water to migrate from the overlying formations into the Evangeline Aquifer is increased. If this occurs, then the iron and manganese concentrations in the City of Victoria's drinking water would be expected to increase. This is a qualitative assessment and it is not possible with the available water quality data to predict future concentrations. The same statements can also be made about the barium concentration.

If concentrations of iron and manganese, or barium rise to the point that treatment is required the following treatment methods are possible alternatives. For iron and manganese the following treatment schemes are possible:

1. Adding chlorine to precipitate the iron, adding potassium permanganate to oxidize the manganese and filtering the water through either a conventional sand filter or a pressure zeolite filter;
2. Lime softening; and
3. Reverse osmosis (RO) or electrodialysis reversal (EDR).

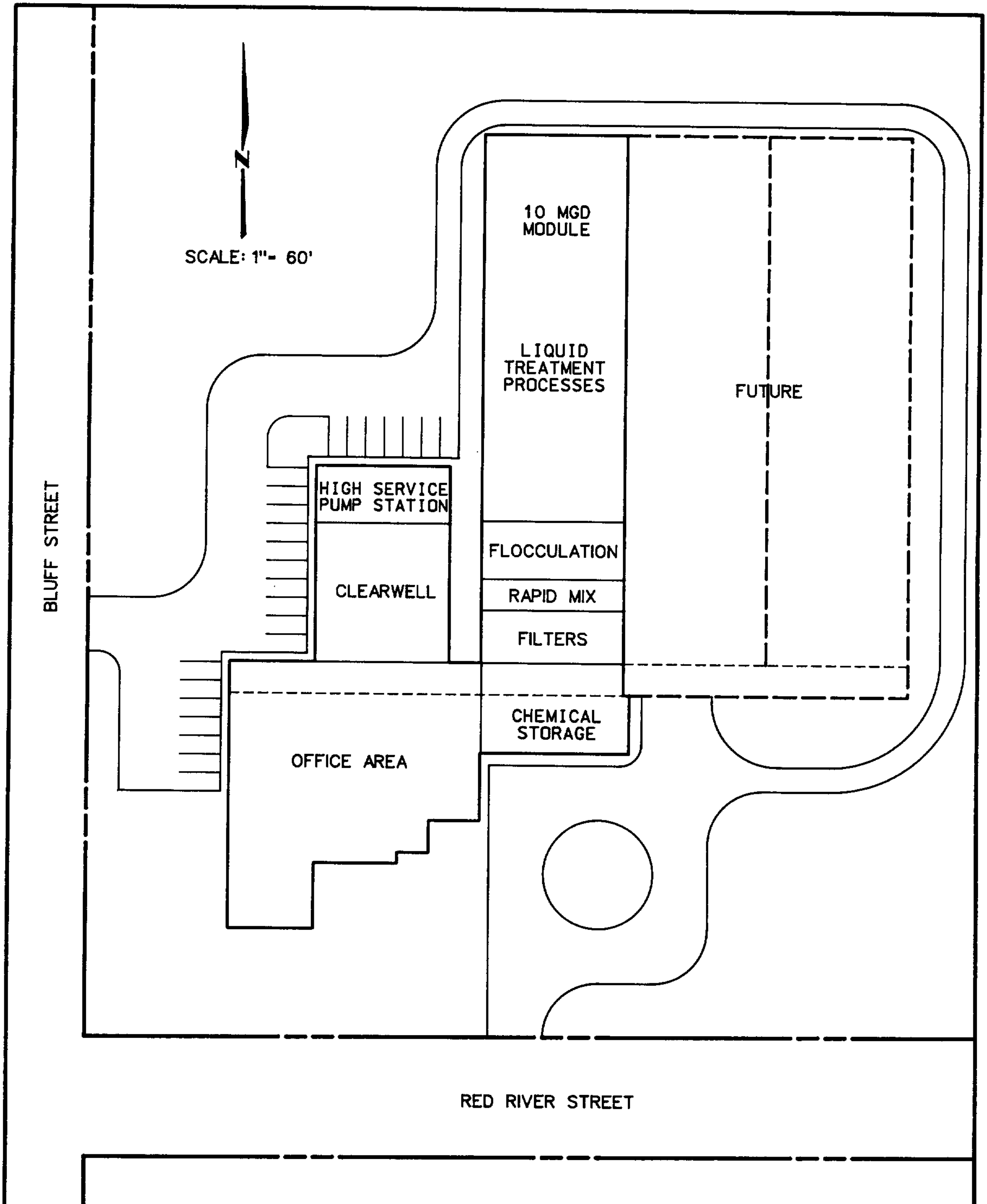
For removal of barium the following treatment schemes are possible:

1. Ion exchange;
2. Lime softening; and
3. Reverse osmosis or electrodialysis reversal.

Of these alternatives, lime softening stands out as a treatment alternative that will remove iron, manganese and barium and can be considered a conventional treatment alternative.

Conventional treatment alternatives will not treat for chloride concentrations if they increase to levels above the secondary drinking water standards. If chloride concentrations become a problem, either reverse osmosis or electrodialysis reversal will be required. Alternatively, rather than treating the groundwater for chlorides, the water could be blended with a surface water to produce a finished water of acceptable quality.

To implement a groundwater treatment plan for the City of Victoria, the water from the existing and all future wells would have to be pumped to the groundwater treatment plant. After treatment, the treated water would be conveyed in new transmission pipelines to the City's four existing pumping plants for distribution. It is assumed that the groundwater treatment plant would be built on city owned property at the corner of Vine Street and Red River Street. A preliminary layout of the plant is shown on Figure 7-1. The layout shown on Figure 7-1 is for a 10 MGD plant expandable in 10 MGD increments to 30 MGD. A preliminary layout of the treated water transmission lines from the water



CITY OF VICTORIA, TEXAS

CONCEPTUAL PLAN—UPPER LEVEL
VICTORIA WATER TREATMENT PLANT

CDM
environmental engineers, scientists, planners, & management consultants

FIGURE NO. 7-1

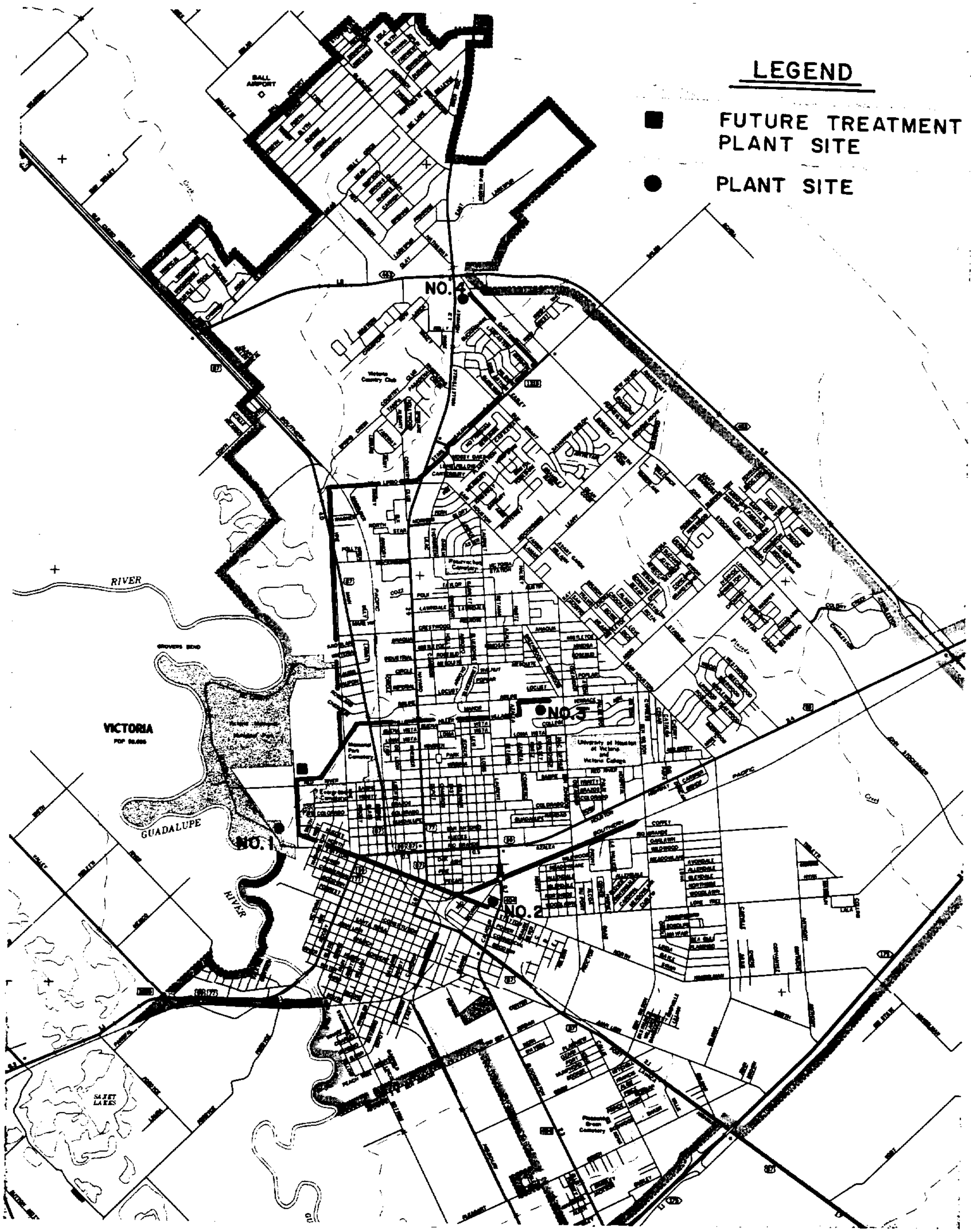
treatment plant to the water pumping plants is shown on Figure 7-2. This report does not address the distribution system improvements that are required to distribute the water from the pumping plants, but this has been studied (Freese & Nichols, 1990). In addition to new pipelines to transfer treated water from the water treatment plant to the water pumping stations, there would need to be a network of collection pipes to collect the water from the existing wells, and any new wells, and convey it to the treatment plant. A preliminary groundwater collection system for the existing wells is shown in Figure 7-3.

Preliminary Cost Estimate

Of course, if the quality of the groundwater deteriorates to the point that a treatment plant to treat all the groundwater is necessary, then the economics of groundwater usage would change considerably. The preliminary construction cost estimate of the groundwater treatment plant is presented in Table 7-3. The preliminary construction cost estimate of the transmission mains from the groundwater treatment plant to the four pumping plants and for the collection lines from the wells to the water treatment plant are listed in Table 7-4.

Table 7-5 is a spreadsheet similar to Table 7-2, and is used to prepare a present worth analysis of this option. Below is a short description of each item included in the economic analysis shown on Table 7-5.

- Number of Connections. The 1990 value was taken from the 1990 Sanitary Survey contained in Appendix A. The values were increased based upon population growth rates established in Section 3.0.
- Average Day Demand. The values were taken from the information presented in Section 3.0.

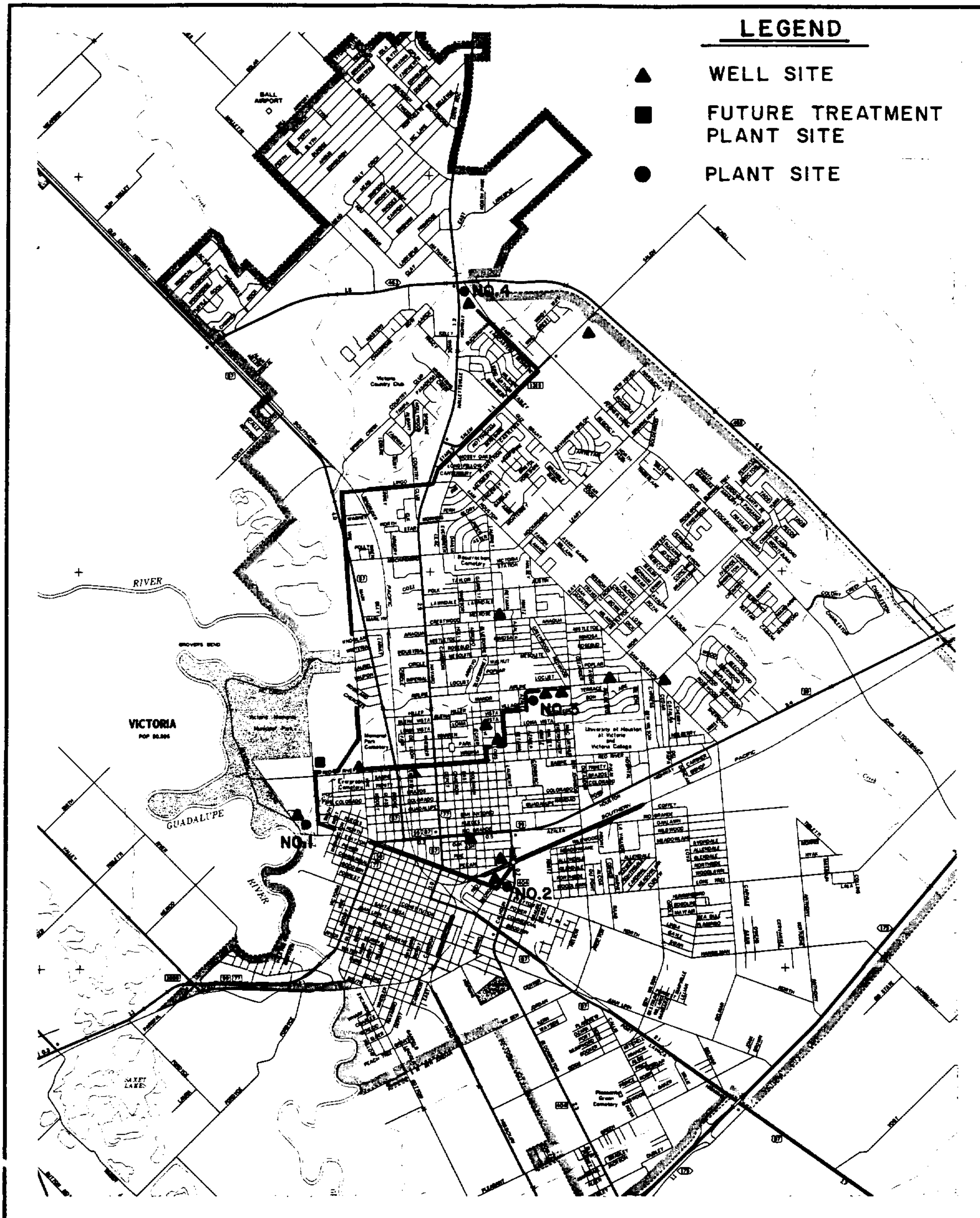


CITY OF VICTORIA, TEXAS

PROPOSED TREATED WATER TRANSMISSION MAINS

CDM
environmental engineers, scientists, planners, & management consultants

FIGURE NO. 7-2



CITY OF VICTORIA, TEXAS

PROPOSED GROUNDWATER COLLECTION SYSTEM

CDM
environmental engineers, scientists, planners, & management consultants

FIGURE NO. 7-3

TABLE 7-3

PRELIMINARY CONSTRUCTION COST ESTIMATE FOR
A 10 MGD AND A 20 MGD WATER TREATMENT PLANT

Item	10 MGD Estimated Cost	20 MGD Estimated Cost
RAW WATER METER VAULT		
A. Structure	$ 17,000	$ 17,000
B. Equipment	30,000	30,000
C. Piping	2,000	2,000
D. Miscellaneous	6,000	6,000
Subtotal	$ 55,000	$ 55,000
RAPID MIX BASINS		
A. Structure	$ 88,000	$ 170,000
B. Equipment	25,000	49,000
C. Miscellaneous	11,000	22,000
Subtotal	$ 124,000	$ 241,000
FLOCCULATION BASINS		
A. Structure	$ 233,000	$ 456,000
B. Equipment	240,000	466,000
C. Miscellaneous	46,000	93,000
Subtotal	$ 519,000	$ 1,015,000
SEDIMENTATION BASINS		
A. Structure	$ 660,000	$ 1,208,000
B. Equipment	327,000	654,000
C. Miscellaneous	100,000	187,000
Subtotal	$ 1,087,000	$ 2,049,000
FILTERS		
A. Structure	$ 340,000	$ 532,000
B. Equipment	282,000	563,000
C. Media	77,000	154,000
D. Miscellaneous	72,000	121,000
Subtotal	$ 771,000	$ 1,370,000

TABLE 7-3

PRELIMINARY CONSTRUCTION COST ESTIMATE FOR
A 10 MGD AND A 20 MGD WATER TREATMENT PLANT
(Continued)

Item	10 MGD Estimated Cost	20 MGD Estimated Cost
CHEMICAL FEED FACILITIES		
A. Structure	$ 700,000	$ 1,200,000
B. Equipment	408,000	700,000
C. Piping	55,000	100,000
D. Miscellaneous	110,000	200,000
Subtotal	$ 1,273,000	$ 2,200,000
ADMINISTRATION/MAINTENANCE BUILDING		
A. Structure	$ 550,000	$ 660,000
B. Equipment	83,000	110,000
C. Miscellaneous	66,000	77,000
Subtotal	$ 699,000	$ 847,000
WASHWATER RECOVERY TANK		
A. Structure	$ 87,000	$ 150,000
B. Equipment	28,000	50,000
C. Miscellaneous	11,000	20,000
Subtotal	$ 126,000	$ 220,000
CLEARWELL	$ 350,000	$ 700,000
HIGH SERVICE PUMP STATION	$ 500,000	$ 800,000
YARD PIPING		
A. Piping	$ 330,000	$ 440,000
B. Valves	330,000	550,000
C. Miscellaneous	66,000	100,000
Subtotal	$ 726,000	$ 1,090,000

TABLE 7-3

PRELIMINARY CONSTRUCTION COST ESTIMATE FOR
A 10 MGD AND A 20 MGD WATER TREATMENT PLANT
(Continued)

Item	10 MGD Estimated Cost	20 MGD Estimated Cost
SITE WORK		
A. Grading	$ 66,000	$ 66,000
B. Landscaping	22,000	22,000
C. Pavement	88,000	88,000
D. Curb and Gutter	33,000	33,000
E. Miscellaneous	27,000	27,000
Subtotal	$ 236,000	$ 236,000
SLUDGE HANDLING	$ 470,000	$ 900,000
ELECTRICAL		
A. General Electric	$ 835,000	$ 1,410,000
B. Instrumentation	694,000	1,180,000
Subtotal	$ 1,529,000	$ 2,590,000
MISCELLANEOUS	$ 1,270,000	$ 2,150,000
TOTAL	$ 9,735,000	$ 16,463,000

TABLE 7-4

PRELIMINARY CONSTRUCTION COST ESTIMATE FOR
A GROUNDWATER COLLECTION SYSTEM AND
TREATED WATER TRANSMISSION MAINS

Line Designation	Diameter (in)	Length (ft)	Unit Cost ($/ft)	Total Cost
COLLECTION SYSTEM				
Line from Plant 1 Wells	24	2,000	75	$ 150,000
Line from Plant 2 Wells to Plant 1 Line	20	7,500	65	487,500
Line from Plant 3 Wells and Plant 4 Wells	36	900	115	103,500
Line from Plant 3 Wells to Plant 3 and Plant 4 Line	36	2,900	115	333,500
	30	4,200	95	399,000
	24	3,600	75	270,000
Line from Plant 4 Wells to Plant 3 and Plant 4 Line	14	23,300	45	1,048,500
Subtotal				$ 2,792,000
TRANSMISSION LINES				
Line to Plant 3 and Plant 4	42	2,300	135	$ 310,500
Line to Plant 3	36	8,200	115	943,000
Line to Plant 4	24	21,800	75	1,635,000
Line to Plant 1 and Plant 2	18	1,900	58	110,200
Line to Plant 1	12	500	40	20,000
Line to Plant 2	12	7,700	40	308,000
Subtotal				$ 3,326,700
TOTAL				$ 6,118,700

TABLE 7-5

CITY OF VICTORIA AND VICTORIA COUNTY
REGIONAL WATER SUPPLY STUDY
GROUNDWATER ONLY WITH ADDITIONAL TREATMENT SCENARIO

	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
NUMBER OF CONNECTIONS	17903	19040	20158	20909	21661	22624	23588	24821	26035	26999	27963
AVERAGE DAY DEMAND, MGD	9.29	9.88	10.46	10.85	11.24	11.74	12.24	12.88	13.51	14.01	14.51
WELL CAPACITY REQUIRED, MGD	15.5	16.5	17.4	18.1	18.7	19.5	20.4	21.4	22.5	23.3	24.2
NUMBER OF EXISTING WELLS	11	10	7	7	9	8	8	11	9	9	11
NUMBER OF WELLS REQUIRED	8	9	9	10	10	10	11	11	12	12	13
NUMBER OF WELLS TO BE DEVELOPED	0	0	2	3	1	2	3	0	3	3	2
ESTIMATED WELL LEVEL	-70	-75	-90	-105	-120	-135	-150	-165	-175	-190	-210
PUMPING HEAD	170	175	190	205	220	235	250	265	275	290	310
ANNUAL ELECTRICITY CONSUMPTION (KW-HR)	2267640	2482587	2853611	3193692	3550573	3961370	4393705	4900848	5334547	5833721	6458603
ANNUAL ELECTRIC COST	$158,735	$173,781	$199,753	$223,558	$248,540	$277,296	$307,559	$343,059	$373,418	$408,360	$452,102
ANNUAL CHLORINE DIOXIDE CONSUMPTION	82577	87821	0	0	0	0	0	0	0	0	0
ANNUAL CHLORINE DIOXIDE COST	$99,918	$106,263	$0	$0	$0	$0	$0	$0	$0	$0	$0
ANNUAL PHOSPHATE CONSUMPTION	28280	33475	31841	33028	34216	35738	37260	39208	41126	42648	44170
ANNUAL PHOSPHATE COST	$51,752	$61,259	$58,270	$60,442	$62,615	$65,400	$68,185	$71,751	$75,260	$78,046	$80,831
ANNUAL CHLORINE CONSUMPTION	155538	165416	63683	66057	68431	71475	74520	78416	82252	85296	88340
ANNUAL CHLORINE COST	$46,661	$49,625	$19,105	$19,817	$20,529	$21,443	$22,356	$23,525	$24,675	$25,589	$26,502
TREATMENT PLANT CAPACITY REQUIRED			20				10				
TREATMENT PLANT CAPITAL COST			$22,581,700				$8,240,000				
TREATMENT PLANT ANNUAL COST			$2,131,487	$2,131,487	$2,131,487	$2,131,487	$777,774	$777,774	$777,774	$777,774	
ANNUAL LIME CONSUMPTION			2865716	2972564	3079412	3216396	3353381	3528721	3701321	3838306	3975290
ANNUAL LIME COST			$107,464	$111,471	$115,478	$120,615	$125,752	$132,327	$138,800	$143,936	$149,073
ANNUAL FERROUS SULFATE CONSUMPTION			191048	198171	205294	214426	223559	235248	246755	255887	265019
ANNUAL FERROUS SULFATE COST			$114,629	$118,903	$123,176	$128,656	$134,135	$141,149	$148,053	$153,532	$159,012
ANNUAL ELEC. CONSUMPTION IN TREATMENT			201585	209101	216617	226253	235889	248223	260365	270001	279637
ANNUAL ELEC. COST IN TREATMENT			$14,111	$14,637	$15,163	$15,838	$16,512	$17,376	$18,226	$18,900	$19,575
CAPITAL COST FOR NEW WELLS REQUIRED	$0	$0	$1,300,000	$1,950,000	$650,000	$1,300,000	$1,950,000	$0	$1,950,000	$1,950,000	$1,300,000
ANNUAL COST FOR WELLS BUILT IN 1995		$0	$0	$0	$0						
ANNUAL COST FOR WELLS BUILT IN 2000			$122,707	$122,707	$122,707	$122,707					
ANNUAL COST FOR WELLS BUILT IN 2005				$184,061	$184,061	$184,061	$184,061				
ANNUAL COST FOR WELLS BUILT IN 2010					$61,354	$61,354	$61,354	$61,354			
ANNUAL COST FOR WELLS BUILT IN 2015						$122,707	$122,707	$122,707	$122,707		
ANNUAL COST FOR WELLS BUILT IN 2020							$184,061	$184,061	$184,061	$184,061	
ANNUAL COST FOR WELLS BUILT IN 2025								$0	$0	$0	$0
ANNUAL COST FOR WELLS BUILT IN 2030									$184,061	$184,061	$184,061
ANNUAL COST FOR WELLS BUILT IN 2035										$184,061	$184,061
ANNUAL COST FOR WELLS BUILT IN 2040											$122,707
TOTAL ANNUAL OPERATING AND CAPITAL COST	$357,066	$390,929	$2,767,525	$2,987,083	$3,085,110	$3,251,562	$2,004,455	$1,875,081	$2,047,033	$2,158,319	$1,377,923
WATER PRODUCTION COST ($/1000 GALLON)	$0.11	$0.11	$0.72	$0.75	$0.75	$0.76	$0.45	$0.40	$0.42	$0.42	$0.26
PRESENT WORTH OF THIS OPTION	$21,365,637										

- Well Capacity Required. Based upon Texas Health Department requirement of 0.6 gallons per minute per connection.

