WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT
IN CONJUNCTION WITH THE
TEXAS WATER DEVELOPMENT BOARD

REGIONAL WATER SUPPLY [illegible]

VOLUME I

REGIONAL WATER SUPPLY PLAN

VOLUME ONE - SUMMARY OF FINDINGS

PREPARED FOR

WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT

IN CONJUNCTION WITH THE

TEXAS WATER DEVELOPMENT BOARD
AND PARTICIPATING ENTITIES

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Engineering Report for the City of Cisco on Alternative Water Supply Facilities prepared by Jacob & Martin, Inc.

1. INTRODUCTION

The West Central Texas area faces a variety of water supply concerns that are typical of semi-arid regions. These concerns center around the need to provide sufficient quantities of water with suitable quality to people spread over a large area. Providing this water on a continuous basis requires foresight and careful planning. Identifying and developing reliable future sources of water will be critical to maintain the quality of life of communities in the area as well as enabling economic growth and development.

In August 1989, a group of 17 cities and other water supply entities within a 10-county area, sponsored by the West Central Texas Municipal Water District, authorized Freese and Nichols, Todd Engineering, and Jacob and Martin to perform a regional water supply study. The project was funded by the participating water supply entities and a grant from the Texas Water Development Board. The purposes of the study were:

a) review current and future raw water supply needs of the area,

b) identify and recommend future raw water supply alternatives for the 10-county area on both a local and regional basis to meet the projected needs through the year 2020,

c) review current and future requirements for the existing water treatment plants,

d) identify and recommend treatment facility alternatives for the potable water supply entities on both a local and regional basis to meet the projected needs through the year 2020,

e) provide estimated schedules and information needed for implementation of the treatment facility alternatives,

f) develop a general water conservation plan that could be adopted to the needs of the participating entities,

g) evaluate legal, financial, and water rate implications of the regional water supply and treatment alternatives,

h) present an evaluation of the effects of the 1986 Safe Drinking Water Act on the existing and proposed water treatment facilities, and

i) prepare evaluations of the proposed Battle Creek Diversion for the City of Cisco and the routing of the O.H. Ivie Reservoir pipeline to the City of Abilene.

The 10-county area of west central Texas encompassed by the study included the following counties:

Callahan
Coleman
Eastland
Fisher
Jones
Nolan
Runnels
Shackelford
Stephens
Taylor

The participants in this study included the following water supply entities.

City of Abilene
City of Albany
City of Anson
City of Baird
City of Breckenridge

City of Cisco
City of Cross Plains
City of Hamlin
Hawley Water Supply Corporation
City of Moran
Shackelford Water Supply Corporation
City of Stamford
City of Sweetwater
Tuscola, Taylor County Fresh Water Supply District No.1
City of Tye
West Central Texas Municipal Water District
City of Woodson

All of the potable water supply entities identified in the 10-county study area, their current customers, and their raw water supply source are listed in Table 1.1. Entities that purchase their water supply, either raw or treated, from a separate entity are included with the entity from which they purchase water. The existing water supply systems are shown in Figures 1.1 and 1.2. Figure 1.1 shows the existing cities and surface water supply reservoirs. Figure 1.2 shows the boundaries of the identified rural water supply corporations. In both, the study participants are designated by an asterisk.

The potable water supply entities, both those that utilize water treatment facilities and groundwater sources, were used as a focal point for the study. Total estimated demands and dependable supplies were developed for each existing entity. Once projected surpluses and deficits of water supply were identified, local and regional alternatives were developed for both water supply and treatment entities. The estimates of future water requirements in the 10-County study area were based on projections made by the Texas Water Development Board (TWDB) dated October 1989 and July 3, 1990. Within each county, municipal uses

Table 1.1, Continued

Water Supply Entity	Potable Water Customers	Raw Water Source
Coleman	Coleman Lawn† Coleman Co/Burkett WSC	Lake Coleman
Cross Plains*	Cross Plains	Trinity Aquifer
Eastland Co.	Eastland Ranger Carbon Morton Valley WSC Westbound WSC (Part) Staff WSC Olden WSC	Lake Leon Lake Eastland
Hamlin*	Hamlin (Part) Moore Feed Lots West Hamlin WSC Flat Top WSC South Hamlin WSC	South Lake City of Stamford
Miles	Miles	Miles Well Field
Rising Star	Rising Star	Rising Star Well Field
Roscoe	Roscoe (Part)	Roscoe Well Field
Santa Anna	Santa Anna	Lake Santa Anna Brown Co. WCID#1
Stamford*	Stamford Lueders Avoca Community Private (near Hamlin) Hamlin (Part)† Sagerton WSC Ericksdahl WSC Paint Creek WSC	Lake Stamford