- Number of Existing Wells. In 1990, this number is the number of wells in place that had a service life less than 30 years. In years beyond 1990, it was existing wells plus wells added that had service lines less than 30 years.

- Number of Wells Required. This was calculated as the Well Capacity Required divided by an average well yield of 2 MGD/well.

- Number of Wells to be Developed. This value is equal to the Number of Wells Required less Number of Existing Wells.

- Estimated Well Level. Water level elevations shown were taken from Case B in Section 5.0.

- Pumping Head. This was calculated using an estimated land surface elevation of 100 feet and the Estimated Well Level.

- Annual Electricity Consumption. Calculated value based upon the Average Day Demand and Pumping Head.

- Annual Electric Cost. Calculated based upon Annual Electricity Consumption and an electrical unit cost of $0.07/kw-hr.

- Annual Chlorine Dioxide Consumption. The City uses chlorine dioxide to help control hydrogen sulfide in the groundwater and oxidize any bacteria in the groundwater. The consumption in 1990 and 1995 is based upon the Average Day Demand and a feed rate of approximately 3 mg/L. It is assumed that groundwater treatment is initiated in the year 2000. After groundwater treatment is in place, it will not be necessary to feed chlorine dioxide.

- Annual Chlorine Dioxide Cost. In 1990 and 1995, the cost is based upon Annual Chlorine Dioxide Consumption and a unit price for chlorine dioxide of $1.21/pound. There is not an annual cost for chlorine dioxide in years 2000 through 2040.

- Annual Phosphate Consumption. The City uses phosphates to sequester the iron and manganese. After the treatment plant is constructed in year 2000, the phosphates will be added to stabilize the treated water. The amount consumed is based upon the Average Day Demand and a feed rate of 1 mg/L.

- Annual Phosphate Cost. This value is calculated based upon Annual Phosphate Consumption and a unit cost for phosphates of $1.83/pound.

- Annual Chlorine Consumption. Chlorine is added as a final disinfectant. The annual consumption in 1990 and 1995 is calculated using the Average Day Demand and a chlorine feed rate of 5.5 mg/L. In years 2000 through 2040, the chlorine feed rate is assumed to be 2 mg/L. The difference in chlorine feed rates is due to the removal of iron, manganese and hydrogen sulfide during the treatment process.

- Annual Chlorine Cost. This value is calculated based upon Annual Chlorine Consumption and a unit cost for chlorine of $600/ton.

- Treatment Plant Capacity Required. This value is the amount of groundwater treatment plant capacity required to treat groundwater to meet the existing demand plus have an ability to treat demands into the future. The original plant would be 20 MGD and would be satisfactory until year 2020. The required capacity is based upon the Texas Health Department requirement of 0.6 gallons per minute per connection.

- Treatment Plant Capital Cost. This cost is the combination of the 20 MGD treatment plant cost shown in Table 7-3 and the distribution and collection system pipeline costs shown in Table 7-4. A 10 MGD expansion is estimated to be $8,240,000. This is less than the 10 MGD treatment plant cost shown in Table 7-3. It is less because, with plant additions, certain work such as administration buildings and site work does not need to be included.

- Treatment Plant Annual Cost. This is the annual payment required to finance the original treatment plant and the expansion in year 2020. It is assumed that financing is for 20 years at seven percent.

- Annual Lime Consumption. Lime would be added to raise the pH of the groundwater. As the pH is increased, the iron, manganese, barium and constituents contributing to hardness would be precipitated from the water. The amount of lime consumed is based upon the Average Day Demand and a lime feed rate of 90 mg/L.

- Annual Lime Cost. This value is computed using the Annual Lime Consumption and a unit cost for lime of $75/ton.

- Annual Ferrous Sulfate Consumption. Ferrous sulfate would be added as a coagulant aid at the treatment plant. The amount of ferrous sulfate consumed is calculated using the Average Day Demand and a ferrous sulfate feed rate of 6 mg/L.

- Annual Ferrous Sulfate Cost. This value is computed using the Annual Ferrous Sulfate Consumption and a unit cost for ferrous sulfate of $0.60/pound.

- Annual Electrical Consumption in Treatment. This is the amount of electricity consumed in the water treatment plant.

- Annual Electric Cost in Treatment. This value is calculated using the Annual Electrical Consumption in Treatment and a unit cost for electricity of $0.07/kw-hr.

- Capital Cost for New Wells Required. As existing wells reach the end of their useful life, they must be replaced. Also, new wells are required to meet the growing demand. The number of new wells required was computed earlier in the spreadsheet. The Capital Cost for New Wells uses the number of wells required and a unit cost per well of $650,000.

- Annual Cost of New Wells. There are several rows showing the annual payment to finance the new wells required. It is assumed that the wells are financed with 20-year bonds with a seven percent interest rate.

- Total Annual Operating and Capital Cost. This value is the sum of costs for electricity, chlorine dioxide, phosphate, chlorine, lime, ferrous sulfate, and financing costs for the wells and treatment plant.

- Water Production Cost. This value is the Total Annual Operating and Capital Cost divided by the Annual Demand (based on the Average Day Demand).

As can be seen, the costs to build a groundwater treatment plant and operate the treatment plant significantly affects the economics of continuing to use groundwater. The present worth of the groundwater option that only included sequestering the iron and manganese and no treatment for the barium is $8,314,962, while the present worth of the groundwater option with lime softening to remove or reduce the concentrations of iron, manganese and barium is $21,365,637. Therefore, treating the groundwater will more than double the present worth of using groundwater. This change in cost is due to the water treatment plant that would be required to treat the groundwater, and the chemicals used in the water treatment process.

7.2 CONJUNCTIVE USE

The conjunctive use scenario assumes that the County's groundwater resources would continue to be utilized, but that it would be supplemented by developing surface water resources. In addition to supplementing the water supply, the quality of the combined groundwater/surface water resource would be better than groundwater alone because the surface water would be void of hydrogen sulfide, and would have low concentrations of chlorides, iron, manganese, and barium. Therefore, even though the groundwater quality may continue to deteriorate, the finished water quality of the combined waters would be improved.

To maintain the combined water quality at the SDWA requirements it is assumed that 50 percent of the water demand is met by groundwater and 50 percent by treated surface water. Based upon 1991 groundwater and Guadalupe River water quality data the combined water quality would be expected to have the following concentrations of the constituents listed below.

Constituent	Concentration
Iron	0.16 mg/L
Manganese	0.02 mg/L
Barium	0.63 mg/L
Chloride	74 mg/L

The above values which are based upon 1991 water quality data are well within the limits of the primary and secondary drinking water standards. With continued development of the groundwater resources which will result in lower groundwater levels, the concentrations of the above listed constituents are expected to increase in the groundwater. If this occurs, then the values listed above would increase at half the rate of the increase in the groundwater.

7.2.1 Facilities Plan

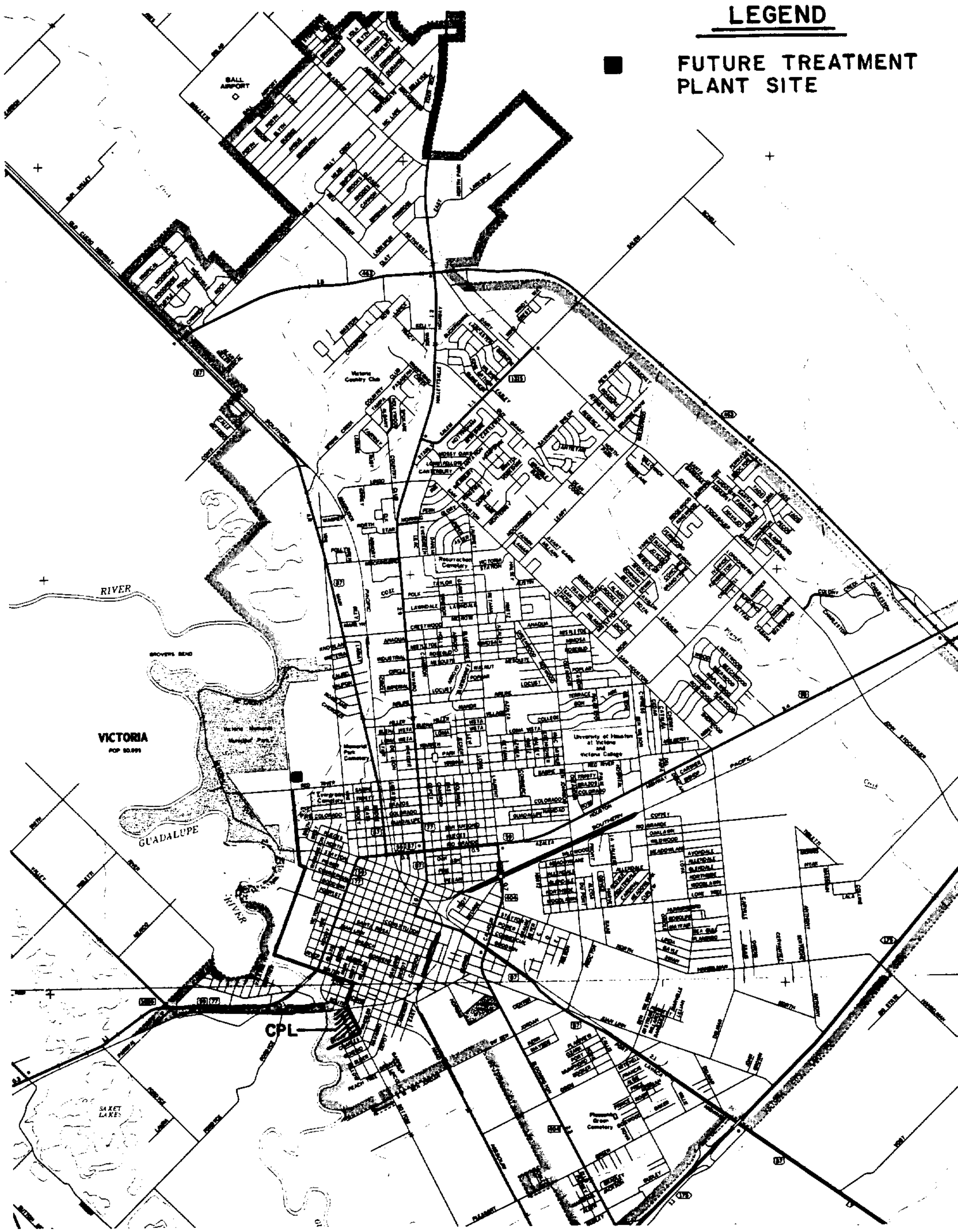
The conjunctive use option would include many of the facilities previously discussed under the groundwater options. At the point when either demand or water quality requires the addition of surface water, a water treatment plant, raw water pump station, raw water transmission line, and treated water transmission lines would be constructed. With the exception of the raw water transmission line, the layout of these facilities would be identical to those presented for the treated groundwater option. The raw water transmission line would be as shown on Figure 7-4. The size of the surface water facilities required for the conjunctive use option would be smaller than those required than if surface water were being used alone because only half of the demand is being met by surface water. The size of the facilities are discussed along with the preliminary cost estimates in Section 7.2.2.

In addition to the surface water facilities, new groundwater wells will be required to replace the wells retired due to age and to maintain the ability to meet half of the demand with groundwater. Water from the wells will continue to be pumped from the well into the pumping plants with only minor treatment.

It is assumed that water will be pumped from the surface water treatment plant to each of the City's four pumping plants for distribution. The quantity of surface water pumped to each pumping plant would be 50 percent of the water pumped into the distribution system from each pumping plant. The other 50 percent of the water pumped from each pumping plant would come from groundwater wells.

7.2.2 Preliminary Cost Estimate

The preliminary capital cost for the surface water treatment plant is basically the same as for the groundwater treatment plant shown in Table 7-3. In the groundwater with



CITY OF VICTORIA, TEXAS

PROPOSED RAW WATER TRANSMISSION MAIN

CDM
environmental engineers, scientists, planners, & management consultants

FIGURE NO. 7-4

treatment option, a 20 MGD plant is initially required, whereas with the conjunctive use option a 10 MGD plant is initially required. The preliminary cost estimate for the raw water pumping station, raw water transmission line and the treated water transmission lines are shown in Table 7-6. The total capital cost to add the surface water treatment plant, raw water pump station, raw water transmission main, and treated water transmission main is $15,379,700. The raw water pump station, raw water transmission main and treated water transmission mains are assumed to have a capacity sufficient to year 2040. The water treatment plant is initially built with a 10 MGD capacity and expanded in year 2030 by 10 MGD to a total of 20 MGD. Wells are added as required to maintain 50 percent of required capacity in the well field. It is assumed that the surface water is obtained by appropriation and, therefore, there is not an annual cost for the surface water.

The present worth of this option was computed using a spreadsheet and estimating operating and capital cost at five-year intervals. Below is a short description of each item included in the economic analysis shown on Table 7-7.

- Number of Connections. The 1990 value was taken from the 1990 Sanitary Survey contained in Appendix A. The values were increased based upon population growth rates established in Section 3.0.
- Average Day Demand. The values were taken from the information presented in Section 3.0.
- Well Capacity Required. Based upon Texas Health Department requirement of 0.6 gallons per minute per connection.
- Number of Existing Wells. In 1990, this number is the number of wells in place that had a service life less than 30 years. In years beyond 1990, it was existing wells plus wells added that had service lines less than 30 years.
- Number of Wells Required. This was calculated as the Well Capacity Required divided by an average well yield of 2 MGD/well.

TABLE 7-6

PRELIMINARY CONSTRUCTION COST ESTIMATE FOR
RAW WATER PUMP STATION, RAW WATER TRANSMISSION LINE
AND TREATED WATER TRANSMISSION MAINS

Line Designation	Diameter (in)	Length (ft)	Unit Cost ($/ft)	Total Cost
RAW WATER PUMP STATION AND INTAKE				$ 800,000
Raw Water Transmission Line	36	13,200	115	$ 1,518,000
TREATED WATER TRANSMISSION MAINS				
Line to Plant 3 and Plant 4	30	2,300	95	$ 218,500
Line to Plant 3	24	8,200	75	615,000
Line to Plant 4	18	21,800	58	1,264,400
Line to Plant 1 and Plant 2	12	1,900	40	76,000
Line to Plant 1	10	500	35	17,500
Line to Plant 2	10	7,700	35	269,500
				$ 4,778,900

TABLE 7-7

CITY OF VICTORIA AND VICTORIA COUNTY
REGIONAL WATER SUPPLY STUDY
GROUNDWATER WITH LIMITED SURFACE WATER SCENARIO (GROUNDWATER WILL MEET HALF OF THE TOTAL DEMAND)

	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
NUMBER OF CONNECTIONS	17903	19040	20158	20909	21661	22624	23588	24821	26035	26999	27963
AVERAGE DAY DEMAND, MGD	9.29	9.88	10.46	10.85	11.24	11.74	12.24	12.88	13.51	14.01	14.51
TOTAL WATER PRODUCTION CAPACITY REQUIRED, MGD	15.5	16.5	17.4	18.1	18.7	19.5	20.4	21.4	22.5	23.3	24.2
NUMBER OF EXISTING WELLS	11	10	7	5	4	3	3	6	6	6	5
NUMBER OF WELLS REQUIRED	8	10	7	5	5	5	6	6	6	6	7
NUMBER OF WELLS TO BE DEVELOPED	0	0	0	0	1	2	3	0	0	0	2
ESTIMATED WELL LEVEL	-70	-75	-90	-105	-120	-135	-150	-165	-175	-190	-210
PUMPING HEAD	170	175	190	205	220	235	250	265	275	290	310
ANNUAL ELECTRICITY CONSUMPTION (KW-HR)	2267640	2482587	2293862	1767826	1897179	2026532	2587062	2742286	2845769	3000992	3742617
ANNUAL ELECTRIC COST	$158,735	$173,781	$160,570	$123,748	$132,803	$141,857	$181,094	$191,960	$199,204	$210,069	$261,983
ANNUAL CHLORINE DIOXIDE CONSUMPTION	82577	87821	74739	53385	53385	53385	64062	64062	64062	64062	74739
ANNUAL CHLORINE DIOXIDE COST	$99,918	$106,263	$90,434	$64,596	$64,596	$64,596	$77,515	$77,515	$77,515	$77,515	$90,434
ANNUAL PHOSPHATE CONSUMPTION	28280	30076	31841	33028	34216	35738	37260	39208	41126	42648	44170
ANNUAL PHOSPHATE COST	$51,752	$55,039	$58,270	$60,442	$62,615	$65,400	$68,185	$71,751	$75,260	$78,046	$80,831
ANNUAL CHLORINE CONSUMPTION	155538	165416	153267	130046	132420	135464	151306	155202	159038	162082	177924
ANNUAL CHLORINE COST	$46,661	$49,625	$45,980	$39,014	$39,726	$40,639	$45,392	$46,561	$47,711	$48,625	$53,377
SURFACE WATER CAPACITY REQUIRED			3.4	8.1	8.7	9.5	8.4	9.4	10.5	11.3	10.2
TREATMENT PLANT CAPACITY REQUIRED			10						10		
TREATMENT PLANT CAPITAL COST			$15,379,700						$8,240,000		
TREATMENT PLANT ANNUAL COST			$1,451,690	$1,451,690	$1,451,690	$1,451,690			$777,774	$777,774	$777,774
ANNUAL COAGULANT CONSUMPTION			93687	221190	238998	261829	229812	259036	287802	310633	278616
ANNUAL COAGULANT COST			$9,369	$22,119	$23,900	$26,183	$22,981	$25,904	$28,780	$31,063	$27,862
RAW WATER PUMPING ELEC. CONSUMPTION			147302	347772	375771	411668	361329	407276	452505	488401	438062
RAW WATER PUMPING ELECTRICAL COST			$10,311	$24,344	$26,304	$28,817	$25,293	$28,509	$31,675	$34,188	$30,664
ANNUAL ELEC. CONSUMPTION IN TREATMENT			39542	93356	100872	110508	96995	109329	121470	131106	117593
ANNUAL ELEC. COST IN TREATMENT			$2,768	$6,535	$7,061	$7,736	$6,790	$7,653	$8,503	$9,177	$8,232
CAPITAL COST FOR NEW WELLS REQUIRED	$0	$0	$0	$0	$650,000	$1,300,000	$1,950,000	$0	$0	$0	$1,300,000
ANNUAL COST FOR WELLS BUILT IN 1995		$0	$0	$0	$0						
ANNUAL COST FOR WELLS BUILT IN 2000			$0	$0	$0	$0					
ANNUAL COST FOR WELLS BUILT IN 2005				$0	$0	$0	$0				
ANNUAL COST FOR WELLS BUILT IN 2010					$61,354	$61,354	$61,354	$61,354			
ANNUAL COST FOR WELLS BUILT IN 2015						$122,707	$122,707	$122,707	$122,707		
ANNUAL COST FOR WELLS BUILT IN 2020							$184,061	$184,061	$184,061	$184,061	
ANNUAL COST FOR WELLS BUILT IN 2025								$0	$0	$0	$0
ANNUAL COST FOR WELLS BUILT IN 2030									$0	$0	$0
ANNUAL COST FOR WELLS BUILT IN 2035										$0	$0
ANNUAL COST FOR WELLS BUILT IN 2040											$122,707
TOTAL ANNUAL OPERATING AND CAPITAL COST	$357,066	$384,708	$1,829,392	$1,792,487	$1,870,047	$2,010,978	$795,371	$817,973	$1,553,190	$1,450,517	$1,453,863
WATER PRODUCTION COST ($/1000 GALLON)	$0.11	$0.11	$0.48	$0.45	$0.46	$0.47	$0.18	$0.17	$0.31	$0.28	$0.27
PRESENT WORTH OF THIS OPTION	$14,064,872										

- Number of Wells to be Developed. This value is equal to the Number of Wells Required less Number of Existing Wells.

- Estimated Well Level. Water level elevations shown were taken from Case B in Section 5.0.

- Pumping Head. This was calculated using an estimated land surface elevation of 100 feet and the Estimated Well Level.

- Annual Electricity Consumption. This value is for electricity used to pump groundwater from the wells. For 1990 and 1995, all the demand is met by groundwater. In years 2000 through 2040, approximately 50 percent of the demand is met by groundwater.

- Annual Electric Cost. Calculated based upon Annual Electricity Consumption and an electrical unit cost of $0.07/kw-hr.

- Annual Chlorine Dioxide Consumption. The City adds chlorine dioxide to help control hydrogen sulfide in the groundwater and oxidize any bacteria in the groundwater. In 1990 and 1995, the amount consumed is based upon the Average Day Demand and a feed rate of approximately 3 mg/L. In years 2000 through 2040, the amount consumed is based upon the amount of groundwater used and a feed rate of 3 mg/L.

- Annual Chlorine Dioxide Cost. The cost is based upon Annual Chlorine Dioxide Consumption and a unit price for chlorine dioxide of $1.21/pound.

- Annual Phosphate Consumption. The City currently uses phosphates to sequester the iron and manganese in the groundwater. It is assumed that phosphates will be added to stabilize the treated water. The amount consumed is calculated using the Average Day Demand and a phosphate feed rate of 1 mg/L.

- Annual Phosphate Cost. This value is calculated based upon Annual Phosphate Consumption and a unit cost for phosphates of $1.83/pound.

- Annual Chlorine Consumption. Chlorine is added as a final disinfectant into the groundwater. It is assumed that chlorine will be added as a final disinfectant at the surface water plant. The chlorine feed rate into the groundwater is assumed to be 5.5 mg/L and the feed rate into the surface water is assumed to be 2.0 mg/L.

- Annual Chlorine Cost. This value is calculated based upon Annual Chlorine Consumption and a unit cost for chlorine of $600/ton.

- Surface Water Capacity Required. This shows the amount of surface water treatment plant capacity required. It is generally equal to 50 percent of the Total Water Production Capacity Required.

- Treatment Plant Capacity Required. This value is based upon meeting the Surface Water Capacity Required for a period of approximately 20 years. The initial plant is constructed in year 2000 as a 10 MGD facility. The next expansion occurs in year 2030 when the plant is expanded by 10 MGD to 20 MGD.

- Treatment Plant Capital Cost. The cost shown in year 2000 includes the cost of a 10 MGD treatment plant as shown in Table 7-3, plus the raw water transmission line and treated water transmission line costs shown in Table 7-6. The treatment plant cost in year 2030 is for a 10 MGD expansion.

- Treatment Plant Annual Cost. This is the annual payment required to finance the original treatment plant and the expansion in year 2030. It is assumed that financing is for 20 years at seven percent.

- Annual Coagulant Consumption. Treatment of surface water typically requires the addition of a coagulant to assist in the removal of turbidity. It is assumed that alum will be used. The amount consumed is calculated using the amount of surface water used and an alum feed rate of 15 mg/L.

- Annual Coagulant Cost. This value is computed based on the Annual Coagulant Consumption and a unit cost for alum of $200/ton.

- Raw Water Pumping Electrical Consumption. This value is computed using the amount of surface water consumed and a pumping head of 50 feet.

- Raw Water Pumping Electric Cost. This value is calculated using the Raw Water Pumping Electrical Consumption and unit cost for electricity of $0.07/kw-hr.

- Annual Electrical Consumption in Treatment. This is the amount of electricity used in treating the surface waters.

- Annual Electric Cost in Treatment. This value is calculated using the Annual Electrical Consumption in Treatment and a unit cost for electricity of $0.07/kw-hr.

- Capital Cost for New Wells Required. As existing wells reach the end of their useful life, they must be replaced. Also, new wells are required to meet the growing demand. The number of new wells required was computed earlier in the spreadsheet. The Capital Cost for New Wells uses the number of wells required and a unit cost per well of $650,000.

- Annual Cost of New Wells. There are several rows showing the annual payment to finance the new wells required. It is assumed that the wells are financed with 20-year bonds with a seven percent interest rate.

- Total Annual Operating and Capital Cost. This value is the sum of costs for electricity used in groundwater pumping, surface water pumping, and surface water treatment; chlorine dioxide; phosphates; chlorine; coagulant; and financing costs for new wells and treatment plants.

- Water Production Cost. This value is the Total Annual Operating and Capital Cost divided by the Annual Demand (based on the Average Day Demand).

Based upon the capital and operation and maintenance costs presented in Table 7-7, the present worth of the conjunctive use option is $14,064,872.

7.3 SURFACE WATER PURCHASED FROM GBRA

We believe that GBRA would enter into a water supply contract with the City or County of Victoria to provide water out of the Guadalupe River. The water would be provided from Canyon Reservoir or by subordination of rights GBRA holds downstream of Victoria County. The typical water supply contract is structured as a take-or-pay agreement. This agreement requires that the water user pay for all of their contracted water whether it is used or not. The rate for water included in the last water agreement signed by GBRA was $56/ac-ft. If 16,000 ac-ft/yr is contracted for, then the annual cost for buying surface water is $896,000.

7.3.1 Facilities Plan

The surface water facilities of this alternative are similar to the surface water facilities in the conjunctive use alternative. The differences are described below. We have assumed that the raw surface water is taken from the Guadalupe River downstream of the CP&L power plant. The location of the raw water pump station and raw water transmission main is the same for this alternative as for the conjunctive use alternative shown in Figure 7-4. It is assumed that since the surface water contract is a take-or-pay agreement that it would be in the best interest of the City of Victoria to use as much of the surface water as possible. Therefore, if water is purchased from GBRA it is assumed that the groundwater wells will be abandoned. As a result, a 20 MGD water treatment plant needs to be built in year 2000. The treated water transmission mains from the water plant to the pumping plants would also be larger than the lines for the conjunctive use alternative because instead of conveying 50 percent of the demand, they would be conveying 100 percent of the demand. These pipes would follow the same routes as shown in Figure 7-2.

7.3.2 Preliminary Cost Estimate

The cost for this alternative includes the capital cost of a 20 MGD water treatment plant, raw water pump station and transmission main, and treated water transmission mains. The capital cost of a 20 MGD water treatment plant is presented in Table 7-3. The capital cost of the raw water pump station and transmission main is shown in Table 7-6. The cost of the treated water transmission mains would be the same as the water transmission mains for the treated groundwater alternative which are itemized in Table 7-4. The total capital cost in year 2000 for this alternative is $22,107,700. The pipelines are sized to serve to year 2040, but the water treatment plant would need to be expanded by 10 MGD to 30 MGD in year 2020.

The present worth of this option was computed using a spreadsheet and estimating operating and capital costs at five-year intervals. Below is a short description of each item included in the economic analysis shown in Table 7-8. Because the conversion to surface water is assumed to take place in year 2000, the detailed cost for this alternative begins in year 2000. For 1990 and 1995, it is assumed that the total annual operating and capital costs would be the same as the groundwater without treatment option.

- Number of Connections. The 1990 value was taken from the 1990 Sanitary Survey contained in Appendix A. The values were increased based upon population growth rates established in Section 3.0.

- Average Day Demand. The values were taken from the information presented in Section 3.0.

- Treatment Plant Capacity Required. This value is based upon Texas Health Department requirements of 0.6 gallons per minute per connection.

- Treatment Plant Capacity Provided. The treatment plant capacity initially installed is intended to provide a 20-year life. Subsequent capacity expansions are in logical units.

- Capital Cost of a 20 MGD Treatment Plant. This cost includes the cost of a 20 MGD treatment plant as shown in Table 7-3, the cost of a raw water pump station and transmission main as shown in Table 7-6, and the cost of treated water transmission mains as shown in Table 7-4.

- Annual Cost of a 20 MGD Treatment Plant. This value is the financing cost of the treatment plant and related improvements, assuming they are financed over 20 years at an interest rate of seven percent.

- Capital Cost of a 10 MGD Expansion. A 10 MGD expansion is required in year 2020.

- Annual Cost of a 10 MGD Expansion. Financing cost for the 10 MGD expansion, assuming a 20-year term and a seven percent interest rate.

- Annual Raw Water Pumping Electrical Consumption. This value is calculated based on Average Day Demand and a pumping head of 50 feet.

TABLE 7-8

CITY OF VICTORIA AND VICTORIA COUNTY
REGIONAL WATER SUPPLY STUDY
SURFACE WATER FROM GBRA ONLY SCENARIO

	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
NUMBER OF CONNECTIONS	17903	19040	20158	20909	21661	22624	23588	24821	26035	26999	27963
AVERAGE DAY DEMAND, MGD	9.29	9.88	10.46	10.85	11.24	11.74	12.24	12.88	13.51	14.01	14.51
TREATMENT PLANT CAPACITY REQUIRED, MGD	*	*	17.4	18.1	18.7	19.5	20.4	21.4	22.5	23.3	24.2
TREATMENT PLANT CAPACITY PROVIDED, MGD			20	20	20	20	30	30	30	30	30
CAPITAL COST OF A 20 MGD TREATMENT PLANT			$22,107,700								
ANNUAL COST OF A 20 MGD TREATMENT PLANT			$2,086,746	$2,086,746	$2,086,746	$2,086,746					
CAPITAL COST OF A 10 MGD PLANT EXPANSION							$8,240,000				
ANNUAL COST OF A 10 MGD EXPANSION							$777,774	$777,774	$777,774	$777,774	
ANNUAL RAW WATER PUMPING ELEC. CONS.			750950	778949	806948	842845	878741	924688	969918	1005814	1041710
ANNUAL RAW WATER PUMPING ELEC. COST			$52,567	$54,526	$56,486	$58,999	$61,512	$64,728	$67,894	$70,407	$72,920
ANNUAL RAW WATER PURCHASES FROM GBRA			$896,000	$896,000	$896,000	$896,000	$896,000	$896,000	$896,000	$896,000	$896,000
ANNUAL ELEC. CONS. FOR TREATMENT			201585	209101	216617	226253	235889	248223	260365	270001	279637
ANNUAL ELEC. COST FOR TREATMENT			$14,111	$14,637	$15,163	$15,838	$16,512	$17,376	$18,226	$18,900	$19,575
ANNUAL COAGULANT AID CONSUMPTION			477619	495427	513235	536066	558897	588120	616887	639718	662548
ANNUAL COAGULANT AID COST			$47,762	$49,543	$51,324	$53,607	$55,890	$58,812	$61,689	$63,972	$66,255
ANNUAL CHLORINE CONSUMPTION			63683	66057	68431	71475	74520	78416	82252	85296	88340
ANNUAL CHLORINE COST			$19,105	$19,817	$20,529	$21,443	$22,356	$23,525	$24,675	$25,589	$26,502
ANNUAL PHOSPHATE CONSUMPTION			31841	33028	34216	35738	37260	39208	41126	42648	44170
ANNUAL PHOSPHATE COST			$58,270	$60,442	$62,615	$65,400	$68,185	$71,751	$75,260	$78,046	$80,831
TOTAL ANNUAL OPERATING AND CAPITAL COST	$357,148	$390,929	$3,174,560	$3,181,711	$3,188,863	$3,198,032	$1,898,229	$1,909,965	$1,921,518	$1,930,687	$1,162,082
WATER PRODUCTION COST ($/1000 GALLON)	$0.11	$0.11	$0.83	$0.80	$0.78	$0.75	$0.42	$0.41	$0.39	$0.38	$0.22
PRESENT WORTH OF THIS OPTION	$22,442,983										

* COSTS IN THE 1990 AND 1995 COLUMNS ARE EQUAL TO THE COSTS IN THE GROUNDWATER ONLY OPTION

- Annual Raw Water Pumping Electric Cost. This cost is computed using the Annual Raw Water Pumping Electrical Consumption and a unit cost for electricity of $0.07/kw-hr.

- Annual Raw Water Purchases From GBRA. This value is calculated on the basis of a take-or-pay agreement for 16,000 ac-ft/yr at a unit cost of $56/ac-ft.

- Annual Electrical Consumption for Treatment. The amount of electricity consumed treating the Average Day Demand.

- Annual Electric Cost for Treatment. This value is computed using the Annual Electrical Consumption for Treatment and a unit cost for electricity of $0.07/kw-hr.

- Annual Coagulant Aid Consumption. It is assumed that alum is added as a coagulant to assist in the removal of turbidity from the surface waters. The amount consumed is based on the Average Day Demand and an alum feed rate of 15 mg/L.

- Annual Coagulant Aid Cost. This value is computed based on the Annual Coagulant Aid Consumption and a unit cost for alum of $200/ton.

- Annual Chlorine Consumption. It is assumed that chlorine would be added as the final disinfectant. The amount consumed is calculated based upon the Average Day Demand and a chlorine feed rate of 2 mg/L.

- Annual Chlorine Cost. This value is computed based upon the Annual Chlorine Consumption and a unit cost for chlorine of $600/ton.

- Annual Phosphate Consumption. It is assumed that phosphate would be added to stabilize the treated surface water. The amount consumed is based upon the Average Day Demand and a feed rate of 1.0 mg/L.

- Annual Phosphate Cost. This value is calculated using the Annual Phosphate Consumption and a unit cost for phosphate of $1.83/pound.

- Total Annual Operating and Capital Cost. This number is the sum of electrical costs for pumping and treatment, cost for alum, chlorine and phosphates, and financing costs for a 20 MGD water treatment plant and a 10 MGD expansion.

- Water Production Cost. This value is the Total Annual Operating and Capital Cost divided by the Annual Demand (based on the Average Day Demand).

In addition to the electrical and chemical costs, the annual cost for raw water purchases is included in this alternative.

All of these capital and operation and maintenance costs are included in Table 7-8. This table also lists the present worth of this alternative as $22,442,983.

7.4 SURFACE WATER PURCHASED FROM LNRA

We believe that Victoria County may be able to buy water from LNRA out of Lake Texana. As discussed earlier, several entities are in negotiation with the LNRA for the remaining yield of Lake Texana at this time. As with the previous option, water purchased from LNRA would be structured as a take-or-pay agreement. The rate for water purchased in the last water agreement signed by LNRA was $55/ac-ft. If 16,000 ac-ft/yr is contracted for, then the annual cost for buying surface water is $880,000.

7.4.1 Facilities Plan

This alternative, which includes the purchase of surface water from LNRA has similar facilities needs that were presented in the alternative that included purchase of surface water from GBRA. Again, in this option, the surface water is on a take-or-pay basis; therefore, we have assumed that it would be used to the greatest extent possible. Therefore, a 20 MGD water treatment plant would be constructed initially as well as treated water transmission mains to deliver 100 percent of the demand to the pumping plants. See Figures 7-1 and 7-2 for the water treatment plant layout and treated water transmission main locations, respectively.

Lake Texana is located approximately 28 miles northeast of the City of Victoria. To deliver water from Lake Texana to the City of Victoria would require the construction of a 28-mile raw water transmission main from the lake to the new water treatment plant in the City of Victoria. See Figure 7-5 for the pipeline route. Based upon engineering and economic analyses, a 36-inch diameter line would be the optimum size for this raw water transmission main.

7.4.2 Preliminary Cost Estimate

The cost for this alternative includes the capital cost for a 20 MGD water treatment plant, a 28-mile long, 36-inch diameter raw water transmission main, and treated water transmission mains. The capital cost of a 20 MGD water treatment plant is presented in Table 7-3. The capital cost of the treated water transmission mains is itemized in Table 7-6. The total capital cost for these two items is $19,789,700. The raw water transmission main is 28 miles (or 147,840 feet) long, at a unit cost of $115 per foot. The total capital cost for this pipeline is $16,977,946. (A 24-inch and 48-inch raw water transmission line were also analyzed; but, based upon the present worth, the 36-inch line is the most economical over the life of the line.) The pipelines are sized to serve to year 2040, but the water treatment plant would need to be expanded to 30 MGD in year 2020.

The present worth of this option was computed using a spreadsheet and estimating operating and capital costs at five-year intervals. Below is a short description of each item included in the economic analysis shown in Table 7-9. Because the conversion to surface water is assumed to take place in year 2000, the detailed cost for this alternative begins in year 2000. For 1990 and 1995, it is assumed that the total annual operating and capital costs would be the same as the groundwater without treatment option.

- Number of Connections. The 1990 value was taken from the 1990 Sanitary Survey contained in Appendix A. The values were increased based upon population growth rates established in Section 3.0.
- Average Day Demand. The values were taken from the information presented in Section 3.0.

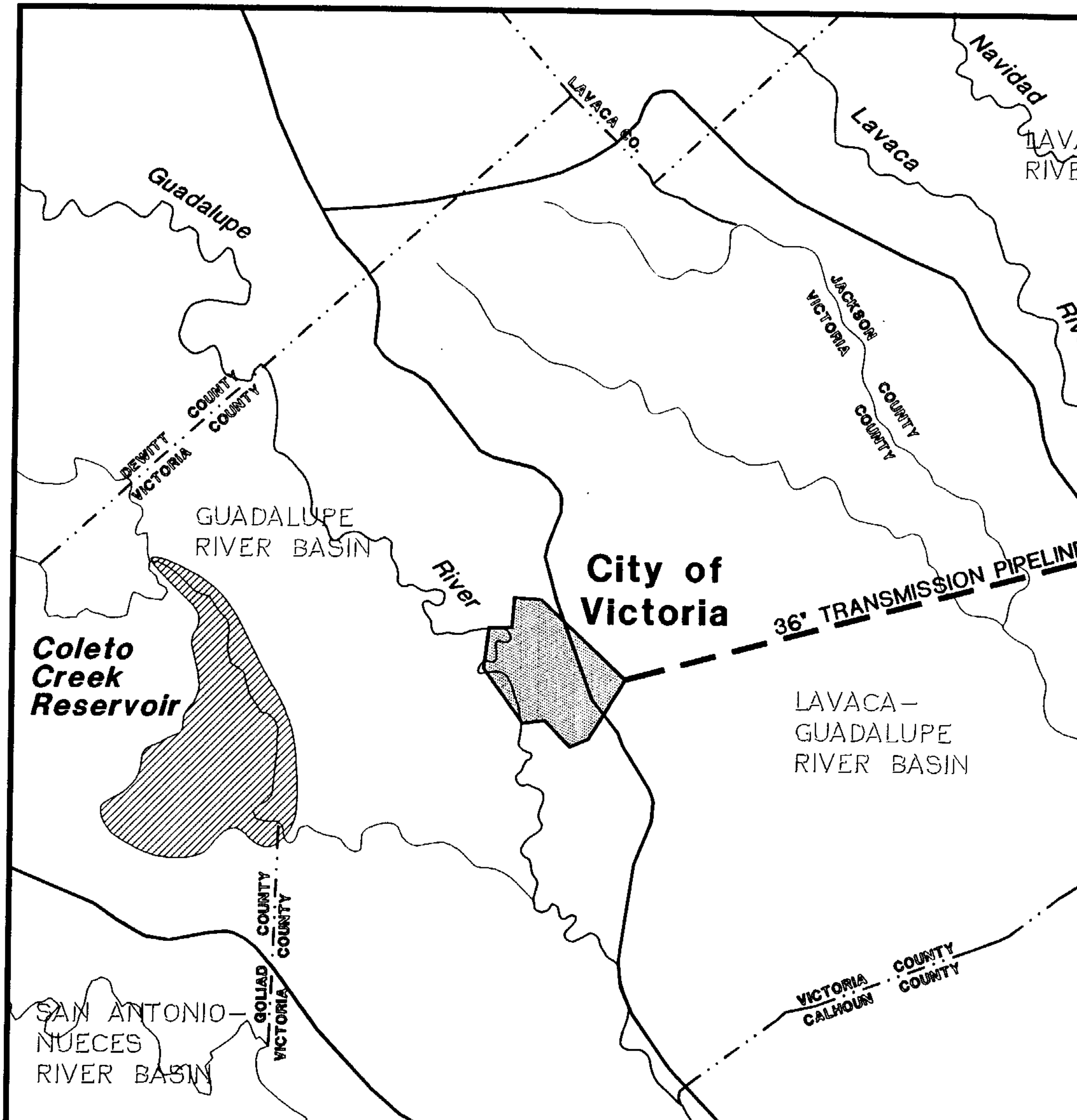


FIGURE 7-5

TRANSMISSION LINE BETWEEN LAKE TEXANA AND THE CITY OF VICTORIA

SUBMITTED TO:
CITY OF VICTORIA

SUBMITTED BY:
CAMP DRESSOR & McKEE, INC.
IN ASSOCIATION WITH
MICHAEL SULLIVAN & ASSOCIATES, INC.

TABLE 7-9

CITY OF VICTORIA AND VICTORIA COUNTY
REGIONAL WATER SUPPLY STUDY
SURFACE WATER FROM LNRA ONLY SCENARIO

	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
NUMBER OF CONNECTIONS	17903	19040	20158	20909	21661	22624	23588	24821	26035	26999	27963
AVERAGE DAY DEMAND, MGD	9.29	9.88	10.46	10.85	11.24	11.74	12.24	12.88	13.51	14.01	14.51
TREATMENT PLANT CAPACITY REQUIRED, MGD	*	*	17.4	18.1	18.7	19.5	20.4	21.4	22.5	23.3	24.2
TREATMENT PLANT CAPACITY PROVIDED, MGD			20	20	20	20	30		30	30	30
CAPITAL COST OF A 20 MGD TREATMENT PLANT			$19,789,700								
CAPITAL COST OF PIPELINE TO LAKE TEXANA			$16,977,946								
ANNUAL COST OF TREATMENT PLANT AND PIPELINE			$3,470,498	$3,470,498	$3,470,498	$3,470,498					
CAPITAL COST OF A 10 MGD PLANT EXPANSION							$8,240,000				
ANNUAL COST OF A 10 MGD EXPANSION							$777,774	$777,774	$777,774	$777,774	
ANNUAL RAW WATER PUMPING ELEC. CONS.			1687318	1824008	1968799	2166746	2379102	2672920	2987436	3255728	3541213
ANNUAL RAW WATER PUMPING ELEC. COST			$118,112	$127,681	$137,816	$151,672	$166,537	$187,104	$209,121	$227,901	$247,885
ANNUAL RAW WATER PURCHASES FROM LNRA			$880,000	$880,000	$880,000	$880,000	$880,000	$880,000	$880,000	$880,000	$880,000
ANNUAL ELEC. CONS. FOR TREATMENT			201585	209101	216617	226253	235889	248223	260365	270001	279637
ANNUAL ELEC. COST FOR TREATMENT			$14,111	$14,637	$15,163	$15,838	$16,512	$17,376	$18,226	$18,900	$19,575
ANNUAL COAGULANT AID CONSUMPTION			477619	495427	513235	536066	558897	588120	616887	639718	662548
ANNUAL COAGULANT AID COST			$47,762	$49,543	$51,324	$53,607	$55,890	$58,812	$61,689	$63,972	$66,255
ANNUAL CHLORINE CONSUMPTION			63683	66057	68431	71475	74520	78416	82252	85296	88340
ANNUAL CHLORINE COST			$19,105	$19,817	$20,529	$21,443	$22,356	$23,525	$24,675	$25,589	$26,502
ANNUAL PHOSPHATE CONSUMPTION			31841	33028	34216	35738	37260	39208	41126	42648	44170
ANNUAL PHOSPHATE COST			$58,270	$60,442	$62,615	$65,400	$68,185	$71,751	$75,260	$78,046	$80,831
TOTAL ANNUAL OPERATING AND CAPITAL COST	$357,148	$390,929	$4,607,858	$4,622,618	$4,637,945	$4,658,457	$1,987,254	$2,016,341	$2,046,744	$2,072,181	$1,321,047
WATER PRODUCTION COST ($/1000 GALLON)	$0.11	$0.11	$1.21	$1.17	$1.13	$1.09	$0.44	$0.43	$0.42	$0.41	$0.25
PRESENT WORTH OF THIS OPTION	$30,365,261										

* COSTS IN THE 1990 AND 1995 COLUMNS ARE EQUAL TO THE COSTS IN THE GROUNDWATER ONLY OPTION

- Treatment Plant Capacity Required. This value is based upon Texas Health Department requirements of 0.6 gallons per minute per connection.

- Treatment Plant Capacity Provided. The treatment plant capacity initially installed is intended to provide a 20-year life. Subsequent capacity expansions are in logical units.