Table 1.1

West Central Texas Regional Water Supply Study
Existing Potable Water Supply Entities
Current Supplies and Customers

Water Supply Entity	Potable Water Customers	Raw Water Source
Abilene*	Abilene Merkel Tye* Feed Lots Pride Refining Potosi WSC View-Caps WSC Sun WSC Steamboat/Tuscola WSC* Blair WSC Hamby WSC Hawley WSC (Part)*	Lake Fort Phantom Hill Hubbard Creek Reservoir Lake Abilene
Albany*	Albany Moran* Shackelford WSC* Moran SWSC	Hubbard Creek Reservoir Lake McCarty
Anson*	Anson Hawley WSC (Part)*	Hubbard Creek Reservoir South Anson Lake
Baird*	Baird	Baird Lake
Ballinger	Ballinger N. Runnels WSC (Part) Rowena WSC	Lake Ballinger
Breckenridge*	Breckenridge Stephens Co. WSC Woodson (Part)	Hubbard Creek Reservoir Lake Daniel
Buffalo Gap	Buffalo Gap	Buffalo Gap Well Field
Cisco*	Cisco Westbound WSC (Part)	Lake Cisco Battle Creek Diversion
Clyde	Clyde Eula WSC	Lake Clyde

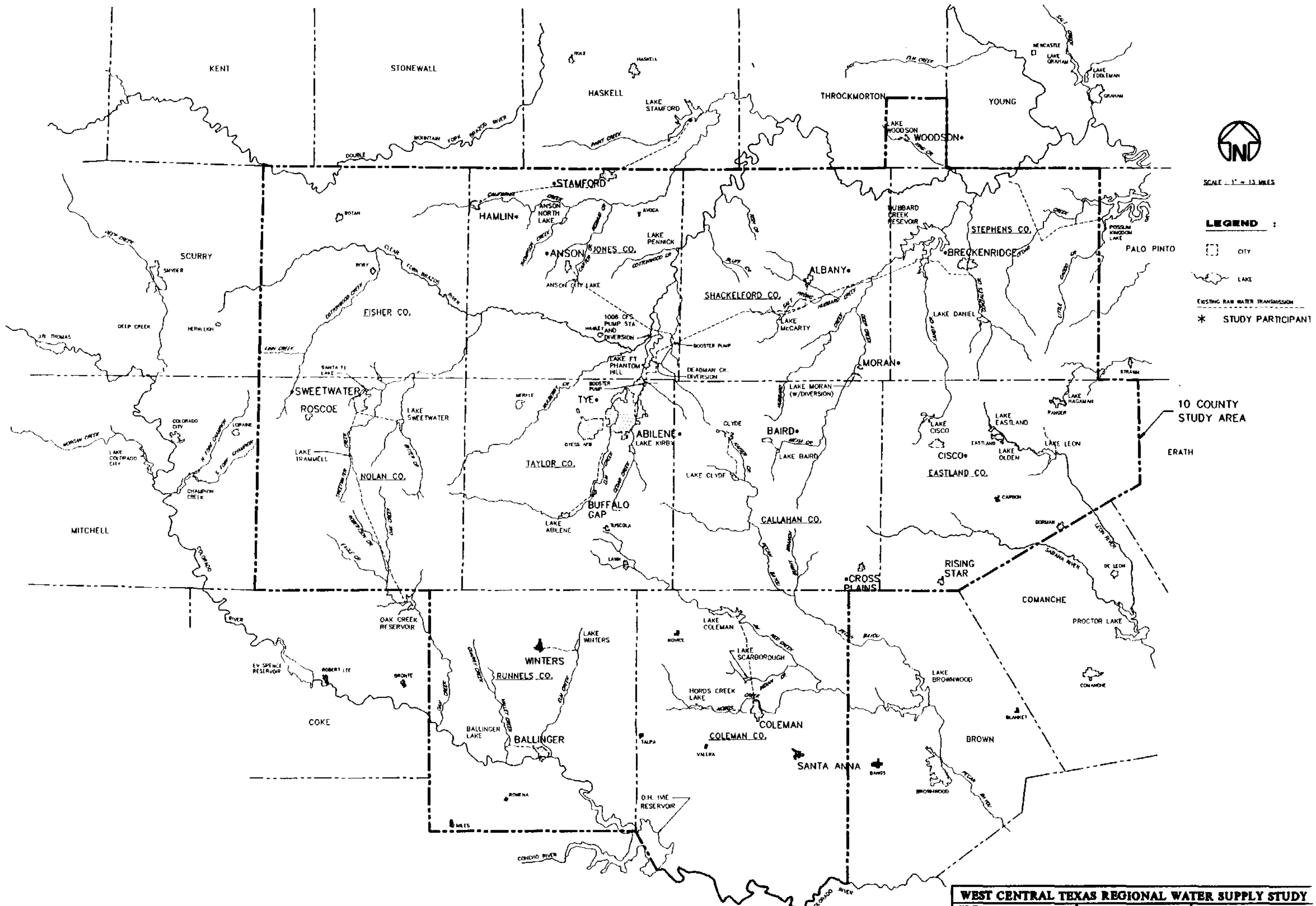
Table 1.1, Continued

Water Supply Entity	Potable Water Customers	Raw Water Source