- Capital Cost of a 20 MGD Treatment Plant. This cost includes the cost of a 20 MGD treatment plant as shown in Table 7-3, and the cost of treated water transmission mains as shown in Table 7-4.

- Capital Cost of Pipeline to Lake Texana. Cost of a 28-mile 36-inch diameter pipeline from Lake Texana to the City of Victoria.

- Annual Cost of Treatment Plant and Pipeline. This value is the financing cost of the treatment plant and related improvements, and the raw water pipeline, assuming they are financed over 20 years at an interest rate of seven percent.

- Capital Cost of a 10 MGD Expansion. A 10 MGD expansion is required in year 2020.

- Annual Cost of a 10 MGD Expansion. Financing cost for the 10 MGD expansion, assuming a 20-year term and a seven percent interest rate.

- Annual Raw Water Pumping Electrical Consumption. This value is calculated based on Average Day Demand and the pumping head resulting from pumping the Average Day Demand in a 28-mile 36-inch pipeline.

- Annual Raw Water Pumping Electric Cost. This cost is computed using the Annual Raw Water Pumping Electrical Consumption and a unit cost for electricity of $0.07/kw-hr.

- Annual Raw Water Purchases From LNRA. This value is calculated on the basis of a take-or-pay agreement for 16,000 ac-ft/yr at a unit cost of $55/ac-ft.

- Annual Electrical Consumption for Treatment. The amount of electricity consumed treating the Average Day Demand.

- Annual Electric Cost for Treatment. This value is computed using the Annual Electrical Consumption for Treatment and a unit cost for electricity of $0.07/kw-hr.

- Annual Coagulant Aid Consumption. It is assumed that alum is added as a coagulant to assist in the removal of turbidity from the surface waters. The amount consumed is based on the Average Day Demand and an alum feed rate of 15 mg/L.

- Annual Coagulant Aid Cost. This value is computed based on the Annual Coagulant Aid Consumption and a unit cost for alum of $200/ton.

- Annual Chlorine Consumption. It is assumed that chlorine would be added as the final disinfectant. The amount consumed is calculated based upon the Average Day Demand and a chlorine feed rate of 2 mg/L.

- Annual Chlorine Cost. This value is computed based upon the Annual Chlorine Consumption and a unit cost for chlorine of $600/ton.

- Annual Phosphate Consumption. It is assumed that phosphate would be added to stabilize the treated surface water. The amount consumed is based upon the Average Day Demand and a feed rate of 1.0 mg/L.

- Annual Phosphate Cost. This value is calculated using the Annual Phosphate Consumption and a unit cost for phosphate of $1.83/pound.

- Total Annual Operating and Capital Cost. This number is the sum of electrical costs for pumping and treatment, cost for alum, chlorine and phosphates, and financing costs for a 20 MGD water treatment plant and a 10 MGD expansion.

- Water Production Cost. This value is the Total Annual Operating and Capital Cost divided by the Annual Demand (based on the Average Day Demand).

In addition to the electrical and chemical costs, the annual cost for raw water purchases is included in this alternative.

All of these capital and operation and maintenance costs are included in Table 7-9. This table lists the present worth of this alternative as $30,365,261.

7.5 CONCLUSIONS

Three major water supply options consisting of five water supply projects were considered in detail. The summary of present worths of the five projects is presented below:

Groundwater Without Treatment	$8,314,962
Groundwater With Treatment	$21,365,637
Conjunctive Use of Surface Water and Groundwater	$14,064,872
Surface Water Purchased from GBRA	$22,442,983
Surface Water Purchased from LNRA	$30,365,261

The project with the lowest present worth is Groundwater Without Treatment. However, this project was primarily evaluated to establish baseline cost and for short-term supplies because, in our opinion, the use of groundwater without treatment is not a plausible alternative for a long-term supply. Groundwater can be used as a long-term option only if it is treated.

Groundwater With Treatment has a present worth of $21,365,637. This is similar to the project which includes buying surface water from GBRA. The similarity in present worths of these projects stem from the similarity in costs associated with the two projects. For example: both include building a 20 MGD treatment plant in 2000 and a 10 MGD expansion in 2020; both include treating all the water; and, although one includes purchasing water from GBRA at an annual cost of $896,000, the other includes building wells and pumping groundwater at an annual cost that varies from $322,460 in year 2000 to $942,931 in year 2040.

The project that includes purchasing water from LNRA has the highest present worth. This is because of the additional $16,977,946 needed to construct a pipeline to Lake

Texana to Victoria, and the fact that many of the other costs are similar to the Groundwater Without Treatment and Purchasing Surface Water from GBRA projects.

The feasible project with the lowest present worth is the conjunctive use of surface water and groundwater. This project will continue to utilize groundwater from the Gulf Coast Aquifer, but supplement that resource with water appropriated from the Guadalupe River. Looking at this project in reverse, it includes the appropriation of surface water from the Guadalupe River and supplementing the surface water with groundwater when surface water is not available. In either perspective, both resources are used wisely to produce a dependable supply with acceptable quality.

8.0 RECOMMENDED DEVELOPMENT PLAN

Based upon the work completed in the study of water supply scenarios for the City and County of Victoria, and summarized in Sections 2.0 through 7.0 of this report, we recommend that the City and County of Victoria pursue the conjunctive use of groundwater and surface water. This project was shown to have the lowest present worth among the projects that will provide an acceptable quality water. The project consists of the appropriation, diversion and treatment of surface water from the Guadalupe River. The water is then pumped to the four existing pumping plants in the City of Victoria for distribution. Capital improvements initially include a raw water intake and pump station on the banks of the Guadalupe River immediately downstream of the CP&L power plant, a raw water transmission main to a 10 MGD water treatment plant and treated water transmission mains.

To implement this project, several concrete steps need to be taken. The first step is to secure the surface water rights that are necessary to make this project work. We recommend that the City and County of Victoria immediately apply to the TWC for an appropriation of at least 16,000 acre-feet/year. Based upon work in Section 6.0, there will be adequate water in the Guadalupe River 86 percent of the time to meet this demand. If a firmer supply is desired, the GBRA has expressed an interest in subordinating some of their irrigation rights downstream of Victoria to Victoria. We recommend that the City and County of Victoria discuss this option with GBRA to determine the cost of firming up the surface water rights.

Preliminary engineering of the project needs to be initiated shortly after the water rights are secured. Preliminary engineering of this project should concentrate on the treatability of the Guadalupe River water and the characteristics of the blended surface water and groundwater. The preliminary engineering report should address physical sizes of units in the treatment plant and changes in groundwater treatment that will be necessary.

The preliminary engineering should be done far enough in advance so that final plan preparation, financing and construction of the required facilities are complete during year 2000. Assuming a construction period of 18 months, a financing, bidding and final engineering period of 12 months and a 6-month report review period requires that the preliminary engineering report be finished by 1997. Assuming a 12-month study period for the preliminary engineering report requires that it be initiated in 1996.

A tabular summary of the action items recommended is shown below.

Date	Recommended Action
October 1992	Begin Water Rights Appropriation Process
October 1994	Estimated Date Water Rights Permit is Issued
April 1996	Begin Preliminary Engineering Rights to Include Surface Water Treatability and Analysis of Combined Water Characteristics
April 1997	Preliminary Engineering Report is Completed and Review Begins
April 1997	Begin 404 Permit Application for Raw Water Intake
October 1997	Begin Final Plan Preparation for Raw Water Intake, Pump Station, Raw Water Transmission Line, Water Treatment Plant and Treated Water Transmission Mains
August 1998	Begin Financing of Improvements
October 1998	Bid Water Improvements
November 1998	Award Construction Contract
April 2000	Complete Construction

The report discusses the future water supply for Victoria County with an emphasis on the City of Victoria. The greatest impact from groundwater drawdown is in the vicinity of the City of Victoria. As the largest municipality, the City would act as a water purveyor to smaller municipalities in the County. In order for the County's smaller communities to construct regional facilities, a regional (county) water authority may be a useful vehicle for financing the water facilities. In fact, the water authority could be the owner of the water rights and of the water treatment plant, depending on how the City and County wish to construct the authority. If a water authority is established, this agency should also actively collect water level and water quality data in the Gulf Coast Aquifer so that trends can be established and a larger data base can be developed so that aquifer model updates can periodically be made. This data is essential to the management of the groundwater resource.

In the short-term, it is recommended that the City of Victoria read water levels and collect water quality data from selected wells that surround the City of Victoria. We recommend that levels be collected at wells previously used by the Texas Water Development Board on at least a quarterly basis. The water quality data should be done on the raw groundwater and the following constituents should be measured:

- Iron
- Manganese
- Barium
- Sulfide
- Chloride
- Total Dissolved Solids

Some of the options for water authorities are discussed below.

LEGAL AND INSTITUTIONAL FACTORS AFFECTING WATER

Planning for the development and use of water and the protection of its quality must be done in accordance with provisions of state water law and other laws, compacts, treaties, established water institutions, etc. Among the fundamental considerations are the distinctly different status of ownership of groundwater and surface water and the local, State and Federal agencies having specific authority and jurisdiction for water resources management.

Groundwater is private property subject to the right of capture by owners beneath whose property groundwater is found. Thus, decisions about the time and quantity of use of groundwater reside with a large number of individuals whose actions are difficult to predict. Although groundwater is private property, under State law, some underground water conservation districts having some regulatory powers have been formed to reduce waste, to conserve, and to manage this very important water resource. Special subsidence districts may also be created, through Legislative action, to regulate groundwater use in areas where control of subsidence is deemed necessary.

In Texas, surface water flowing in a public watercourse is public property, the use of which is subject to administration by the State. The Water Rights Adjudication Act of 1967 was enacted to standardize claims to surface water rights granted under Spanish, Mexican, English, Republic of Texas, and United States laws, in addition to the State's Appropriation Doctrine. The Water Rights Adjudication Act of 1967 investigated rights and claims of all 23 river and coastal basins. The principal of first-in-time, first-in-right establishes the seniority of each recognized water use permit.

REGIONAL SURFACE WATER AUTHORITIES

Regional surface water planning authority for the study area is by definition afforded to Victoria County and the City of Victoria. Additional authority can be gained through creation of an official Regional Water Authority. Regional water authorities are simply a voluntary association of political subdivisions and water supply entities created for the development and beneficial use of regional surface water resources.

Regional water authorities can be created in two ways. The first mechanism for creation of a regional water authority is through the Texas Water Commission (TWC). The sponsoring entity petitions the TWC for creation of an Authority with defined geographical planning boundaries and specified voluntary participating entities. This creation mechanism may, however, be relatively expensive as it requires an election of affected entities to determine participation and board representation. The second mechanism of Authority creation is through legislative action. A member of the Texas House of Representatives, in whose district at least a portion of the political subdivisions and supply entities that wish to form a Regional Water Authority are located, must sponsor a bill creating the district. The House then holds hearings on the need of forming such an authority and, if there are no protests, the authority is formed.

Functionally, TWC and Legislatively created Regional Water Authorities are identical. Politically created subdivisions, however, generally carry more weight with State and Federal regulatory and funding agencies. Regional water authorities can plan for any and all member political subdivisions within its boundaries and, in some cases, beyond its boundaries. The results of planning efforts are not, however, binding on those entities choosing not to participate in the plan.

UNDERGROUND WATER CONSERVATION DISTRICTS

As a prelude to any discussion of the groundwater law of Texas, it is desirable to understand the term "groundwater" as defined by statute and case law. A more accurate term would be "percolating water". Percolating waters are defined as those waters below the surface of the ground not flowing through the earth in known or defined channels, but are waters percolating, oozing, or filtering through the earth. Percolating waters are distinguished from: 1) "subterranean streams flowing in well-defined beds and having ascertainable channels"; and 2) "the ordinary underflow of every river and natural stream of the state."

The state of the law with respect to ownership of subterranean streams flowing in well-defined channels is not settled in Texas. However, "stream underflow" (the water that flows beneath and alongside of a surface stream channel) is the property of the State (Texas Water Code Chapter 11 §11.021). Both stream underflow and subterranean streams have been expressly excluded from the definition of underground water in Texas Water Code Chapter 52 §52.001.

There exists a legal presumption in Texas that all sources of groundwater are percolating waters as opposed to subterranean streams. Consequently, the surface landowner is presumed to own underground water until it is conclusively rebutted by a showing that the source of such supply is a subterranean stream or stream underflow, a burden of proof that may be very difficult to carry.

Texas courts have followed unequivocally the "English" or "common law" rule that the landowner has a right to take for use or sale all the water he can capture from beneath his land. Consequently, neither an injured neighbor nor the State can effectively exercise control over water-use practices involving groundwater.

Regarding the City of Victoria, the status of Texas law pertaining to groundwater and the desirability of forming an underground water conservation district "... to serve as a groundwater management agency to protect this supply ..." has previously been addressed in a November 21, 1984 letter from attorney Frank R. Booth (Booth, Simmons & Newsom) to Elvin C. Copeland, P.E. (Freese and Nichols, Inc.). The letter presents a historical account of Texas court decisions and opinions regarding the rights of individuals and corporations to remove groundwater residing beneath their "surface estates" and the impacts which removal of the groundwater may have on adjacent landowners. A thorough analysis of the purpose, powers and limitations of underground water conservation districts (Texas Water Code Chapter 52) is also presented. A copy of this letter is included in Appendix E.

Mr. Booth's general conclusions were as follows:

> "We perceive from Victoria's standpoint that the police powers of underground water conservation districts may prove to be insufficient. These districts do not have the power to prohibit the owner of the surface estate from producing groundwater under his estate. Prevention of waste, recharge work, and education alone are not enough to protect groundwater supplies as may be desired by the city. Hence regulation of the resource is incumbent if the city desires to fully protect the aquifer from either excessive use of pollution.
>
> "Rather than resorting to the general law type district, Texas Water Code Chapter 52, consideration should be given to special legislation to deal specifically with anticipated problems and need for protection. This was the recourse selected to cope with the subsidence problem in and around Houston.

"In 1975, the Legislature passed a special groundwater district act for the purpose to reduce and prevent subsidence. The district is the Harris-Galveston Coastal Subsidence District Acts 1975, 64th Legislature, R.S., Ch. 284, p. 672. To accomplish its purpose, the district was generally empowered to regulate withdrawals of groundwater in the district, Section 6, and to require permits for such wells charging a fee therefore, Section 37 ...

"By creating a special district, the Legislature avoided the problems faced by the traditional groundwater districts. Boundaries of underground aquifers, to which traditional districts are tied, become immaterial. And, power to regulate groundwater withdrawals is delegated to the district that are not included under the general law relating to underground conservation districts. Another consideration might be to seek an amendment to Texas Water Code, Chapter 52, to authorize regulating groundwater withdrawals by underground conservation districts."

Mr. Booth concludes his letter by stating:

"Since 1904, the Texas Supreme Court consistently has ruled that landowners possessed absolute ownership of groundwater and that they can divert it even to the extent of drying up a neighbor's well and water supply. The only recourse offered is in limited circumstances in the context of litigation.

"Use of an underground water district created under Texas Water Code Chapter 52, to protect the resource is of limited value. This is due to the restrictions and lack of power vested in the district to fully regulate the groundwater in the district.

"To fully protect the aquifer, resort should be to special legislation or legislation expanding the powers of the underground conservation districts. The legislation may address the unique regulatory problems associated as well as to permit control over withdrawals of groundwater. In this fashion, the aquifer supplying Victoria water might be protected through the year 2030."

APPENDIX A

VICTORIA COUNTY WATER SUPPLY SYSTEMS
DETAILED DESCRIPTION

Table A-1
City of Victoria
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)	RATED CAPACITY (GPM)
PLANT #1			
PLANT #1 - RED RIVER ST.	19	2,100	
YOUNG DRIVE	21	1,800	
TOTAL PLANT #1			3,900
PLANT #2			
N. ST. LOUIS & PINE	12	700	
E. ASH & N. EAST	28	1,900	
GEORGE ST.	22	1,900	
TOTAL PLANT #2			4,500
PLANT #3			
AIRLINE & BEN JORDAN	14	1,300	
AIRLINE & NIMITZ	15	1,500	
AIRLINE & PALMETTO	16	1,300	
AIRLINE & SAM HOUSTON	17	1,300	
CITIZENS MEMORIAL HOSPITAL	20	1,600	
NIMITZ ST.	23	1,950	
LOUIS & WARREN	25	2,000	
SABINE & DE LEON	26	2,200	
TOTAL PLANT #3			13,150
PLANT #4			
DAIRY ROAD & HWY. 77	24	2,000	
SALEM & BLEEKER b/	27	N/A	
TOTAL PLANT #4			2,000

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)	RATED CAPACITY (GPM)
PLANT #1			
PLANT #1	1	750	
PLANT #1	2	1,500	
PLANT #1	3	1,500	
TOTAL PLANT #1			3,750
PLANT #2			
PLANT #2	1	1,600	
PLANT #2	2	1,600	
TOTAL PLANT #2			3,200
PLANT #3			
PLANT #3	1	1,000	
PLANT #3	2	3,000	
PLANT #3	3	2,000	
PLANT #3	4	3,000	
PLANT #3	5	2,000	
TOTAL PLANT #3			11,000
PLANT #4			
PLANT #4	1	1,600	
PLANT #4	2	1,600	
PLANT #4	3	1,600	
TOTAL PLANT #4			4,800

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)	CAPACITY (GAL)
PLANT #1			
PLANT #1	GROUND	1,000,000	
HWY 77 & MOCKINGBIRD	ELEVATED	500,000	
TOTAL PLANT #1			1,500,000
PLANT #2			
PLANT #2	GROUND	350,000	
PLANT #2	GROUND	350,000	
PLANT #2	GROUND	1,000,000	
N. ST. LOUIS & E. PINE	ELEVATED	500,000	
TOTAL PLANT #2			2,200,000
PLANT #3			
PLANT #3 (AIRLINE & BEN JORDAN)	GROUND	1,000,000	
PLANT #3 (AIRLINE & BEN JORDAN)	GROUND	1,000,000	
PLANT #3 (AIRLINE & BEN JORDAN)	GROUND	2,000,000	
N. WEST ST.	ELEVATED	1,000,000	
TOTAL PLANT #3			5,000,000
PLANT #4			
PLANT #4 (DAIRY RD. & HWY. 77)	GROUND	500,000	
N. HWY. 77	ELEVATED	500,000	
EXTENSION OF MOKINGBIRD LANE	ELEVATED	1,000,000	
TOTAL PLANT #4			2,000,000

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS	DEFICIT
WELL PUMP CAPACITY (GPM)	10,742	23,550	12,808	N/A
ELEVATED TANK (GAL)	1,790,300	3,500,000	1,709,700	N/A
GROUND STORAGE (GAL)	1,790,300	7,200,000	5,409,700	N/A
SERVICE PUMPS (GPM)	35,806	22,750	N/A	13,056

MISCELLANEOUS DATA

CONNECTIONS SERVED	17,903
POTENTIAL NUMBER OF CONNECTIONS	18,338
METERS	17,903
AREA SERVED	CITY OF VICTORIA
ESTIMATED POPULATION SERVED	50,700
MAXIMUM DAILY USAGE (GAL)	13,752,000
AVERAGE DAILY USAGE (GAL)	9,000,000
SYSTEM PRESSURE (PSI)	40-70
DATE OF MOST RECENT SANITARY SURVEY	23-May-90

TOTAL WATER PUMP CAPACITY	**(GPM)**	**23,550**
TOTAL HIGH SERVICE PUMP CAPACITY	**(GPM)**	**22,750**
TOTAL STORAGE CAPACITY	**(GALLONS)**	**10,700,000**

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey
b/ Not In Use Until Summer of 1990

Table A-2
Victoria County WCID #1
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
HACHETT & COMMERCE ST.	4	350
INDIANA & SECOND ST.	5	350
TOTAL		700

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
AT WELL #4	1	500
AT WELL #5	2	500
TOTAL		1,000

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
BEHIND OFFICE AT WELL #5	GROUND	126,000
AT WELL #4	GROUND	126,000
LEONARD & SEVENTH ST.	ELEVATED	100,000
TOTAL		352,000

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	375	700	325
ELEVATED TANK (GAL)	62500	100,000	37,500
GROUND STORAGE (GAL)	62500	252,000	189,500
SERVICE PUMPS (GPM)	N/A	1,000	N/A

MISCELLANEOUS DATA	
CONNECTIONS SERVED	625
POTENTIAL NUMBER OF CONNECTIONS	796
WHOLESALE CONNECTIONS	1
AREA SERVED	CITY OF BLOMMINGTON
ESTIMATED POPULATION SERVED	1,800
MAXIMUM DAILY USAGE (GAL)	249,000
AVERAGE DAILY USAGE (GAL)	206,000
SYSTEM PRESSURE (PSI)	42-55
DATE OF MOST RECENT SANITARY SURVEY	22-Jun-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-3
Victoria County WCID #2
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WATER PLANT OFFICE NORTH OF BROADWAY ST.	1	150
TOTAL		150

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WATER PLANT	1	150
WATER PLANT	2	150
WATER PLANT	3	600
TOTAL		900

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WATER PLANT	GROUND	31,500
WATER PLANT	PRESSURE	7,500
TOTAL		39,000

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	109	150	41
PRESSURE TANK (GAL)	3640	7,500	3,860
GROUND STORAGE (GAL)	N/A	31,500	N/A
SERVICE PUMPS (GPM)	364	900	536

MISCELLANEOUS DATA	
CONNECTIONS SERVED	182
POTENTIAL NUMBER OF CONNECTIONS	230
METERS	182
WHOLESALE CONNECTIONS	0
AREA SERVED	PLACEDO COMMUNITY
ESTIMATED POPULATION SERVED	550
MAXIMUM DAILY USAGE (GAL)	75,000
AVERAGE DAILY USAGE (GAL)	48,000
SYSTEM PRESSURE (PSI)	35-45
DATE OF MOST RECENT SANITARY SURVEY	22-Jun-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-4
Quail Creek MUD
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
PUMP STATION #1 CHAPARRAL & DUCK STREETS	1	640
SOUTH OF PUMP #1 DUCK & GROUSE STREETS	2	500
TOTAL		1,140

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
PLANT #1 BY OFFICE	1	500
PLANT #1 BY OFFICE	2	500
PLANT # 1 BY OFFICE	3	250
TOTAL		1,250

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
PUMP STATION #1	GROUND	400,000
PUMP STATION #1	PRESSURE	10,000
TOTAL		410,000

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	162	769	607
PRESSURE TANK (GAL)	5400	10,000	4,600
GROUND STORAGE (GAL)	N/A	400,000	N/A
SERVICE PUMPS (GPM)	540	1,250	710

MISCELLANEOUS DATA

CONNECTIONS SERVED	270
AREA SERVED	QUAIL CREEK SUBDIVISION
POTENTIAL NUMBER OF CONNECTIONS	345
METERS	270
ESTIMATED POPULATION SERVED	1,500
MAXIMUM DAILY USAGE (GAL)	207,000
AVERAGE DAILY USAGE (GAL)	130,000
SYSTEM PRESSURE (PSI)	40-60
DATE OF MOST RECENT SANITARY SURVEY	15-Oct-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-5
E.I. Du Pont Company
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
EAST SIDE OF PLANT	1	1,500
WEST SIDE OF PLANT	2	1,500
EAST SIDE OF PLANT (STAND-BY)	3	500
TOTAL		3,500