Coleman	Coleman Lawn† Coleman Co/Burkett WSC	Lake Coleman
Cross Plains*	Cross Plains	Trinity Aquifer
Eastland Co.	Eastland Ranger Carbon Morton Valley WSC Westbound WSC (Part) Staff WSC Olden WSC	Lake Leon Lake Eastland
Hamlin*	Hamlin (Part) Moore Feed Lots West Hamlin WSC Flat Top WSC South Hamlin WSC	South Lake City of Stamford
Miles	Miles	Miles Well Field
Rising Star	Rising Star	Rising Star Well Field
Roscoe	Roscoe (Part)	Roscoe Well Field
Santa Anna	Santa Anna	Lake Santa Anna Brown Co. WCID#1
Stamford*	Stamford Lueders Avoca Community Private (near Hamlin) Hamlin (Part)† Sagerton WSC Ericksdahl WSC Paint Creek WSC	Lake Stamford

Table 1.1, Continued

Water Supply Entity	Potable Water Customers	Raw Water Source
Sweetwater*	Sweetwater	Oak Creek Reservoir
	Trent	Lake Trammel
	Roby	Lake Sweetwater
	Roscoe (Part)	Getty (Texaco) Well Field
	Blackwell	
	Bronte	
	Chadborne Ranch	
	Blackwell-Nolan FWSD	
	Bitter Creek WSC	
	Sylvester-McCauley WSC	
Winters	Winters	Lake Winters
	N. Runnels WSC (Part)	
Woodson*	Woodson (Part)	Lake Woodson