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WELL SITE # 1	1	1,500
WELL SITE # 1	2	1,500
WELL SITE # 2	3	1,500
TOTAL		4,500

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE # 1	GROUND	27,000
WELL SITE # 2	GROUND	27,000
TOTAL		54,000

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED
WELL PUMP CAPACITY (GPM)	N/A	3,500
GROUND STORAGE (GAL)	N/A	54,000
SERVICE PUMPS (GPM)	N/A	4,500

MISCELLANEOUS DATA

CONNECTIONS SERVED	25
AREA SERVED	CHEMICAL PLANT
ESTIMATED POPULATION SERVED	1,400
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	65-120
DATE OF MOST RECENT SANITARY SURVEY	15-May-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-6
Wagner Utility Company
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
KENT & CAMBRIDGE ST. (PRIMARY PUMP)	1	340
KENT & CAMBRIDGE ST.	2	140
TOTAL		480

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WELL SITE	1	150
WELL SITE	2	150
TOTAL		300

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	GROUND	42,000
WELL SITE	PRESSURE	10,800
TOTAL		52,800

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	86	600	514
PRESSURE TANK (GAL)	2,860	10,800	7,940
GROUND STORAGE (GAL)	N/A	42,000	N/A
SERVICE PUMPS (GPM)	286	300	14

MISCELLANEOUS DATA	
CONNECTIONS SERVED	143
AREA SERVED	BRENTWOOD ESTATES SUBDIVISION
ESTIMATED POPULATION SERVED	465
MAXIMUM DAILY USAGE (GAL)	83,000
AVERAGE DAILY USAGE (GAL)	44,000
SYSTEM PRESSURE (PSI)	36-52
DATE OF MOST RECENT SANITARY SURVEY	15-May-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-7
Bloomington I.S.D. High School
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
BEHIND MAIN HIGH SCHOOL BLDG. S.E.	1	15
BEHIND HIGH SCHOOL BLDG. b/	2	0
BEHIND MAIN HIGH SCHOOL BLDG. S.W.	3	15
BEHIND HIGH SCHOOL BLDG.	4	120
TOTAL		150

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
GROUND WATER STORAGE	1	175
TOTAL		175

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
NEAR WELL #1 TO THE EAST	GROUND	10,000
NEAR WELL #1 TO THE EAST	PRESSURE	8,000
WELL # 3 (SERVES AS STAND-BY SUPPLY)	PRESSURE	315
TOTAL		18,315

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED
WELL PUMP CAPACITY (GPM)	N/A	45
PRESSURE TANK (GAL)	N/A	8,315
GROUND STORAGE (GAL)	N/A	10,000
SERVICE PUMPS (GPM)	N/A	20

MISCELLANEOUS DATA

CONNECTIONS SERVED	6
AREA SERVED	SCHOOL BUILDINGS
ESTIMATED POPULATION SERVED	400
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	45-60
DATE OF MOST RECENT SANITARY SURVEY	3-Dec-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey
b/ Plugged With Concrete Since 12/5/89

Table A-8
Industrial I.S.D. (Inez Elementary School)
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
BEHIND SCHOOL CAFETERIA.	1	20
TOTAL		20

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	PRESSURE	225
TOTAL		225

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	N/A	20	N/A
PRESSURE TANK (GAL)	225	225	0

MISCELLANEOUS DATA	
CONNECTIONS SERVED	4
AREA SERVED	SCHOOL BUILDINGS
ESTIMATED POPULATION SERVED	227
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	40-60
DATE OF MOST RECENT SANITARY SURVEY	3-Dec-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-9
Mission Valley Elementary School
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
NORTH EAST CORNER OF SCHOOL GROUNDS	1	15
TOTAL		15

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WELL HOUSE	1	20
TOTAL		20

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	GROUND	1,500
WELL SITE	PRESSURE	250
WELL SITE	PRESSURE	115
TOTAL		1,865

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	N/A	18	N/A
PRESSURE TANK (GAL)	250	365	115
GROUND STORAGE (GAL)	N/A	1,500	N/A
SERVICE PUMPS (GPM)	0	20	20

MISCELLANEOUS DATA	
CONNECTIONS SERVED	5
AREA SERVED	SCHOOL BUILDINGS
ESTIMATED POPULATION SERVED	250
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	30-45
DATE OF MOST RECENT SANITARY SURVEY	4-Oct-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-10
Coleto Water Company, Inc.
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WEST CORNER OF SHADY OAKS	1	150
TOTAL		150

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	PRESSURE	6,609
TOTAL		6,609

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	44	125	81
PRESSURE TANK (GAL)	1,480	6,609	5,129

MISCELLANEOUS DATA

CONNECTIONS SERVED	74
AREA SERVED	SHADY OAKS & RIVER OAKS SUBD.
ESTIMATED POPULATION SERVED	200
MAXIMUM DAILY USAGE (GAL)	30,000
AVERAGE DAILY USAGE (GAL)	19,000
SYSTEM PRESSURE (PSI)	40-60
DATE OF MOST RECENT SANITARY SURVEY	6-Jul-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-11
Devereux Foundation
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WEST SIDE OF PROPERTY	1	160
TOTAL		160

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WATER PLANT	1	240
WATER PLANT	2	240
TOTAL		480

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WATER PLANT	PRESSURE	20,000
WATER PLANT	PRESSURE	5,000
TOTAL		25,000

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	N/A	160	N/A
PRESSURE TANK (GAL)	250	5,000	4,750
SERVICE PUMPS (GPM)	N/A	480	N/A

MISCELLANEOUS DATA

CONNECTIONS SERVED	12
AREA SERVED	SCHOOL BUILDINGS
ESTIMATED POPULATION SERVED	122
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	45-60
DATE OF MOST RECENT SANITARY SURVEY	6-Jul-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-12
Nursery Elementary School
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
FRONT OF SCHOOL b/	1	0
FRONT OF SCHOOL	2	10
TOTAL		10

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	PRESSURE	120
WELL SITE	PRESSURE	100
TOTAL		220

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS	DEFICIT
WELL PUMP CAPACITY (GPM)	5	10	5	N/A
PRESSURE TANK (GAL)	250	220	N/A	30

MISCELLANEOUS DATA

CONNECTIONS SERVED	3
AREA SERVED	SCHOOL BUILDINGS
ESTIMATED POPULATION SERVED	120
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	28-50
DATE OF MOST RECENT SANITARY SURVEY	3-Oct-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey
b/ Abandoned 9/17/88

Table A-13
Kincer's Inc.
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
FRONT OF STORE	1	18
TOTAL		18

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE N.E. CORNER OF LOT	PRESSURE	120
WELL SITE	PRESSURE	200
TOTAL		320

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	N/A	18	N/A
PRESSURE TANK (GAL)	250	320	70

MISCELLANEOUS DATA

CONNECTIONS SERVED	1
AREA SERVED	CONVENIENCE STORE
ESTIMATED POPULATION SERVED	100
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	45-50
DATE OF MOST RECENT SANITARY SURVEY	4-Oct-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-14
Linden Hill Motel
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
CENTER OF COMPLEX	1	15
CENTER OF COMPLEX	2	15
TOTAL		30

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	PRESSURE	86
TOTAL		86

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS	DEFICIT
WELL PUMP CAPACITY (GPM)	23	30	7	N/A
PRESSURE TANK (GAL)	230	86	N/A	144

MISCELLANEOUS DATA	
CONNECTIONS SERVED	23
AREA SERVED	MOTEL AREA
ESTIMATED POPULATION SERVED	69
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	35-40
DATE OF MOST RECENT SANITARY SURVEY	6-Jul-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-15
Victoria Machine Works
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
BEHIND ADMINISTRATION BUILDING	1	50
TOTAL		50

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WELL SITE	1	50
TOTAL		50

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	GROUND	1,000
WELL SITE	PRESSURE	80
WELL SITE	PRESSURE	80
WELL SITE	PRESSURE	80
TOTAL		1,240

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS	DEFICIT
WELL PUMP CAPACITY (GPM)	1	50	49	N/A
PRESSURE TANK (GAL)	250	240	N/A	10
GROUND STORAGE (GAL)	N/A	1,000	N/A	N/A
SERVICE PUMPS (GPM)	N/A	50	N/A	N/A

MISCELLANEOUS DATA

CONNECTIONS SERVED	2
AREA SERVED	MACHINE SHOP
ESTIMATED POPULATION SERVED	60
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	35-50
DATE OF MOST RECENT SANITARY SURVEY	11-Dec-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-16
Chubby's
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
SOUTH OF BUILDING	1	50
TOTAL		50

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	PRESSURE	120
WELL SITE	PRESSURE	200
TOTAL		320

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	N/A	50	N/A
PRESSURE TANK (GAL)	250	320	70

MISCELLANEOUS DATA

CONNECTIONS SERVED	1
AREA SERVED	CONVENIENCE STORE
ESTIMATED POPULATION SERVED	50
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	40-60
DATE OF MOST RECENT SANITARY SURVEY	4-Dec-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-17
Carnes Mobile Home Park
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
BOBBIE CIRCLE ST. IN WOODS	1	15
BOBBIE CIRCLE ST. IN WOODS	2	15
END OF BARBARA DRIVE	3	15
TOTAL		45

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE # 1	PRESSURE	315
WELL SITE # 3	PRESSURE	525
TOTAL		840

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS	DEFICIT
WELL PUMP CAPACITY (GPM)	27	45	18	N/A
PRESSURE TANK (GAL)	900	840	N/A	60

MISCELLANEOUS DATA	
CONNECTIONS SERVED	18
AREA SERVED	MOBILE HOME PARK
ESTIMATED POPULATION SERVED	43
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	40-60
DATE OF MOST RECENT SANITARY SURVEY	15-May-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-18
Coleto Creek Mobile Home Park
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
SOUTH ENTRANCE TO PARK (BACK-UP)	1	40
SOUTH ENTRANCE TO PARK (MAIN WELL)	2	75
TOTAL		115

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	PRESSURE	1,000
WELL SITE	PRESSURE	1,000
TOTAL		2,000

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	19.5	115	95.5
PRESSURE TANK (GAL)	650	2000	1350

MISCELLANEOUS DATA

CONNECTIONS SERVED	13
AREA SERVED	MOBILE HOME PARK
ESTIMATED POPULATION SERVED	32
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	40-50
DATE OF MOST RECENT SANITARY SURVEY	28-Sep-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-19
Arenosa Creek Esates
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WEST END OF MHP BY ENTRANCE (STANDBY)	1	30
WEST END OF MHP BY ENTRANCE	2	15
TOTAL		45

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	PRESSURE	2,000
TOTAL		2,000

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS
WELL PUMP CAPACITY (GPM)	9	45	36
PRESSURE TANK (GAL)	300	2,000	1,700

MISCELLANEOUS DATA

CONNECTIONS SERVED	6
AREA SERVED	MOBILE HOME PARK
ESTIMATED POPULATION SERVED	21
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	35-80
DATE OF MOST RECENT SANITARY SURVEY	11-Dec-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-20
Spring Creek R.V. Park
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
BEHIND HOUSE	1	24
TOTAL		24

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	PRESSURE	525
WELL SITE	PRESSURE	20
TOTAL		545

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED	EXCESS	DEFICIT
WELL PUMP CAPACITY (GPM)	31	24	N/A	7
PRESSURE TANK (GAL)	310	545	235	N/A

MISCELLANEOUS DATA	
CONNECTIONS SERVED	9
AREA SERVED	R.V. PARK
ESTIMATED POPULATION SERVED	18
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	30-70
DATE OF MOST RECENT SANITARY SURVEY	15-May-90

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey

Table A-21
River Ranch States
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
EAST SIDE OF PARK	1	150
TOTAL		150

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	PRESSURE	2,500
TOTAL		2,500

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED
WELL PUMP CAPACITY (GPM)	N/A	150
PRESSURE TANK (GAL)	N/A	2,500

MISCELLANEOUS DATA	
CONNECTIONS SERVED	2
AREA SERVED	RESIDENTIAL
ESTIMATED POPULATION SERVED	8
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	30-45
DATE OF MOST RECENT SANITARY SURVEY b/	27-Sep-89

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey
b/ Inactive as of 9/25/90

Table A-22
Lord's Land Trailer Park
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
BEHIND RESIDENCE	1	88
TOTAL		88

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	PRESSURE	150
TOTAL		150

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED
WELL PUMP CAPACITY (GPM)	N/A	88
PRESSURE TANK (GAL)	N/A	150

MISCELLANEOUS DATA	
CONNECTIONS SERVED	7
AREA SERVED	RESIDENTIAL
ESTIMATED POPULATION SERVED	30
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	40-60
DATE OF MOST RECENT SANITARY SURVEY b/	27-Sep-89

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey
b/ Inactive as of 9/25/90

Table A-23
Guadalupe Elementary School
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
NORTH END OF SCHOOL	1	15
TOTAL		15

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WELL SITE	1	135
TOTAL		135

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	GROUND	2,000
WELL SITE	PRESSURE	525
WELL SITE	PRESSURE	315
WELL SITE	PRESSURE	170
TOTAL		3,010

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED
WELL PUMP CAPACITY (GPM)	N/A	15
PRESSURE TANK (GAL)	N/A	1,010
GROUND STORAGE (GAL)	N/A	2,000
SERVICE PUMPS (GPM)	N/A	135

MISCELLANEOUS DATA	
CONNECTIONS SERVED	1
AREA SERVED	SCHOOL
ESTIMATED POPULATION SERVED	143
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	40-52
DATE OF MOST RECENT SANITARY SURVEY b/	5-Dec-89

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey
b/ School Closed as of 11/26/90

Table A-24
Wood-Hi Elementary School
System Component Summary a/

WELL/RAW WATER PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
S.W. OF GYM	1	15
TOTAL		15

HIGH SERVICE PUMP CAPACITY

LOCATION	PUMP NUMBER	RATED CAPACITY (GPM)
WELL SITE	1	20
TOTAL		20

STORAGE FACILITIES

LOCATION	TYPE	CAPACITY (GAL)
WELL SITE	GROUND	1,500
WELL SITE	PRESSURE	525
WELL SITE	PRESSURE	82
WELL SITE	PRESSURE	50
TOTAL		2,157

EVALUATION OF SYSTEM CAPACITIES (MINIMUM REQUIREMENTS)

ITEM	AMOUNT REQUIRED	AMOUNT PROVIDED
WELL PUMP CAPACITY (GPM)	N/A	15
PRESSURE TANK (GAL)	N/A	657
GROUND STORAGE (GAL)	N/A	1,500
SERVICE PUMPS (GPM)	N/A	20

MISCELLANEOUS DATA	
CONNECTIONS SERVED	3
AREA SERVED	SCHOOL
ESTIMATED POPULATION SERVED	143
MAXIMUM DAILY USAGE (GAL)	N/A
AVERAGE DAILY USAGE (GAL)	N/A
SYSTEM PRESSURE (PSI)	30-55
DATE OF MOST RECENT SANITARY SURVEY b/	5-Dec-89

a/ Taken Verbatim from the Texas Department of Health Sanitary Survey
b/ School Closed as of 11/26/90

APPENDIX B

WATER AND WASTEWATER ORDINANCES FOR THE CITY OF VICTORIA

ORDINANCE NO. 91-24

AN ORDINANCE INCREASING THE RATES FOR WATER AND SEWER SERVICES; ESTABLISHING FEES FOR CHANGING THE SIZE OF WATER METERS; REQUIRING APPROVAL FOR THE INSTALLATION OF CERTAIN WATER METERS; AMENDING SECTION 13-46 OF THE CITY CODE PROVIDING FOR APPROVAL OF CONNECTIONS GREATER THAN ONE INCH; PROVIDING MISCELLANEOUS FEES; PROVIDING FOR A PENALTY NOT TO EXCEED $500.00 UPON CONVICTION; REPEALING ALL ORDINANCES IN CONFLICT HEREWITH; PROVIDING FOR SEVERABILITY; PROVIDING FOR CODIFICATION; PROVIDING FOR PUBLICATION; AND PROVIDING AN EFFECTIVE DATE.

BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF VICTORIA, TEXAS:

1.

Water Service Base Charge

The monthly water service base charge, as authorized by §13-33 of the City Code, shall be based upon meter size, and with allowed gallonage, as follows:

Meter Size	Monthly Base Charge	Gallonage Allowance Included in Base Charge	
3/4"	$ 7.50	2,000	3.75/1000
1"	$ 18.75	5,000	3.75/1000
1-1/2"	$ 37.50	10,000	[illegible]
2"	$ 60.00	16,000	3.75/1000
3"	$ 120.00	32,000	3.75
4"	$ 187.50	50,000	2.75
6"	$ 375.00	100,000	3.75
10"	$1875.00	550,000	2.41/1000

2.

Sewer Service Base Charge

The monthly sewer service base charge, as authorized by §13-88 of the City Code, shall be based upon water meter size, and with allowed gallonage, as follows:

Meter Size	Monthly Base Charge	Gallonage Allowance Included in Base Charge
3/4"	$ 9.70	2,000
1"	$ 24.25	2,000
1-1/2"	$ 48.50	2,000
2"	$ 77.60	2,000
3"	$ 155.20	2,000
4"	$ 242.50	2,000
6"	$ 485.00	2,000
10"	$2425.00	2,000

3.

Charges for Sewer Services Not Connected to Water Service

In the event that any person using the sewer system and sewer lines of the city is not a user of water supplied by the waterworks department of the city, and the water used therein or thereon is not measured by a city water meter or a meter acceptable to the director, water and wastewater department, then the rate applicable to such user shall be fixed as follows:

(1) If the use being made is for a residential purpose, then the user shall pay the current monthly sewer service base charge plus an amount equivalent to the current monthly sewer consumption rate multiplied by seven (7) for each dwelling unit.

(2) If the use being made is for any use other than a residential purpose, then the monthly consumption to be assessed shall be determined by the director, water and wastewater department and the current monthly sewer consumption rate shall be applied to determine the monthly sewer service base charge, which shall be determined by the director of water and wastewater department based on the monthly consumption, to determine the total monthly sewer service charge.

4.

Fees for Changing Meter Size

That, pursuant to Section 13-33 of the City Code, and subject to the approval of the change by the director of the water and wastewater department, the charge for changing the size of an existing water meter shall be as follows:

(a) When an existing meter is changed to a larger size, the fee shall be the difference between the amount of the connection fees for the two meter sizes.

(b) When an existing meter is changed to a smaller size, the fee shall be $50.00, regardless of the size of the old and new meters.

5.

That Section 13-46 of the City Code is hereby amended by designating the existing wording of the section as subsection (a) and by adding a new subsection (b) to read as follows:

(b) All water service connections greater than one (1) inch in diameter shall be subject to the review and approval of the director of the water and wastewater department.

6.

That, pursuant to Section 13-33 of the City Code, the fee for temporary water services requiring the use of a fireplug meter for a period of up to 90 days is hereby set at $75.00. Any person requesting to extend a temporary water service beyond a 90 day period will be required to reapply for service and pay a new $75.00 fee for each period of extension. In addition to these fees, all water obtained from such fireplug meter shall be paid for at the rate of $1.14 per 1,000 gallons with no gallonage allowance. All other bulk sales of water shall be billed at the rate of $1.14 per 1,000 gallons, and shall be subject to the approval of the director, water and wastewater department.

7.

That, pursuant to Section 13-33 of the City Code, the fee for the turn on of service to a new account shall be Ten and No/100 Dollars ($10.00). In the event the city is required to turn on the service after normal business hours at the request of the customer, the fee shall be Fifteen and No/100 Dollars ($15.00).

8.

Advance Payment of Base; Disconnection for Nonpayment

The base rate for water services shall be due and payable monthly in advance, together with any consumption charges accrued for the preceding month(s). If these charges are not paid within twenty-four (24) days after the billing date indicated on the bill, the utility billing office may terminate the account and cause the water service to be disconnected without further notice except as may be required by law, and the account shall not be restored nor the water service reconnected until such charges, together with an additional service restoration fee of $15.00, are paid. If the service is to be restored during non-business hours, the service restoration fee shall be $20.00. In the event the city is required to remove or lock a water meter because of unauthorized use by a user, the user shall be charged an additional $25.00 for removing or locking the meter.

9.

Any person violating any of the provisions of this ordinance shall be deemed guilty of a misdemeanor and upon conviction thereof shall be fined any sum not to exceed Five Hundred Dollars ($500.00) as provided in §1-8 of the City Code.

10.

All ordinances or parts of ordinances, including Ordinance No. 90-20, which set rates and service charges other than as provided herein are repealed as of the effective date of this ordinance. Nothing herein contained shall be construed to repeal any provisions of the City Code or other ordinances pertaining to methods of computing or measuring services, methods of billing and collection, or imposition of surcharges or late payment penalties.

11.

If any portion of this ordinance is held invalid or unconstitutional by a Court of competent jurisdiction, the remaining provisions of this ordinance shall nevertheless be valid, the same as if the portion or portions held invalid or unconstitutional had not been adopted.

12.

It is the intention of the City Council that Section 5 of this ordinance shall become a part of the Code of the City of Victoria, Texas, and it may be renumbered and codified therein accordingly.

13.

The City Secretary shall publish the caption or a descriptive title of this ordinance one time within ten (10) days after final passage of the ordinance in a newspaper of general circulation in the City of Victoria in accordance with Art. II §10 of the City Charter.

14.

The provisions of this ordinance shall become effective ten (10) days after final passage and approval by the City Council of the City of Victoria, Texas, for all billings made on or after October 1, 1991.

PASSED FIRST READING, this the 19th day of August, 1991.
PASSED SECOND READING, this the 3rd day of September, 1991.
PASSED THIRD READING, this the 16th day of September, 1991.
APPROVED AND ADOPTED, this the 16th day of September, 1991.

TED B. REED, Mayor of the
City of Victoria, Texas

ATTEST:

VIRGINIA K. BELLER, City Secretary

APPROVED AS TO LEGAL FORM:

TERESA ANN SPECIAL, City Attorney

ORDINANCE NO. 91-25

AN ORDINANCE AMENDING THE FEES FOR CONNECTIONS TO THE CITY WASTEWATER SYSTEM AND FOR PAVEMENT BREAKAGES ASSOCIATED WITH WATER AND WASTEWATER CONNECTIONS; READOPTING WATER CONNECTION FEES; READOPTING AN AMENDMENT TO CHAPTER 13 OF THE CITY CODE ADDING SECTION 54 PROVIDING LIMITATIONS ON CONNECTIONS TO SERVICE LINES; PROVIDING A PENALTY NOT TO EXCEED $500.00 UPON CONVICTION; PROVIDING FOR ENFORCEMENT; REPEALING ALL OR PARTS OF ORDINANCES IN CONFLICT HEREWITH; PROVIDING FOR SEVERABILITY; PROVIDING A SAVINGS CLAUSE; PROVIDING FOR CODIFICATION; PROVIDING FOR PUBLICATION; AND DECLARING AN EFFECTIVE DATE.

BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF VICTORIA, TEXAS:

1.