*Study Participant
†Raw Water Customer



WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY

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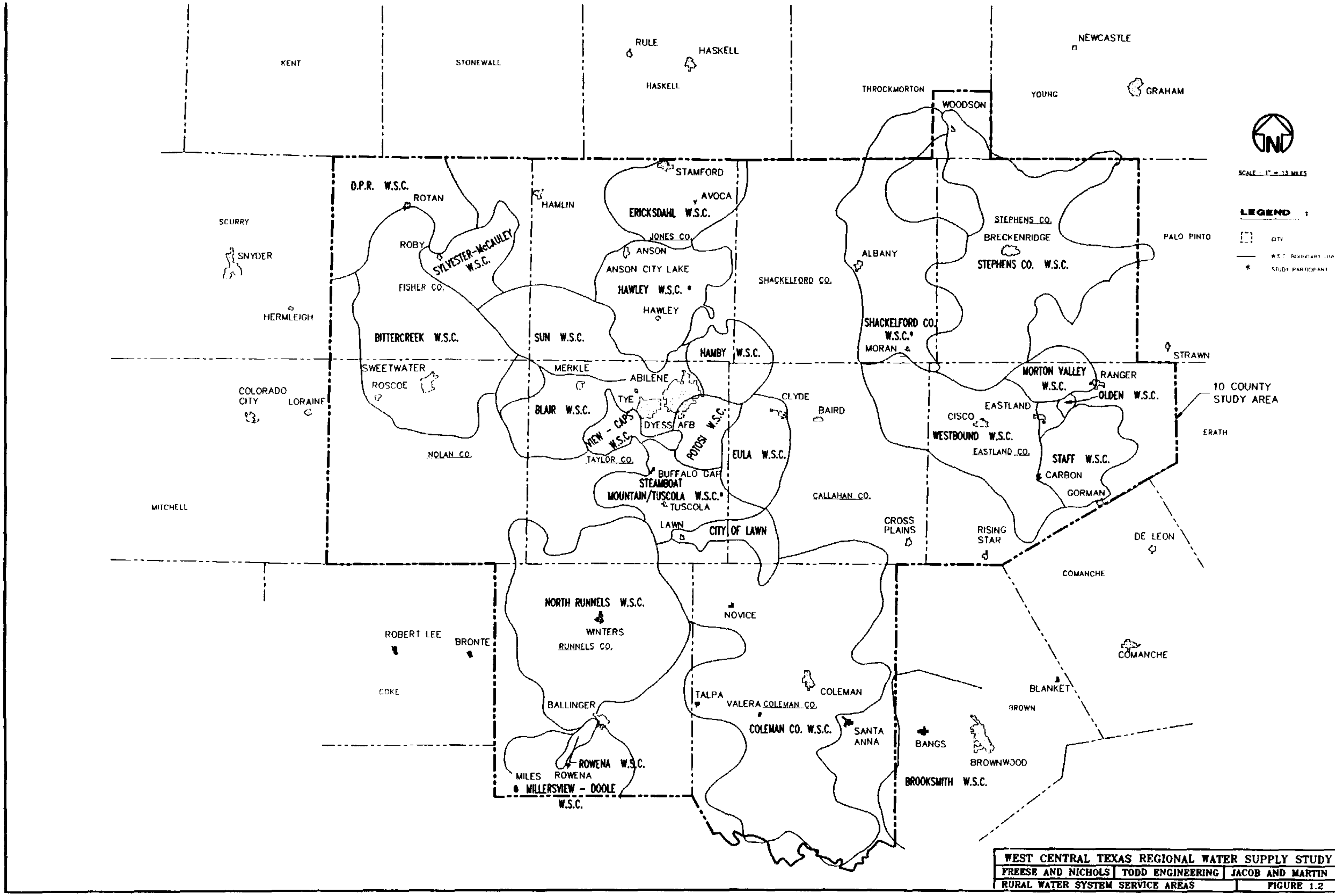
EXISTING POTABLE WATER SUPPLY ENTITIES		FIGURE I.I



WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY

FREESE AND NICHOLS | TODD ENGINEERING | JACOB AND MARTIN

RURAL WATER SYSTEM SERVICE AREAS | FIGURE 1.2

are also estimated individually for the principal cities. For the purposes of this study, the TWDB projections for both the low and the high population series assuming high per capita municipal use with additional conservation were used. Available supplies were based on the estimated safe yields of the raw water sources. The yields were evaluated for the existing supply sources and projected over the study period from the latest reports available. The safe yield of a reservoir is the annual withdrawal that can be taken that would leave a quantity of water equal to one year's use stored in the reservoir at the end of the critical period.

For the study area, the available groundwater is being used by a few cities and for irrigation. However due to the concerns about dependability, quality, and the lack of suitable recharge, groundwater is not considered a sound solution for long term water supply. For all entities that currently depend on groundwater, alternatives were developed that assumed groundwater would not be available, though the timing of the replacement with surface water is left open in the implementation recommendations in order to allow for full utilization of the groundwater resource.