That, pursuant to §13-88 of the City Code, the fees for connection to the city wastewater system and associated pavement breakage fees, as previously established in Ordinance No. 85-2, Section 1, are hereby amended as follows:

Wastewater Connection and Pavement Breakage Fees

For each individual connection where such connection is made to a pre-existing stub installed at no expense to the City: $100.00.

For each individual connection where such connection is made to a pre-existing stub installed at city expense or where such connection is not made to a pre-existing stub:

Tap Size	Connection Fee
4"	$325.00
6"	$375.00
8"	$475.00

In addition, when existing pavement must be broken in order to make a connection, a fee of $100.00 shall be charged.

2.

That, pursuant to §13-33 of the City Code, the schedule of fees for connection to the city water system, as previously established in Ordinance No. 88-25, Section 1, is hereby readopted as follows, with the fee to be based on the size of the meter connection, and whether the connection has been pre-stubbed at no expense to the city:

A. Pre-stubbed at no expenses to city:

Meter Size	Connection Fee
3/4"	$125.00
1"	$175.00
1-1/4"	$175.00
1-1/2"	$375.00

B. Not Pre-stubbed or Pre-stubbed at city expense:

Meter Size	Connection Fee
3/4"	$525.00

1"	$ 600.00
1-1/4"	$ 725.00
1-1/2"	$ 1,125.00
2"	$ 1,300.00
3"	$ 1,500.00
4"	$ 2,000.00
6"	$ 3,000.00
10"	$10,000.00

3.

That, pursuant to Section 13-33 of the City Code, the schedule of fees for the installation by the city of taps on existing water mains for the connection of new water mains established in Ordinance No. 88-25, Section 2 is readopted to read as follows:

Existing Main Size	New Main Size	Connection Fee
24"	16"	$5,000.00
	12"	$2,500.00
	10"	$2,300.00
	8"	$2,100.00
16"	16"	$4,000.00
	12"	$2,100.00
	10"	$1,900.00
	8"	$1,700.00
12"	12"	$1,800.00
	10"	$1,650.00
	8"	$1,400.00
10"	10"	$1,600.00
	8"	$1,350.00
8"	8"	$1,300.00

4.

That, pursuant to §13-33 of the City Code, the fees for pavement breakage, as previously established in Ordinance No. 85-2, Section 2, are hereby amended as follows:

Meter Size	Breakage Fee
3/4" & 1"	$ 60.00
1 1/2"	$ 75.00
3" and larger	$100.00

5.

That Section 13-54 of the City Code, which was added by Ordinance No. 88-25, Section 4, is hereby readopted to read as follows:

Sec. 13-54. Limitation on Connection to service lines.

(a) Within this section, the following words and phrases shall have the following meanings:

(1) "Use" shall mean one dwelling, one commercial business, or one underground lawn sprinkler system.

(2) "3/4-inch line capacity" shall mean the capacity for water flow through a 3/4-inch inside diameter pipe. A 1-inch water service line is the equivalent of two 3/4-inch line capacities, and a 1-1/4-inch

water service line is the equivalent of four 3/4-inch line capacities.

(3) "Multiple lot service line" shall mean a water service line that serves two or more lots, or that is designed to serve two or more lots.

(4) "Lot" shall mean a parcel of land legally defined as a lot on a duly approved subdivision plat of record, or a parcel of land defined by a legal record or survey map.

(b) It shall be unlawful for any person to connect a use to a multiple lot service line unless the line is of sufficient size to provide at least 3/4-inch capacity for each use connected to the line, including the use proposed to be connected.

(c) The restriction in subdivision (b) shall not affect connections to a service line that serves, and is designed to serve, only one lot.

6.

That ordinance numbers 85-2 and 88-25 are hereby repealed.

7.

Any person violating any of the provisions of this ordinance shall be deemed guilty of a misdemeanor and upon conviction thereof shall be fined any sum not to exceed Five Hundred Dollars ($500.00) as provided in §1-8 of the City Code.

8.

In addition to any other remedy provided by law, the City and its officers shall have the right to enjoin any violation of this article by injunction issued by a court of competent jurisdiction.

9.

All ordinances or parts of ordinances in conflict herewith are hereby repealed to the extent of such conflict.

10.

If any portion of this ordinance is held invalid or unconstitutional by a Court of competent jurisdiction, the remaining provisions hereof shall nevertheless be valid, the same as if the portion or portions held invalid or unconstitutional had not been adopted.

11.

The Code of the City of Victoria, Texas, as amended, shall remain in full force and effect, save and except as amended by this ordinance.

12.

It is the intention of the City Council that Section 5 of this ordinance shall become a part of the Code of the City of Victoria, Texas, and it may be renumbered and codified therein accordingly.

13.

The City Secretary shall publish the caption or a descriptive title of this ordinance one time within ten (10) days after final passage of the ordinance in a newspaper of general circulation in the City of Victoria in accordance with Art. II, §10 of the City Charter.

14.

The provisions of this ordinance shall become effective ten (10) days after final passage and approval by the City Council of the City of Victoria, Texas, for connections or breakages made on or after October 1, 1991.

PASSED FIRST READING, this the 19th day of August, 1991.
PASSED SECOND READING, this the 3rd day of September, 1991.
PASSED THIRD READING, this the 16th day of September, 1991.
APPROVED AND ADOPTED, this the 16th day of September, 1991.

Ted B. Reed
TED B. REED, Mayor of the
City of Victoria, Texas

ATTEST:

Virginia K. Beller
VIRGINIA K. BELLER, City Secretary

APPROVED AS TO LEGAL FORM:

Teresa Ann Special
TERESA ANN SPECIAL, City Attorney

APPENDIX C

MASS BALANCE ANALYSIS
OF AQUIFER SYSTEM IN VICTORIA COUNTY

	DATE	RAINFALL (inches)	RUNOFF (inches)	PAN EVAP. (inches)	POTENTIAL E.T. (inches)	POTENTIAL RECHARGE (inches)
1970	JAN	2.74		2.50	1.90	
	FEB	1.68		3.73	2.50	
	MAR	4.44		5.37	3.40	
	APR	2.38		5.62	3.60	
	MAY	9.93		7.61	5.20	
	JUN	2.87		9.09	6.80	
	JUL	3.51	0.02	10.71	8.60	0.00
	AUG	1.44	0.01	11.81	10.10	0.00
	SEP	7.41	0.57	6.76	6.10	0.74
	OCT	2.63	0.20	6.01	5.50	0.00
	NOV	0.1	0.01	4.79	4.40	0.00
	DEC	0.65	0.01	3.30	2.90	0.00
	TOTAL	39.78		77.30	61.00	0.74
1971	JAN	0.02	0.01		2.98	0.00
	FEB	1.1	0.00		3.42	0.00
	MAR	0.18	0.01	7.44	4.66	0.00
	APR	1.75	0.01		4.91	0.00
	MAY	1	0.00		6.14	0.00
	JUN	5.23	0.29		7.67	0.00
	JUL	0.27	0.07	12.50	9.10	0.00
	AUG	4.01	0.10		7.75	0.00
	SEP	12.03	2.86		6.16	3.01
	OCT	6.87	1.93	5.99	5.24	0.00
	NOV	1.37	0.13		4.98	0.00
	DEC	2.23	0.61		2.88	0.00
	TOTAL	36.06	6.03		65.89	3.01
1972	JAN	1.74	0.82		2.48	0.00
	FEB	0.72	0.27		2.51	0.00
	MAR	1.55	0.02		3.99	0.00
	APR	0.35	0.01		5.12	0.00
	MAY	11.24	3.67		5.69	1.88
	JUN	3.17	0.06	9.50	6.83	0.00
	JUL	7.3	0.29	10.20	8.26	0.00
	AUG	4.38	0.49	9.70	6.88	0.00
	SEP	5.97	0.04		6.77	0.00
	OCT	3.44	0.03		5.32	0.00
	NOV	2.19	0.05		3.44	0.00
	DEC	0.36	0.02	2.56	2.41	0.00
	TOTAL	42.41	5.77		59.70	1.88

	DATE	RAINFALL (inches)	RUNOFF (inches)	PAN EVAP. (inches)	POTENTIAL E.T. (inches)	POTENTIAL RECHARGE (inches)
1973	JAN	2.4	0.13		2.36	0.00
	FEB	2.75	0.67		2.28	0.00
	MAR	1.04	0.29		2.90	0.00
	APR	4.73	2.57		4.60	0.00
	MAY	1.22	0.11	9.70	6.11	0.00
	JUN	12.68	4.25		5.70	2.73
	JUL	2.89	0.07	11.70	8.53	0.00
	AUG	2.55	0.07		6.94	0.00
	SEP	7.2	0.66		5.72	0.82
	OCT	6.26	2.09		5.65	0.00
	NOV	0.8	0.08	4.52	4.27	0.00
	DEC	1.13	0.05		3.43	0.00
	TOTAL	45.65	11.04		58.49	3.55
1974	JAN	2.89	0.36		2.23	0.30
	FEB	0.27	0.06	5.17	3.12	0.00
	MAR	1.75	0.04		3.17	0.00
	APR	0.9	0.02		4.59	0.00
	MAY	11.16	1.83		5.99	3.34
	JUN	3.33	1.18		6.94	0.00
	JUL	0.99	0.06	11.10	7.76	0.00
	AUG	7.3	0.07		6.84	0.39
	SEP	5.84	1.07		6.19	0.00
	OCT	2.88	0.05	6.72	5.43	0.00
	NOV	3.43	0.76		3.59	0.00
	DEC	2.6	0.43		2.61	0.00
	TOTAL	43.34	5.93		58.46	4.03
1975	JAN	0.96	0.17		2.36	0.00
	FEB	0.46	0.04		2.08	0.00
	MAR	0.36	0.03	5.37	3.32	0.00
	APR	0.89	0.02	5.91	3.65	0.00
	MAY	6.73	1.78		5.17	0.00
	JUN	7.68	0.56	9.50	6.32	0.80
	JUL	3.71	0.19		6.74	0.00
	AUG	2.38	0.05		6.78	0.00
	SEP	1.93	0.1		6.26	0.00
	OCT	3.88	0.03	7.34	6.02	0.00
	NOV	1.01	0.03	5.24	4.70	0.00
	DEC	6.97	2.64		3.25	1.08
	TOTAL	36.96	5.64		56.65	1.88

	DATE	RAINFALL (inches)	RUNOFF (inches)	PAN EVAP. (inches)	POTENTIAL E.T. (inches)	POTENTIAL RECHARGE (inches)
1976	JAN	0.77	0.09	3.87	3.07	0.00
	FEB	0.39	0.03	5.24	3.50	0.00
	MAR	1.45	0.04	4.98	3.17	0.00
	APR	5.9	1.51		4.27	0.12
	MAY	2.61	2.1		5.57	0.00
	JUN	1.32	0.16	11.00	7.68	0.00
	JUL	5.75	0.38		7.25	0.00
	AUG	2.76	0.03		8.25	0.00
	SEP	7.61	0.52	7.64	6.61	0.48
	OCT	6.18	1.68		5.54	0.00
	NOV	3.05	0.91		3.97	0.00
	DEC	5.46	3.31		2.99	0.00
	TOTAL	43.25	10.76		61.87	0.60
1977	JAN	2.39	0.52		1.99	0.00
	FEB	2.56	1.25		2.87	0.00
	MAR	1.1	0.1	5.68	3.61	0.00
	APR	3.9	0.27		4.72	0.00
	MAY	2.26	0.06		5.46	0.00
	JUN	12.21	1.95		6.94	3.32
	JUL	0.76	0.06	10.70	8.20	0.00
	AUG	2.53	0.04		8.25	0.00
	SEP	3.2	0.06		8.12	0.00
	OCT	4.21	0.14		6.93	0.00
	NOV	3.64	0.19		4.27	0.00
	DEC	0.45	0.04	4.44	3.87	0.00
	TOTAL	39.21	4.68		65.23	3.32
1978	JAN	3.43	0.28		2.14	1.01
	FEB	2.87	0.6		2.05	0.22
	MAR	0.54	0.03	6.54	4.17	0.00
	APR	1.95	0.18		3.94	0.00
	MAY	1.05	0.04	9.80	6.47	0.00
	JUN	4.88	0.71		7.49	0.00
	JUL	2.51	0.01	11.20	8.70	0.00
	AUG	2.08	0.01		8.41	0.00
	SEP	19.05	9.6		6.02	3.43
	OCT	0.57	0.08	6.70	5.90	0.00
	NOV	2.88	0.1		3.32	0.00
	DEC	1.27	0.05		2.62	0.00
	TOTAL	43.08	11.69		61.23	4.66

	DATE	RAINFALL (inches)	RUNOFF (inches)	PAN EVAP. (inches)	POTENTIAL E.T. (inches)	POTENTIAL RECHARGE (inches)
1979	JAN	5.21	2.51		2.30	0.40
	FEB	2.32	1.19	2.53	1.79	0.00
	MAR	1.69	0.11	5.83	3.79	0.00
	APR	5.16	0.79		3.27	1.10
	MAY	6.66	6.33	8.22	4.59	0.00
	JUN	4.03	1.34		6.02	0.00
	JUL	6.94	0.49		6.21	0.24
	AUG	2.07	0.06	9.80	6.62	0.00
	SEP	10.5	4.11		6.08	0.31
	OCT	1.65	0.13	7.50	6.04	0.00
	NOV	0.89	0.05		3.81	0.00
	DEC	2.18	0.05		2.79	0.00
	TOTAL	49.30	17.16		53.31	2.05
1980	JAN	4.52	1.59		2.65	0.28
	FEB	1.78	0.23		2.30	0.00
	MAR	1.97	0.06		3.43	0.00
	APR	0.48	0.04	7.81	4.97	0.00
	MAY	8.16	3.86		5.55	0.00
	JUN	0	0.06	12.70	9.10	0.00
	JUL	0.41	0.02	12.40	9.70	0.00
	AUG	5.65	0.02		9.30	0.00
	SEP	6.07	0.08		7.11	0.00
	OCT	0.9	0.1		5.66	0.00
	NOV	1.81	0.02	4.44	4.02	0.00
	DEC	0.79	0.01	3.58	3.06	0.00
	TOTAL	32.54	6.09		66.85	0.28
1981	JAN	2.22	0.03	3.22	2.49	0.00
	FEB	1.01	0.02		2.08	0.00
	MAR	1.4	0.02		3.26	0.00
	APR	1.42	0.02		4.48	0.00
	MAY	8.39	0.74		5.41	2.24
	JUN	9.29	9.07		6.01	0.00
	JUL	4.37	0.39		8.02	0.00
	AUG	4.23	0.04	10.70	8.67	0.00
	SEP	1.22	0.03	8.47	7.23	0.00
	OCT	10.16	0.25		5.82	4.09
	NOV	0.02	0.85	4.47	3.97	0.00
	DEC	1.37	0.03		3.49	0.00
	TOTAL	45.10	11.50		60.93	6.33

	DATE	RAINFALL (inches)	RUNOFF (inches)	PAN EVAP. (inches)	POTENTIAL E.T. (inches)	POTENTIAL RECHARGE (inches)
1982	JAN	0.39	0.03		2.27	0.00
	FEB	5.38	0.96		2.56	1.86
	MAR	0.23	0.13		2.50	0.00
	APR	1.4	0.13	6.05	3.79	0.00
	MAY	8.61	6.02		4.79	0.00
	JUN	0.06	0.09	11.00	7.68	0.00
	JUL	0.07	0.02	12.30	9.50	0.00
	AUG	1.78	0.01	11.20	9.20	0.00
	SEP	1.11	0.02		8.20	0.00
	OCT	4.07	0.24		5.70	0.00
	NOV	8.68	3.54		3.91	1.23
	DEC	0.75	0.3		3.16	0.00
	TOTAL	32.53	11.49		63.26	3.09
1983	JAN	1.64	0.13		2.29	0.00
	FEB	3.79	1.33		2.56	0.00
	MAR	4.21	0.83		3.76	0.00
	APR	0.24	0.06	7.67	4.86	0.00
	MAY	1.76	0.04	7.68	5.20	0.00
	JUN	2.96	0.01		6.60	0.00
	JUL	10.47	2.74		7.51	0.22
	AUG	1.88	0.23	8.80	7.37	0.00
	SEP	4.8	0.31		6.38	0.00
	OCT	7	2.02	6.91	6.04	0.00
	NOV	3.14	0.64		4.66	0.00
	DEC	0.52	0.06		2.32	0.00
	TOTAL	42.41	8.40		59.55	0.22
1984	JAN	3.02	0.68	3.37	2.63	0.00
	FEB	1.34	0.22	5.55	3.64	0.00
	MAR	1.74	0.05	6.43	4.16	0.00
	APR	0.09	0.03	8.76	5.66	0.00
	MAY	4.02	0.06	9.80	6.71	0.00
	JUN	2.05	0.01	11.10	8.06	0.00
	JUL	1.02	0.01	11.10	8.73	0.00
	AUG	4.16	0.02	10.60	8.81	0.00
	SEP	1.87	0.02	8.38	7.36	0.00
	OCT	8.52	0.44	5.31	4.89	3.19
	NOV	2.16	0.14	5.15	4.48	0.00
	DEC	3.93	0.12	3.50	3.15	0.66
	TOTAL	33.92	1.80	89.05	68.28	3.85

	DATE	RAINFALL (inches)	RUNOFF (inches)	PAN EVAP. (inches)	POTENTIAL E.T. (inches)	POTENTIAL RECHARGE (inches)
1985	JAN	3.37	0.66		1.98	0.73
	FEB	1.97	0.31	3.55	2.38	0.00
	MAR	5.51	2.55	4.98	3.13	0.00
	APR	8.56	3.47	6.88	4.28	0.81
	MAY	1.03	0.17	9.10	6.02	0.00
	JUN	6.97	0.14	9.50	6.77	0.06
	JUL	1.26	0.39	10.70	8.21	0.00
	AUG	1.88	0.03	11.80	9.70	0.00
	SEP	3.29	0.02	9.60	8.17	0.00
	OCT	2.03	0.08	6.28	5.61	0.00
	NOV	1.74	0.07	3.57	3.27	0.00
	DEC	2.38	0.08	2.91	2.55	0.00
	TOTAL	39.99	7.97		62.07	1.60
1986	JAN	1.12	0.05	4.21	3.18	0.00
	FEB	0.5	0.02	4.41	3.01	0.00
	MAR	1.03	0.02	7.61	4.83	0.00
	APR	0.5	0.02	8.22	5.17	0.00
	MAY	6.77	0.13	7.70	5.26	1.38
	JUN	7.45	1.02	8.55	6.17	0.26
	JUL	0.81	0.01	12.80	10.00	0.00
	AUG	3.62	0.01	10.90	8.99	0.00
	SEP	3.56	0.01	8.05	6.93	0.00
	OCT	6.79	0.23	5.54	5.05	1.51
	NOV	2.79	0.09	3.47	3.12	0.00
	DEC	4.25	1.98	2.52	2.24	0.03
	TOTAL	39.19	3.59	83.98	63.95	3.18
1987	JAN	2.42	0.61	3.35	2.55	0.00
	FEB	4.24	1.17	3.38	2.26	0.81
	MAR	0.43	0.22	6.78	4.18	0.00
	APR	0	0		5.27	0.00
	MAY	4.96	0.14		4.77	0.05
	JUN	11.7	8.91		5.70	0.00
	JUL	4.98	0.24		6.69	0.00
	AUG	3.07	0		8.27	0.00
	SEP	3.2	0.06		6.50	0.00
	OCT	0.34	0.03		6.17	0.00
	NOV	5.89	0.93		3.42	1.54
	DEC	1.86	0.29		2.37	0.00
	TOTAL	43.09	12.60		58.15	2.40

	DATE	RAINFALL (inches)	RUNOFF (inches)	PAN EVAP. (inches)	POTENTIAL E.T. (inches)	POTENTIAL RECHARGE (inches)
1988	JAN	0.3	0.08		2.46	0.00
	FEB	0.23	0.03		2.30	0.00
	MAR	1.68	0.03	5.89	3.76	0.00
	APR	1.1	0.04	7.73	4.89	0.00
	MAY	1.03	0.03	8.90	5.97	0.00
	JUN	1.73	0.01	9.80	7.06	0.00
	JUL	2.79	0.01	10.40	8.12	0.00
	AUG	1.12	0	11.50	9.30	0.00
	SEP	2.77	0	8.77	7.57	0.00
	OCT	0.77	0	7.60	6.73	0.00
	NOV	0.15	0	4.95	4.57	0.00
	DEC	2.24	0.01	3.51	3.12	0.00
	TOTAL	15.91	0.24		65.85	0.00
1989	JAN	3.91	0.25	3.09	2.31	1.35
	FEB	0.47	0.1	2.25	1.65	0.00
	MAR	1.72	0.01	4.82	3.17	0.00
	APR	1.1	0.01	7.27	4.62	0.00
	MAY	0.69	0	10.40	6.77	0.00
	JUN	4.35	0	9.30	6.71	0.00
	JUL	2.47	0.01	9.20	7.32	0.00
	AUG	1.73	0	9.40	7.92	0.00
	SEP	2.43	0	7.84	7.01	0.00
	OCT	3.89	0	7.36	6.61	0.00
	NOV	1.9	0	4.44	4.04	0.00
	DEC	1.13	0		2.78	0.00
	TOTAL	25.79	0.38		60.91	1.35
1990	JAN	1.73	0	3.21	2.25	0.00
	FEB	2.04	0	3.62	2.53	0.00
	MAR	3	0.09	5.54	3.88	0.00
	APR	3.63	0.2	5.69	3.98	0.00
	MAY	1.19	0.02	7.76	5.43	0.00
	JUN	0.82	0	10.40	7.28	0.00
	JUL	13.59	1.57	9.70	6.79	5.23
	AUG	1.47	0.04	9.90	6.93	0.00
	SEP	3.59	0.06	7.51	5.26	0.00
	OCT	1.56		6.36	4.45	0.00
	NOV	2.34		4.31	3.02	0.00
	DEC	0.81		2.72	1.90	0.00
	TOTAL	35.77		76.72	53.70	5.23
ANNUAL AVERAG		38.48	7.11		61.58	2.40

APPENDIX D

DIVERSIONS FROM THE GUADALUPE RIVER BASIN
SECTIONS 21 AND 22

Table C-1
Guadalupe River Basin (Run I - Revised 3/93)
Simulated Diversions in SW (21,1)a/ in acre-feet

Year	January	February	March	April	May	June	July	August	September	October	November	Devember	Annual
1940	1	0	1	1	1	1	1	1	0	1	1	1	10
1941	1	0	1	1	1	1	1	1	0	1	1	1	10
1942	1	0	1	1	1	1	1	1	0	1	1	1	10
1943	1	0	1	1	1	1	1	1	0	1	1	1	10
1944	1	0	1	1	1	1	1	1	0	1	1	1	10
1945	1	0	1	1	1	1	1	1	0	1	1	1	10
1946	1	0	1	1	1	1	1	1	0	1	1	1	10
1947	1	0	1	1	1	1	1	1	0	1	1	1	10
1948	1	0	1	1	1	1	1	1	0	1	1	1	10
1949	1	0	1	1	1	1	1	1	0	1	1	1	10
1950	1	0	1	1	1	1	1	1	0	1	1	1	10
1951	1	0	1	1	1	1	1	1	0	1	1	1	10
1952	1	0	1	1	1	1	1	1	0	1	1	1	10
1953	1	0	1	1	1	1	1	1	0	1	1	1	10
1954	1	0	1	1	1	1	1	1	0	1	1	1	10
1955	1	0	1	1	1	1	1	1	0	1	1	1	10
1956	1	0	1	1	1	1	0	1	0	1	1	1	9
1957	1	0	1	1	1	1	1	1	0	1	1	1	10
1958	1	0	1	1	1	1	1	1	0	1	1	1	10
1959	1	0	1	1	1	1	1	1	0	1	1	1	10
1960	1	0	1	1	1	1	1	1	0	1	1	1	10
1961	1	0	1	1	1	1	1	1	0	1	1	1	10
1962	1	0	1	1	1	1	1	1	0	1	1	1	10
1963	1	0	1	1	1	1	1	1	0	1	1	1	10
1964	1	0	1	1	1	1	1	1	0	1	1	1	10
1965	1	0	1	1	1	1	1	1	0	1	1	1	10
1966	1	0	1	1	1	1	1	1	0	1	1	1	10
1967	1	0	1	1	1	1	1	1	0	1	1	1	10
1968	1	0	1	1	1	1	1	1	0	1	1	1	10
1969	1	0	1	1	1	1	1	1	0	1	1	1	10
1970	1	0	1	1	1	1	1	1	0	1	1	1	10
1971	1	0	1	1	1	1	1	1	0	1	1	1	10
1972	1	0	1	1	1	1	1	1	0	1	1	1	10
1973	1	0	1	1	1	1	1	1	0	1	1	1	10
1974	1	0	1	1	1	1	1	1	0	1	1	1	10
1975	1	0	1	1	1	1	1	1	0	1	1	1	10
1976	1	0	1	1	1	1	1	1	0	1	1	1	10
1977	1	0	1	1	1	1	1	1	0	1	1	1	10
1978	1	0	1	1	1	1	1	1	0	1	1	1	10
1979	1	0	1	1	1	1	1	1	0	1	1	1	10

a/ Simulated diversions for water right A-1722 (W.L. Lipscomb) for 10 ac-ft/mo for municipal use.

Table C-2
Guadalupe River Basin (Run I - Revised 3/93)
Simulated Diversions in SW (21,1)S in acre-feet

Year	January	February	March	April	May	June	July	August	September	October	November	Devember	Annual
1940	0	0	0	39	98	137	201	123	32	20	0	0	650
1941	0	0	0	39	98	137	201	123	32	20	0	0	650
1942	0	0	0	39	98	137	201	123	32	20	0	0	650
1943	0	0	0	39	98	137	201	123	32	20	0	0	650
1944	0	0	0	39	98	137	201	123	32	20	0	0	650
1945	0	0	0	39	98	137	201	123	32	20	0	0	650
1946	0	0	0	39	98	137	201	123	32	20	0	0	650
1947	0	0	0	39	98	137	201	123	32	20	0	0	650
1948	0	0	0	39	98	137	201	123	32	20	0	0	650
1949	0	0	0	39	98	137	201	123	32	20	0	0	650
1950	0	0	0	39	98	137	201	123	32	20	0	0	650
1951	0	0	0	39	98	137	201	123	32	20	0	0	650
1952	0	0	0	39	98	137	201	123	32	20	0	0	650
1953	0	0	0	39	98	137	201	123	32	20	0	0	650
1954	0	0	0	39	98	137	201	123	32	20	0	0	650
1955	0	0	0	39	98	137	201	123	32	20	0	0	650
1956	0	0	0	39	98	137	201	123	32	20	0	0	650
1957	0	0	0	39	98	137	201	123	32	20	0	0	650
1958	0	0	0	39	98	137	201	123	32	20	0	0	650
1959	0	0	0	39	98	137	201	123	32	20	0	0	650
1960	0	0	0	39	98	137	201	123	32	20	0	0	650
1961	0	0	0	39	98	137	201	123	32	20	0	0	650
1962	0	0	0	39	98	137	201	123	32	20	0	0	650
1963	0	0	0	39	98	137	201	123	32	20	0	0	650
1964	0	0	0	39	98	137	201	123	32	20	0	0	650
1965	0	0	0	39	98	137	201	123	32	20	0	0	650
1966	0	0	0	39	98	137	201	123	32	20	0	0	650
1967	0	0	0	39	98	137	201	123	32	20	0	0	650
1968	0	0	0	39	98	137	201	123	32	20	0	0	650
1969	0	0	0	39	98	137	201	123	32	20	0	0	650
1970	0	0	0	39	98	137	201	123	32	20	0	0	650
1971	0	0	0	39	98	137	201	123	32	20	0	0	650
1972	0	0	0	39	98	137	201	123	32	20	0	0	650
1973	0	0	0	39	98	137	201	123	32	20	0	0	650
1974	0	0	0	39	98	137	201	123	32	20	0	0	650
1975	0	0	0	39	98	137	201	123	32	20	0	0	650
1976	0	0	0	39	98	137	201	123	32	20	0	0	650
1977	0	0	0	39	98	137	201	123	32	20	0	0	650
1978	0	0	0	39	98	137	201	123	32	20	0	0	650
1979	0	0	0	39	98	137	201	123	32	20	0	0	650

a/ Simulated diversions for water right A-1722 (W.L. Lipscomb) and A-1732A (Big Rack Lt.) for 650 ac-ft/mo for irrigation use.

Table C-3
Guadalupe River Basin (Run I - Revised 3/83)
Simulated Diversions in SW (21,1)a/ in acre-feet

Year	January	February	March	April	May	June	July	August	September	October	November	Devember	Annual
1940	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1941	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1942	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1943	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1944	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1945	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1946	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1947	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1948	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1949	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1950	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1951	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1952	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1953	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1954	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1955	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1956	3,600	4,200	4,800	5,400	4,800	5,005	5,943	5,870	6,000	4,800	4,200	4,800	59,418
1957	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1958	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1959	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1960	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1961	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1962	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1963	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1964	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1965	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1966	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1967	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1968	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1969	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1970	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1971	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1972	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1973	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1974	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1975	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1976	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1977	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1978	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000
1979	3,600	4,200	4,800	5,400	4,800	5,400	6,000	6,000	6,000	4,800	4,200	4,800	60,000

a/ Simulated diversions for water right A-1578B (E.I. DuPont de Nemours) for 60,000 ac-ft/mo for industrial use.

Table C-4
Guadalupe River Basin (Run I - Revised 3/83)
Simulated Diversions in SW (21,1)$ in acre-feet

Year	January	February	March	April	May	June	July	August	September	October	November	Devember	Annual
1940	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1941	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1942	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1943	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1944	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1945	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1946	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1947	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1948	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1949	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1950	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1951	581	677	774	871	774	871	0	546	968	774	677	774	8,287
1952	581	677	774	871	774	871	968	738	968	774	677	774	9,447
1953	581	677	774	871	774	871	695	968	968	774	677	774	9,404
1954	581	677	774	871	774	871	0	0	0	774	677	774	6,773
1955	581	677	774	871	774	871	159	258	968	0	0	774	6,707
1956	581	677	0	322	774	208	0	0	0	774	677	774	4,787
1957	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1958	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1959	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1960	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1961	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1962	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1963	581	677	774	871	774	871	656	0	968	774	677	774	8,397
1964	581	677	774	871	774	871	788	968	968	774	677	774	9,497
1965	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1966	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1967	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1968	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1969	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1970	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1971	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1972	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1973	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1974	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1975	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1976	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1977	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1978	581	677	774	871	774	871	968	968	968	774	677	774	9,677
1979	581	677	774	871	774	871	968	968	968	774	677	774	9,677

a/ Simulated diversions for water right A-3895 (Gulf Oil Chemicals Co.) for 9,677 ac-ft/mo for industrial use.

Table C-5
Guadalupe River Basin (Run I - Revised 3/83)
Simulated Diversions in SW (21,1)S in acre-feet

Year	January	February	March	April	May	June	July	August	September	October	November	Devember	Annual
1940	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1941	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1942	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1943	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1944	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1945	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1946	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1947	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1948	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1949	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1950	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1951	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1952	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1953	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1954	0	0	0	192	480	672	877	523	136	96	0	0	2,976
1955	0	0	0	192	480	672	992	608	160	91	0	0	3,195
1956	0	0	0	192	480	672	844	473	144	96	0	0	2,901
1957	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1958	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1959	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1960	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1961	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1962	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1963	0	0	0	192	480	672	992	558	160	96	0	0	3,150
1964	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1965	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1966	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1967	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1968	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1969	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1970	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1971	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1972	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1973	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1974	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1975	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1976	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1977	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1978	0	0	0	192	480	672	992	608	160	96	0	0	3,200
1979	0	0	0	192	480	672	992	608	160	96	0	0	3,200

a/ Simulated diversions for water right A-1672B (J.A. McFaddin Estate) for 3,200 ac-ft/mo for irrigation use.

Table C-6
Guadalupe River Basin (Run I - Revised 3/83)
Simulated Diversions in SW (21,1)a in acre-feet

Year	January	February	March	April	May	June	July	August	September	October	November	Devember	Annual
1940	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1941	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1942	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1943	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1944	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1945	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1946	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1947	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1948	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1949	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1950	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1951	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1952	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1953	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1954	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1955	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1956	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1957	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1958	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1959	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1960	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1961	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1962	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1963	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1964	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1965	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1966	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1967	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1968	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1969	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1970	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1971	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1972	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1973	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1974	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1975	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1976	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1977	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1978	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941
1979	837	976	1,115	1,255	1,115	1,255	1,394	1,394	1,394	1,115	976	1,115	13,941

a/ Simulated diversions for water right A-1691, A-1410, and A1469B (Union Carbide) for a total of 13,942 ac-ft/mo for industrial use.

Table C-7
Guadalupe River Basin (Run I - Revised 3/03)
Simulated Diversions in SW (21,1)ß in acre-feet

Year	January	February	March	April	May	June	July	August	September	October	November	Devember	Annual
1940	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1941	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1942	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1943	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1944	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1945	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1946	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1947	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1948	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1949	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1950	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1951	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1952	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,324	12,685	12,685	11,099	11,099	158,027
1953	11,099	11,099	12,685	12,685	14,270	15,856	15,769	15,856	12,685	12,685	11,099	11,099	156,887
1954	11,099	11,099	12,685	12,685	14,270	15,116	8,753	7,466	7,612	12,685	11,099	11,099	135,668
1955	11,099	11,099	12,685	12,685	14,270	15,856	12,438	15,856	12,685	8,951	9,948	11,099	148,671
1956	11,099	11,099	12,656	11,689	14,270	2,051	1,261	3,678	11,403	12,685	11,099	11,099	114,089
1957	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1958	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1959	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1960	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1961	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1962	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1963	11,099	11,099	12,685	12,685	14,270	15,856	16,907	14,533	12,685	12,685	11,099	11,099	156,702
1964	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1965	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1966	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1967	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1968	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1969	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1970	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1971	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1972	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1973	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1974	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1975	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1976	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1977	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1978	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559
1979	11,099	11,099	12,685	12,685	14,270	15,856	17,441	15,856	12,685	12,685	11,099	11,099	158,559

a/ Simulated diversions for water right A-1736E (Union Carbide), A1469A (GBRA et. al.), A-1469G (Union Carbide), A1713 (West S. Calhoun) for a total of 158,559 ac-ft/mo for municipal with some irrigation uses.

APPENDIX E

LETTER FROM FRANK BOOTH
CONCERNING GROUNDWATER DISTRICTS
(FREESE & NICHOLS, 1984)

LAW OFFICES
BOOTH, SIMMONS & NEWSOM
A PROFESSIONAL CORPORATION
300 SAN JACINTO BUILDING
9TH & SAN JACINTO
AUSTIN, TEXAS 78701-2554
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FRANK R. BOOTH
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TIMOTHY L. BROWN
MICHAEL J. BOOTH
SHERRY L. PEEL
BRETT G. BRAY

November 21, 1984

Elvin C. Copeland, P.E.
Freese and Nichols, Inc.
811 Lamar Street
Fort Worth, Texas 76102

**RE: Victoria, Texas
Water Supply Study**

Dear Elvin:

In conjunction with Freese and Nichols' long range studies of the city of Victoria's water supply and water distribution system, you advise that William F. Guyton & Associates have ascertained that there probably is sufficient groundwater to meet Victoria's needs to the year 2030. You also indicate that Victoria has requested advice concerning the status of Texas law pertaining to groundwater and the desirability of forming an underground water conservation district to serve as a groundwater management agency to protect this supply. In this regard, Victoria desires that the Texas Department of Water Resources planning document, Water for Texas, Planning for the Future, volume 2, concerning underground water conservation districts be considered.

Any discussion about groundwater in Texas water law should make clear that the term is not inclusive of all water under the ground. The term "groundwater" does not apply to water flowing in a subterranean stream or to the under flow of rivers and streams. Bartley v. Sone, 527 S.W.2d 754 (Tex. Civ. App.--San Antonio 1975, writ ref'd n.r.e.). Rather, the term "groundwater" should be understood to refer to that water which percolates, oozes, or filters through the earth. Houston & T.C. Ry. Co. v. East, 98 Tex. 146, 81 S.W. 279 (1904).

OWNERSHIP AND USE OF GROUNDWATER

The leading Texas court decision on legal rights in groundwater is Houston & T.C. Ry. Co. v. East, supra. In that case, the railroad company, with full knowledge of the long existence of

Mr. East's small shallow well on his homestead, dug a well twenty feet in diameter and 66 feet deep on its own adjacent property, from which it pumped 25,000 gallons of water per day. This resulted in lowering the water level on East's land and drying up his well, for which East sought damages. The trial court rendered judgment for the railroad, which was reversed by the Court of Civil Appeals. The Court of Civil Appeals followed what has since become known as the "reasonable use" or "American rule" legal doctrine as set forth in Bassett v. Salisbury Mfg. Co., 43 N.H. 569, 82 Am. Dec. 179 (1862), which held that the right of a landowner to draw groundwater from his land was not absolute, but limited to the amount necessary for the reasonable use of his land, and that the rights of adjoining landowners are correlative and limited to reasonable use. The court also noted the contrary English doctrine laid down in Acton v. Blundell, 12 M.&W. 324, 152 E.R. 1223 (Ex. 1843), that, "if a man digs a well on his own field and thereby drains his neighbor's, he may do so unless he does it maliciously." The court said that "to apply that rule under the facts shown here would shock our sense of justice."

On appeal of the East case to the Texas Supreme Court, the conflicting aspects of the reasonable use rule and the common law rule, referred to as the "English rule" or "absolute ownership rule," were clearly presented. The Supreme Court discussed both rules and made a deliberate choice of the common law rule as announced in Acton v. Blundell, reciting that it had been followed since 1843 in all the courts of England "and probably by all the courts of last resort in this country before which the [subject] has come, except the Supreme Court of New Hampshire. Houston & T.C. Ry. Co. v. East, supra at p. 280. In reversing the Court of Appeals and rejecting the "reasonable use" rule, the Texas Supreme Court adopted the absolute ownership doctrine of underground percolating waters. It cited with approval the language of the Supreme Court of Ohio in Frazier v. Brown, 12 Ohio St. 294 (1861):

> In the absence of express contract and a positive authorized legislation, as between proprietors of adjoining land, the law recognizes no correlative rights in respect to underground waters percolating, oozing, or filtering through the earth; and this mainly from considerations of public policy: (1) Because the existence, origin, movement, and course of such waters, and the causes which govern and direct their movements, are so secret, occult, and concealed that an attempt to administer any set of legal rules in respect

> to them would be involved in hopeless uncertainty, and would, therefore, be practically impossible. (2) Because any such recognition of correlative rights would interfere, to the material detriment of the commonwealth, with drainage and agriculture, mining, the construction of highways and railroads, with sanitary regulations, building, and the general progress of improvement in works of embellishment and utility. (emphasis supplied).

The underscored portion makes clear that had there been legislation prescribing a different rule, then the result would also have been different. One can conclude that the court was inviting legislative action by the inclusion of this language, "in the absence of . . . legislation," and was admitting that the courts were neither prepared nor equipped to handle the problems of groundwater management. Indeed, the case can further be considered as authority for the proposition that the Texas judicial system in 1904 would make no attempt to adjust private rights in a property whose movements were so secret and occult (at least, to the judges) as water under the surface of the ground.

The East case also is considered as having established the law of capture in Texas. Brown v. Humble Oil and Refining Co., 126 Tex. 296, 83 S.W.2d 935 (1935). Writing in 22 Texas Law Review 9 (1922), former Texas Supreme Court Justice Joe Greenwood cited the East case as one of the finest opinions of Justice F. W. Williams, concluding that it formed the basis for just rules with respect to the rights of adjoining owners in the appropriation of petroleum.

In the field of water law, no consolation is found in the law of capture. Of what value would it be to a landowner to offset a neighbor's wells and produce an enormous amount of water for which he had no use. This would further deplete the reservoir, reduce the pressure and lower the standing level with consequent increase of pumping expense. To use the law of capture in such a situation is simply to say that one who has been injured may go and inflict a like injury upon his neighbor. If the law of capture has any true application to underground water, it is an extremely limited one. No one can live in a vacuum. Therefore, all property rights are, to some extent, correlative. C.f. dissent by Justice Wilson, City of Corpus Christi v. Pleasenton, 154 Tex. 284, 276 S.W.2d 798 (1955).

The historic rule of the East case was sought to be modified or overruled in Pecos County Water Control and Improvement District No. 1 v. Williams, 271 S.W.2d 503 (Tex. Civ. App.--El Paso 1954, writ ref'd n.r.e.), known as the Comanche Springs case. But the Court of Appeals unswervingly followed East saying: "the landowner owns the percolating water under his land and that he can make a non-wasteful use thereof, and such is based on a concept of property ownership." 271 S.W.2d at 505.

The Comanche Springs case might have had a different result had the controversy been between competing adjoining landowners contesting for water underlying their land. But instead, the case involved surface water users from a stream whose source of water was springs. The spring-surface water users had sued other landowners whose deep irrigation wells and the pumping therefrom had dried up the springs. As in the East case, the court again seemed to invite legislative action to adjust the rights of the parties. This can be found in the following language:

> With regard to plaintiff's plea . . . to have its correlative rights declared we do not find an authority sufficient to authorize the granting of such request. In the field of oil and gas correlative production was created by specific statutory authority, which authority expressly recognizes the ownership of the surface owner and merely regulates the production of said oil and gas and is therefore administrative in nature. There is no similar statute in this field except such as is found in those permitting creation of a water district. (Emphasis supplied).

The court obviously was referring to creation of an underground water conservation district.

At about the same point in time 1954, the Texas Supreme Court again reaffirmed its agreement with the rule in the East case. In City of Corpus Christi v. City of Pleasanton, supra, the court reversed the San Antonio Court of Civil Appeals, 263 S.W.2d 799, and allowed Corpus Christi to pump its groundwater wells into the Nueces River and flow it downstream 118 miles, even though as much as 75% of the water was lost in transit. Contrary to the San Antonio Civil Appeals Court's finding, the Supreme Court's majority said this loss was not waste because 25% was beneficially used in meeting the city's municipal requirements. The court concluded:

> It thus appears that under the common law rule adopted in this state an owner of land could use all of the percolating water he could capture from wells on his land for whatever beneficial purpose he needed it, on or off of the land, and could likewise sell it to others for use off of the land and outside of the basin where produced, just as he could sell any other species of property. We know of no common-law limitation of the means of transporting the water to the place of use.

Justices Meade Griffin and Will Wilson dissented from the majority in the Corpus Christi case on both the issue of absolute ownership and waste. Their view was that legal rights in groundwater should be declared correlative because people are producing from a common reservoir "which is physical in nature and in fact correlative." They agreed with the argument advanced by the losers in the Comanche Springs case that modern development and knowledge in geology and hydrology has outmoded the reasoning of Acton v. Blundell and the East case. They likewise dissented on the ground that even under the ownership theory the common law would not countenance the waste of 75% of the flow of groundwater wells. They reasoned that water is never destroyed in the hydrological cycle: seawater is evaporated and falls as rain and ultimately reaches the sea again. "For this reason, the legal term waste does not mean the destruction of water but rather its escape from beneficial use . . . It is an illegal handling or abandonment . . ." Since reasonable minds could differ as to whether too much water had been allowed to escape, the question, they said, was one of fact. The trial court having found upon abundant evidence that waste was occurring and 75% was lost and that this loss was unreasonable, they would have affirmed the action of the trial court. C.f. Joe R. Greenhill and Thomas Gibbs Gee, Ownership of Groundwater in Texas, The East Case Reconsidered, 33 Texas Law Review 620 (1955).

The decision in the Corpus Christi case and the refusal of writ in the Comanche Springs case makes clear that the Texas Supreme Court intends for the present at least to adhere to the rule of the East case, which has become a rule of property apparently confirmed by the legislature. This does not mean, of course, that if the whole question were now before the court for the first time the East rule would be chosen. Legislative action on the question of waste is all but invited, as the excerpts quoted above show. Management of groundwater, under the decision, is primarily a legislative, not a judicial problem. The court apparently believes that front-line regulations of groundwater production should not be on a suit-by-suit basis in the courts.

The most recent federal judicial expression respecting Texas Property rights in groundwater is City of Altus v. Carr, 255 F. Supp. 828 (1966). This case fairly summarized Texas law on the subject, as follows:

> Under the law of the State of Texas, a landowner has the right to drill wells and appropriate all the underground percolating waters found to his own purposes, and if in the exercise of such right, he intercepts or drains off water from beneath his neighbor's land, this inconvenience to his neighbor falls within the description of damnum absque injuria, which cannot be on the ground of an action. City of Corpus Christi v. City of Pleasanton, 154 Tex. 289, 276 S.W.2d 798 (1955), Houston & T.C. Ry. Co. v. East, 98 Tex. 146, 81 S.W. 279 (1904). This right to enter upon the land and appropriate underground percolating waters is an interest in real estate, and may be exercised by the landowner or made the subject of an independent grant of ownership. Evans v. Ropte, 128 Tex. 75, 96 S.W.2d 973 (1936). Further, after the water has been appropriated, the landowner, his lessee or assign, has the right to sell the water to others for use off of the land and outside the basin where produced, just as he could sell any other species of property. City of Corpus Christi v. City of Pleasanton, 154 Tex. 289, 276 S.W.2d at 802 (1955); Pecos County Water Control & Improvement Dist. No. 1 v. Williams, 271 S.W.2d 503, 505 (Tex. Civ. App. 1954, err. ref. n.r.w.); Texas Co. v Burkett, 117 Tex. 16, 296, S.W.273, 278, 54 A.L.R. 1397 (1927). These rights, although not codified, have been generally recognized by statute as property rights of sufficient character for ownership. Art. 7880-3c, subsection D, Vernon's Ann. Tex. Civ. Stats. and Art. 7477b, Section 7, Vernon's Ann. Tex Civ. Stats. Thus, except for Section 2 of Article 7477b, the general law of the State of Texas, which recognizes water that has been withdrawn from underground sources

> as personal property subject to sale and commerce, would allow the Plaintiffs to withdraw water from the Mock's land and transport same to the City of Altus. "This statute, however, seeks to prohibit the production of underground water for the purpose of transporting same in interstate commerce, and has the effect of prohibiting the interstate transportation of such water after it has become personal property. Whether a statute by its phraseology prohibits the interstate transportation of an article of commerce after it has become the personal property of someone as in the Pennsylvania and West cases, or prohibits the withdrawal of such substance where the intent is to transport such in interstate commerce the result upon interstate commerce is the same. In both situations, the purpose and intent of the statute and the end result thereof is to prohibit the interstate transportation of an article of commerce. Clearly, then, Section 2 of this statute constitutes an unreasonable burden upon interstate commerce. Plaintiffs should not be denied by the provisions of such statute the right to withdraw and move water in interstate commerce." City of Altus, Oklahoma, et al. v. Carr, 255 F.Supp. 828.