2. COMPARISON OF SUPPLY AND DEMAND

2.1 Introduction

A thorough description of the demand for both potable water supply and production is presented in chapter 3 of the main text for the various potable water supply entities. It was estimated that the overall potable water demand for the 10- county area will increase from 52,533 ac-ft/yr in 1990 to 64,788 ac-ft/yr in 2020 under the high population projections. Under the low population projections these estimates are 52,054 ac-ft/yr and 58,806 ac-ft/yr in 1990 and 2020, respectively. Chapter 4 in the main text presents the estimates of the water supply available for potable use within the area. These estimates showed a total of 70,329 ac-ft per year of safe yield available for municipal use in 1990 and 65,143 ac-ft per year available in 2020. Though across the 10-county area, the total water supply available exceeds the total potable demand, the locations of the supply sources do not match the locations of the demands. Several cities show a net deficit of water supply available, while others show a surplus. The comparison of supply and demand for each of the potable water supply entities is shown in the following sections for both water supply and potable water production capacities.

2.2 Comparison of Potable Water Supply and Demand

Summaries of the projected potable water demands and supplies for each of the identified potable water supply entities are listed in Table 2.1 for both the high and low population projections. The cities of Buffalo Gap, Cross Plains, Miles, and Rising Star are shown to have

Table 2.1
Regional Water Supply Study
Comparison of Potable Water Supply and Demand
(Acre-Feet/Year)

		High Population High Per Capita Use				Low Population High Per Capita Use			
		1990	2000	2010	2020	1990	2000	2010	2020
ABILENE*	Total Demand	31,310	33,514	35,902	40,528	31,137	33,172	34,774	37,648
	Total Available	41,736	41,482	41,428	41,374	41,736	41,482	41,428	41,374
	Surplus/(Deficit)	10,426	7,968	5,526	846	10,599	8,310	6,654	3,726
ALBANY*	Total Demand	737	742	731	700	723	732	721	690
	Total Available	2,033	1,995	1,957	1,919	2,033	1,995	1,957	1,919
	Surplus/(Deficit)	1,296	1,253	1,226	1,219	1,310	1,263	1,236	1,229
ANSON*	Total Demand	711	743	767	850	708	710	709	732
	Total Available	2,061	2,061	2,061	2,061	2,061	2,061	2,061	2,061
	Surplus/(Deficit)	1,350	1,318	1,294	1,211	1,353	1,351	1,352	1,329
BAIRD*	Total Demand	428	485	541	593	428	472	458	500
	Total Available	0	0	0	0	0	0	0	0
	Surplus/(Deficit)	(428)	(485)	(541)	(593)	(428)	(472)	(458)	(500)
BALLINGER	Total Demand	1,156	1,136	1,107	1,107	1,156	1,106	1,076	1,077
	Total Available	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,596
	Surplus/(Deficit)	440	460	489	489	440	490	520	519
BRECKENRIDGE*	Total Demand	1,894	2,044	2,097	2,284	1,845	1,921	1,960	2,026
	Total Available	3,527	3,267	3,007	2,747	3,527	3,267	3,007	2,747
	Surplus/(Deficit)	1,633	1,223	910	463	1,682	1,346	1,047	721

Table 2.1, Continued

		High Population High Per Capita Use				Low Population High Per Capita Use			
		1990	2000	2010	2020	1990	2000	2010	2020
BUFFALO GAP	Total Demand	59	65	72	82	59	64	69	75
	Total Available	0	0	0	0	0	0	0	0
	Surplus/(Deficit)	(59)	(65)	(72)	(82)	(59)	(64)	(69)	(75)
CISCO*	Total Demand	1,143	1,104	1,068	1,116	1,096	979	886	889
	Total Available	540	510	480	450	540	510	480	450
	Surplus/(Deficit)	(603)	(594)	(588)	(666)	(556)	(469)	(406)	(439)
CLYDE	Total Demand	631	870	962	1,048	630	849	814	883
	Total Available	498	482	466	450	498	482	466	450
	Surplus/(Deficit)	(133)	(388)	(496)	(598)	(132)	(367)	(348)	(433)
COLEMAN (incl. Lawn)	Total Demand	1,912	2,254	2,226	2,342	1,881	2,070	2,027	2,025
	Total Available	8,855	8,715	8,573	8,435	8,855	8,715	8,573	8,435
	Surplus/(Deficit)	6,943	6,461	6,347	6,093	6,974	6,645	6,546	6,410
CROSS PLAINS*	Total Demand	269	278	311	341	268	271	263	287
	Total Available	165	165	165	0	165	165	165	0
	Surplus/(Deficit)	(104)	(113)	(146)	(341)	(103)	(106)	(98)	(287)
EASTLAND CO.	Total Demand	3,066	3,006	2,891	2,993	2,931	2,647	2,363	2,334
	Total Available	4,113	3,646	3,179	2,713	4,113	3,646	3,179	2,713
	Surplus/(Deficit)	1,047	640	288	(280)	1,182	999	816	379