PROTECTION OF WATER QUALITY

The groundwater underlying one's land is deserving of protection from pollution, and where damages can be shown the courts will allow a monetary award. Thus, where an oil operator negligently permits saltwater to escape from his disposal pit and fails to protect the fresh water stratum underlying the lessor's land, he is liable to the lessor for damages. Brown v. Lundell, 344 S.W.2d 863 (Tex. Sup. 1961); Murfee v. Phillips Petroleum Co., 492 S.W.2d 667 (Tex. Civ. App.--El Paso 1973, writ ref'd n.r.e.). An oil operator also is liable for damages if the groundwater of an adjoining property owner is polluted by saltwater intrusion from saltwater disposal pits. Gulf Oil Corp. v. Alexander, 295 S.W.2d 901 (Tex. Sup. 1956). In each of these cases, the parties damaged were using their groundwater for irrigation purposes. The Amarillo Court of Civil Appeals in the Alexander case placed great reliance on Rule 20 of the Railroad Commission of Texas which reads as follows:

> "Rule 20. Fresh water, whether above or below the surface shall be protected from pollution, whether in drilling, plugging or disposing of saltwater already produced."

The court said, "It is apparent this rule specifically prohibits the pollution of fresh water by the disposal of saltwater without any reference to negligence. Since appellant admits, as established by the undisputed record, that it pollutes appellee's fresh water strata with saltwater, appellant is liable for such pollution by reason of its violation of Rule 20 above set forth." The Supreme Court, per curiam, concluded there was evidence to support the jury's findings of common law negligence and approximate cause, and writ of error was refused, no reversible error. Apparently the Supreme Court was reluctant to overturn Turner v. Big Lake Oil Company, 128 Tex. 155, 96 S.W.2d (1936), and by so doing hold there could be liability without fault. Since this decision the question has been up in the air, although Justice Smith in his dissent in Lundell, supra, accused his colleagues of holding "that the mere happening of the saltwater percolating downward and polluting the fresh water strata is sufficient to convict the petitioners of negligent acts against the public policy of the state." It is reasonable to conclude that Justice Smith judged the effect of his colleague's decision with perspicacity, and the courts will find liability without fault--regardless of what it is called or how the ruling is camouflaged by semantice--in those cases where good groundwater is polluted by oil and gas exploration operations. If this be so, then the courts have definitely recognized that the private ownership of water underlying a person's land is such that compensation can be received when this property is damaged.

No recent cases have been found where an injunction was given to protect a landowner from a threat of groundwater pollution. The Eastland Court of Civil Appeals declined to do so in Beatty v. City of Abilene, 458 S.W.2d 496 (Tex. Civ. App.--Eastland 1970, no writ), concluding that the landowner could later seek damages if his groundwater was polluted by the city's land fill garbage disposal project. This is believed to be bad law because once pure water is polluted, it is ruined forever and will migrate onward to pollute other waters. An earlier court had enjoined establishment of a cemetery on the land next to an adjoining landowner's domestic well, but there the jury had found that rain water falling on the cemetery would have carried disease-producing germs from the cemetery so as to reach the plaintiff's well used by his family and thereby endangered the family's health which would have been irreparable injury. Elliott V. Ferguson, 103 S.W. 453 (Tex. Civ. App. 1907), reversed on other grounds, 101 Tex. 317, 107 S.W. 51 (1908). An even earlier case had also enjoined location of a cemetery in order to protect domestic wells. Jung et al. v. Neraz, 9 S.W. 344 (Tex. Sup. 188').

SUBSIDENCE

The Gulf Coast Aquifer underlies the Houston-Galveston gulf coast complex, an area where a large number of Texans live. Massive withdrawals of groundwater for municipal, industrial and irrigation uses are causing serious land subsidence problems. The hydraulics of the aquifer system are such that when water is withdrawn from the sands, hydrostatic pressure in the sands is reduced, causing water to move from the clays and silts. The latter thereby become compacted, reducing their volume, and land subsidence results. This drastically affects structures on the surface.

The general and widespread problem of subsidence particularly found in the Harris and Galveston Counties area has been considered in numerous writings. Land Surface Subsidence in the Houston-Galveston Region, Texas, compiled by R. K. Gabrysch and C. W. Bonnet, Texas Water Development Board Report 188 (1975); Winslow and Wood, Relation of Land Subsidence to Ground-Water Withdrawals in the Upper Gulf Coast Region, Texas, Mining Eng., October 1959, pp 1030-1034; Wood and Gabrysch, Analog Model Study of Ground Water in the Houston District, Texas, Texas Water Rights Commission Bulletin 6508 (1965); Land Subsidence in the Houston Gulf Coast Area, a Report to the 64th Legislature prepared by the Gulf Coast Waste Disposal Authority pursuant to H.B. 705 of the 63rd Legislature (1975).

The detrimental effects of this phenomenon are: (1) structural damage, probably due to faulting, that has cracked buildings and disrupted pavements; (2) damage to well casings and buried utility lines; and (3) submergence of coastal lowlands. The total amount of subsidence is dependent upon the groundwater withdrawals. USGS Open File Report, Land Surface Subsidence in the Houston-Galveston Region, Texas, (1969), by Gabrysch.

The subsidence problem raises substantial legal questions regarding the rights of landowners to have their land supported so that it doesn't cave in or subside. Support is of two kinds, lateral and subjacent. Lateral support is the right of land to be supported by the land which lies under it. Couch v. Clinchfield Coal Corp., 148 Va. 455, 139 S.E. 314 (1927).

The question of liability for removal of subjacent support is far from clear in Texas. However, the Texas Supreme Court has recently indicated that some claims for damages resulting from subsidence may be recoverable. In Friendswood Development Co. v. Smith-Southwest Industries, Inc., 576 S.W.2d 21 (Tex. Sup. 1978) the Supreme Court considered the question of whether landowners who withdrew percolating groundwaters from wells located on their own land are liable for subsidence which resulted on lands of others in the same general area. The court noted that the wells from which the water was pumped were drilled and completed between 1964 and 1969. During this period of time other jurisdictions adhering to the English groundwater rule denied liability for neighboring land subsidence.

On the basis of earlier decisions from both England and other states, the American Law Institute adopted the following rule in the Restatement of Torts § 818 (1939):

> § 818 Withdrawing Subterranean Water. To the extent that a person is not liable for withdrawing subterranean waters from the land of another, he is not liable for a subsidence of the other's land which is caused by the withdrawal.

The American Law Institute, however, in 1969 reversed itself regarding the liability. In the Restatement of Torts, 2nd, § 818 now reads:

> § 818 Withdrawing Subterranean Substances. One who is privileged to withdraw subterranean water, oil, minerals or other substances from under the land of another is not for that reason privileged to cause a subsidence of the other's land by such withdrawal.

The Supreme Court noted that this shift in the Restatement occurred after the wells had been completed and was reluctant to change the age old rule pronounced in the East case. But the court noted that there was "no valid reason to continue this special immunity insofar as it relates to future subsidence proximately caused by negligence in the manner which wells are drilled or produced in the future." 376 S.W.2d at p. 30. As a result, the court ruled that if the landowner's manner of withdrawing groundwater from his land is negligent, willfully wasteful, or for the purpose of malicious injury, and such conduct is the proximate cause of the subsidence of the land of others, he will be liable for the consequences of his conduct. This rule applies to wells drilled after November 29, 1978.

SUMMARY OF TEXAS STATUTORY LAW OF GROUNDWATER

Texas statutes relating to groundwater are scattered throughout several volumes of the statutes and the Texas Water Code. A number of state agencies, such as the Texas Department of Water Resources, Texas Railroad Commission, and Texas Department of Health, each have jurisdiction of groundwater. In addition, numerous water districts and river authorities have limited jurisdiction and underground water districts may be created to regulate the development of groundwater in specifically designated areas.

GENERAL APPLICATION LAWS

The Legislature has declared it to be the public policy of the State to maintain the quality of water in the State. This includes groundwater, percolating or otherwise. The law forbids unauthorized or unpermitted discharges of waste which will cause pollution of any of the water in the State, Texas Water Code § 26.121 (Vernon Supp. 1984), and violators subject themselves to $50 to $1,000 per day civil penalty or injunctive restraint and the same civil penalty. Texas Water Code § 26.123, supra. Although the Texas Department of Water Resources seeks the relief with the Attorney General as its lawyer, local governments may also institute suit for the same relief and the Department of Water Resources is a necessary party to the action Texas Water Code § 26.124, supra, because it is the principal authority in the State on matters relating to the quality of the water. Texas Water Code § 26.127, supra.

The Texas Railroad Commission is solely responsible for the abatement and prevention of pollution of subsurface water resulting from activities associated with the exploration, development and production of oil or gas. Texas Water Code § 26.131, supra. A private corporation or individual may still pursue any available common-law remedy to abate pollution or other nuisance or to recover damages. Texas Water Code § 26.131, supra.

The Legislature has further sought to protect groundwater when subsurface disposal wells are drilled to dispose of industrial and municipal waste or oil and gas waste into a subsurface stratum. If industrial and municipal wastes are being disposed of underground a permit for the well is required from the Texas Water Commission; Texas Water Code § 27.011, supra; the Railroad Commission grants permits to dispose of oil or gas waste underground. Texas Water Code § 27.031, supra. Permits granted by either Commission will provide for necessary casing as well as other safeguards designed to protect the groundwater. Civil penalties of up to $5,000 to $10,000 per day are provided for violators as well as injunctive relief. Texas Water Code §§ 27.101 and 27.102. The fact that a person has a permit does not relieve him from any civil liability. Texas Water Code § 27.104.

Since 1931, the Texas Water Development Board or its predecessor, the Board of Water Engineers has been authorized to "make and enforce rules and regulations for conserving, protecting, preserving, and distributing underground, subterranean, and percolating water located in this state, and shall do all things necessary for these purposes." Texas Water Code § 28.011, supra. Owners of water wells are further required to securely plug or case wells to prevent the water from escaping. Texas Water Code § 28.012, supra. These never used sections of the law were enacted by the Forty-second Legislature in 1931 and apparently were aimed at preventing contamination of the state's groundwater, as evidenced by the Act's emergency clause:

> "The fact there is no Statute in Texas sufficient to protect the underground water supply of the State from pollution and contamination and that irreparable loss and injury is being suffered by landowners of the State from pollution and contamination and that irreparable loss and injury is being suffered by landowners of the State from pollution and contamination of fresh water supply because of improperly cased and plugged wells, create an emergency and an imperative public necessity . . ." (General Laws, 42nd Legislature, 1931, Regular Session, Chapter 261, p.432)

The 1931 Act became effective on May 28 of that year and rules were speedily implemented. The rules and regulations on the subject were immediately published, "effective on and after May 28, 1931.

The 1931 law was construed by Attorney General Gerald C. Mann in Opinion No. 0-3205 of the Assistant Attorney General James P.

Hart, on March 11, 1941. The conclusion was that the law was constitutional and "the State may impose reasonable regulations for the preservation and conservation of underground, subterranean, and percolating waters within this State." Further, "the Board of Water Engineers may require of owners of water wells, other than artesian, annual reports covering the same information required by Article 7615, V. A. C. S. (Section 5.207, Texas Water Code), of owners of artesian wells . . ."

Then in an abrupt about face five weeks later on April 18, 1941, Opinion No. 0-3205 was withdrawn and Opinion No. 0-3205-A, by the same author, was substituted. The Board was advised that it no longer had rule-making power under then Article 7615, Vernon's Civil Statutes or then Article 848A, Penal Code because the Legislature had not established sufficient guidelines or standards for the Board to make and enforce rules "for the conservation, protection, preservation and distribution of all underground, subterranean and percolating waters." Great reliance was placed on Brown v. Humble Oil and Refining Co., quoting:

> "In the absence of a well-defined standard or rule in the statutes defining the public policy of the state with respect to the mineral interest, the Railroad Commission would be without authority to promulgate rules, regulations, or orders relating to the protection of oil and gas. The power to pass laws rests with the Legislature, and that power cannot be delegated to some commission or other tribunal."

Later cases are believed to have modified the decision in the Brown case relative to rules of administrative agencies and Opinion No. 0-3265-A probably would not be sustained by the Texas Supreme Court. Cf. Texarkana & F. S. RY. Co. v. Houston Gas & Fuel Co., 51 S.W.2d 284 (Tex. Sup. 1932); Gulfland Co. v. Atlantic Refining Co., 131 S.W.2d 73 (Tex. Sup. 1939); Northeast Tarrant County Water Authority v. Board of Water Engineers, 367 S.W.2d 720 (Tex. Civ. App.--Austin 1963, no writ).

At the present time, the Texas Water Development Board has no rules relating to filing of annual reports by those producing water from wells. Nor has the Board currently promulgated rules to "conserving, protecting, preserving, and distributing underground water," as Section 28.011 apparently mandates.

These sections of the water code suggest some intriguing possibilities for Statewide management of groundwater. At the same time, the political questions raised by an attempt to resurrect these long dormant statutes and the attendant weakness of the statutes probably rule these out as a viable alternate for groundwater management.

UNDERGROUND WATER DISTRICTS

In the 1940's it became obvious to those living in the High Plains of far West Texas that the water table of the vast Ogallala groundwater formation was being lowered by irrigation pumpage, that waste was occurring, that competition between closely-spaced wells was reducing their efficiency, and that the water was being mined because withdrawals greatly exceeded the recharge. A High Plains Water Association of concerned citizens and public officials was formed to push for remedial legislation which culminated in 1949 with enactment of the law authorizing creation of Underground Water Conservation Districts. Texas Water Code, Chap. 52, supra.

The purposes of these districts are "to provide for the conservation, preservation, protection, recharging, and prevention of waste of the underground water of underground water reservoirs or their subdivisions, consistent with the objectives of Article XVI, Section 59, of the Texas Constitution." Waste is defined as:

> "(A) Withdrawal of underground water from an underground water reservoir at a rate and in an amount that causes or threatens to cause intrusion into the reservoir of water unsuitable for agricultural, gardening, domestic, or stock raising purposes;
>
> "(B) The flowing or producing of wells from an undergound water reservoir if the water produced is not used for a beneficial purposes;
>
> "(C) Escape of underground water from an underground water reservoir to any other reservoir that does not contain underground water;
>
> "(D) Pollution or harmful alteration of underground water in an underground water reservoir by salt water, other deleterious matter admitted from another stratum or from the surface of the ground; or

> "(E) Willfully causing, suffering, or permitting underground water to escape into any river, creek, natural watercourse, depression, lake, reservoir, drain, sewer, street, highway, road, or road ditch, or onto any land other than that of the owner of the well." Texas Water Code § 52.001(6), supra.

Before a district can be created the Texas Water Commission must first delineate an underground water reservoir or subdivision thereof which the Water Code, in Section 52.001(4) and (5) define as:

> "(4) 'Underground water reservoir' means a specific subsurface water-bearing reservoir having ascertainable boundaries and containing underground water that can be produced from a well at a rate of 150,000 gallons or more a day.
>
> "(5) 'Subdivision of an underground water reservoir' means a reasonably definable part of an underground water reservoir in which the underground water supply will not be unreasonably affected by withdrawing water from any part of the reservoir, as indicated by known geological and hydrological conditions and relationships and on foreseeable economic development at the time the subdivision is designated or altered."

Section 52.024 sets forth the means of initiating proceedings by allowing persons to petition the Commission to designate the boundaries of a reservoir or its subdivision, or the Commission may act on its own motion and call upon the Executive Director of the Texas Department of Water Resources to prepare available evidence relating to the existence, area and characteristics of the reservoir or its subdivision. A delineation order is entered by the Commission, and, following this action, persons may petition for creation of a district whose boundaries will be coterminous with the boundaries of the reservoir or its subdivision. Texas Water Code § 52.023, supra. Petitions are filed with the Commission unless the area is wholly within one county, in which event the petition is filed with the commissioners' court. If the commissioners' court or the Commission "finds that the district is feasible and practicable, that it would be a benefit to land in the district, and that it would be a public benefit or utility, the commissioners court or the Commission shall make these findings and grant the petition." Texas Water Code § 52.025(a), supra.

One of the basic weaknesses of the present groundwater district law is its reliance on certain provisions of the general law governing water control and improvement district law, Texas Water Code, Chap. 51, particularly as these relate to confirmation of the district. Thus, although confirmation should be by majority vote of the electors in the proposed district, disapproving counties and cities can vote themselves out. This results because under §52.051 the administrative and procedural provisions of Chapter 51 (W.C.&I.D. law) apply. Thus a county, bcause of §51.306, can vote not to be included even though its entire area overlies a part of the reservoir or its subdivision. Hale County voted not to be a part of the High Plains Underground Water Conservation District even though the district now wholly surrounds it, and production of water by Hale County farmers is probably greater than in any other county in the State. Likewise for cities, since §51.035 will not allow a city to be included in the district unless a majority of the city's voters approve. Even Section 52.026 of the underground water district law permits segregated irrigated areas to vote not to be included. This nibbling away of support of a district can do nothing but weaken its structure, limit its area of control and reduce its effectiveness.

Once created and the five directors constituting its governing board are elected, an underground water conservation district can exercise substantial powers. Principally, these can be enumerated as follows:

1. Require permits for wells (Sec. 52.114).
2. Require drillers' logs of wells (Sec. 52.113).
3. Acquire land for dams, erect dams, drain lakes, and recharge the underground reservoir (Sec. 52.104).
4. Conduct surveys (Sec. 52.104).
5. Develop comprehensive plans (Sec. 52.108).
6. Carry out research projects (Sec. 52.109).
7. Collect information on water use and recharge (Sec. 52.110).
8. Require reports on completion of wells and production and use of water (Sec. 52.112).
9. Publish plans and information (Sec. 52.111).
10. Space wells and regulate their production (Sec. 52.117).
11. Make and enforce rules (Sec. 52.101).

The most active of the districts are the High Plains Underground Water Conservation District, headquartered at Lubbock;

North Plains Ground Water Conservation District, Dumas; Panhandle Ground Water Conservation District No. 3, White Deer; and Edwards Underground Water Conservation District, San Antonio. The latter was created by the Legislature, and the others were established under Chapter 52 and overlie subdivisions of the Ogallala. The Legislature declined to give the Edwards District the authority to prorate production of wells and, although having the power, the other districts have declined to exercise it. Most have directed their efforts toward prevention of waste, recharge work, educating the people in the district on the need for conservation efforts and gathering data on the decline of water table levels. Information on the latter is important because the Internal Revenue Service must now grant a 15% depletion allowance on reduction in property values due to reduction in the water table of the Ogallala formation in the Southern High Plains. This was established in the Shurbet case. United States v. Shurbet, 247 F.2d 103 (5th Cir., 1965). The High Plains District at Lubbock actively participated in this litigation and financed the major portion of the tremendous costs incurred in winning the case against the federal government. The district claims that its residents annually save millions of income tax dollars as a direct result of this decision.

There is no appellate case specifically upholding the constitutionality of underground water conservation districts following a direct challenge, although district courts in Hockly, Deaf Smith, and Lubbock Counties have upheld the ditricts' well spacing authority. In a 1951 case, Section A(9) of Article 7880-3c (Chap. 52 of the Texas Water Code) relative to exclusion of grazing lands was held unconstitutional, but the remainder of the Act was not in any way here invalidated. Ground Water Conservation District No. 2 v. Hawley, 304 S.W.2d 764 (Tex. Civ. App.--Amarillo, 1957) error ref'd 306 S.W.2d 352. The constitutionality of river authorities and other types of water districts has been upheld in numerous decisions and there is little doubt since Corzelious v. Harrell, 143 Tex. 509, 186 S.W.2d 961 (1945), that the police power of the State may be constitutionally exercised over natural resources, whether oil or groundwater, pursuant to the Conservation Amendment of the Texas Constitution.

We perceive from Victoria's standpoint that the police powers of underground water conservation districts may prove to be insufficient. These districts do not have the power to prohibit the owner of the surface estate from producing groundwater under his estate. Prevention of waste, recharge work, and education alone are not enough to protect groundwater supplies as may be desired by the city. Hence regulation of the resource is incumbant if the city desires to fully protect the aquifer from either excessive use or pollution.

Rather than resorting to the general law type district, Texas Water Code Chap. 52, consideration should be given to special legislation to deal specifically with anticipated problems and need for protection. This was the recourse selected to cope with the subsidence problem in and around Houston.

In 1975, the Legislature passed a special groundwater district act for the purpose to reduce and prevent subsidence. The district is the Harris-Galveston Coastal Subsidence District Acts 1975, 64th Leg., R.S., Ch. 284, p.672. To accomplish its purpose, the district was generally impowered to regulate withdrawals of groundwater in the district, Section 6, and to require permits for such wells charging a fee therefore. Section 37. A copy of this Act is attached for comparative purposes.

By creating a special district, the Legislature avoided the problems faced by the traditional groundwater districts. Boundaries of underground aquifers, to which traditional districts are tied, become immaterial. And, power to regulate groundwater withdrawals is delegated to the district that is not included under the general law relating to underground conservation districts. Another consideration might be to seek an amendment to Texas Water Code, Chapt. 52, to authorize regulating groundwater withdrawals by underground conservation districts.

Opponents to the district challenged its creation on a number of grounds. In overruling all the points, the Court of Civil Appeals found the district constitutional and its method of regulation within the power of the legislature to authorize. Beckendorff v. Harris-Galveston Coastal Subsidence District, 558 S.W.2d 75 (Tex. Civ. App.--Houston [14th] 1977) aff'd 563 S.W.2d (1978).

CONCLUSION

Since 1904, the Texas Supreme Court consistantly has ruled that landowners possessed absolute ownership of groundwater and that they can divert it even to the extent of drying up a neighbor's well and water supply. The only recourse offered is in limited circumstances in the context of litigation.

Use of an underground water district created under Texas Water Code Chap. 52, to protect the resource is of limited value. This is due to the restrictions and lack of power vested in the district to fully regulate the groundwater in the district.

To fully protect the aquifer, resort should be to special legislation or legislation expanding the powers of underground conservation districts. The legislation may address the unique regulatory problems anticipated as well as to permit control over withdrawals of ground water. In this fashion, the aquifer supplying Victoria water might be protected through the year 2030.

Very truly yours,

Frank R. Booth

FRB:shm