Table 2.1, Continued

		High Population High Per Capita Use				Low Population High Per Capita Use			
		1990	2000	2010	2020	1990	2000	2010	2020
MILES	Total Demand	105	108	109	115	105	105	106	107
	Total Available	0	0	0	0	0	0	0	0
	Surplus/(Deficit)	(105)	(108)	(109)	(115)	(105)	(105)	(106)	(107)
RISING STAR	Total Demand	157	154	145	141	150	135	119	110
	Total Available	0	0	0	0	0	0	0	0
	Surplus/(Deficit)	(157)	(154)	(145)	(141)	(150)	(135)	(119)	(110)
STAMFORD*	Total Demand	2,130	2,189	2,235	2,483	2,125	2,091	2,066	2,140
(Incl. Hamlin*)	Total Available	(170)	(348)	(525)	(703)	(170)	(348)	(525)	(703)
	Surplus/(Deficit)	(2,300)	(2,537)	(2,760)	(3,186)	(2,295)	(2,439)	(2,591)	(2,843)
SWEETWATER*	Total Demand	5,807	6,030	6,468	7,083	5,796	5,842	6,097	6,416
	Total Available	4,015	3,871	3,726	2,741	4,015	3,871	3,726	2,741
	Surplus/(Deficit)	(1,792)	(2,159)	(2,742)	(4,342)	(1,781)	(1,971)	(2,371)	(3,675)
WINTERS	Total Demand	959	965	927	912	958	938	900	853
	Total Available	1,360	1,360	1,360	1,360	1,360	1,360	1,360	1,360
	Surplus/(Deficit)	401	395	433	448	402	422	460	507

Table 2.1, Continued

		High Population High Per Capita Use				Low Population High Per Capita Use			
		1990	2000	2010	2020	1990	2000	2010	2020
WOODSON*	Total Demand	59	67	63	60	58	64	59	54
	Total Available	0	0	0	0	0	0	0	0
	Surplus/(Deficit)	(59)	(67)	(63)	(60)	(58)	(64)	(59)	(54)
Grand Total Demand		52,533	55,754	58,622	64,778	52,054	54,168	55,467	58,806
Grand Total Available		70,329	68,802	67,473	65,143	70,329	68,802	64,473	65,143
Overall Surplus/(Deficit)		17,796	13,048	8,851	365	18,275	14,634	12,006	6,337

*participant
Water supply based on safe yields.

deficits equal to their projected demand because of their dependance on groundwater, for which no dependable withdrawal rate was available. The Cities of Baird and Woodson show deficits equal to their demands, because their sole sources of surface water supply have no dependable yield in a critical drought. The Cities of Abilene, Albany, Anson, Ballinger, Breckenridge, Coleman, and Winters show a net surplus of water supply throughout the study period for both the high and low population projections. Eastland County shows a surplus of water supply under the high population estimates until the year 2020, for which they show a deficit. However, it shows a net surplus through 2020 under the low population projections. Abilene also has water rights for 15,000 ac-ft per year from O.H. Ivie Reservoir that will provide them with additional surplus water supply beyond the year 2020 once the pump station and pipeline are completed. This quantity of water is not included in the quantity listed as water supply currently available for the City of Abilene, as the water cannot be used until a pipeline is constructed. The remaining entities, Cisco, Clyde, Moran, Stamford, and Sweetwater show net deficits in water supply for the entire study period.

2.3 Comparison of Potable Water Production Capacity and Demand

Summaries of the total potable water demands and treatment plant capacities for each of the identified potable water supply entities are listed in Table 2.2 for both the high and low population projections. Using the high population projections, the entities of Abilene, Albany, Baird, Breckenridge, Eastland Co., Hamlin, Lawn, Sweetwater, and Woodson

Table 2.2

Regional Water Supply Study
Comparison of Treatment Plant Capacity and Demand

Water Supply Entity		High Population Peak Day (MGD) 1990	High Population Peak Day (MGD) 2000	High Population Peak Day (MGD) 2010	High Population Peak Day (MGD) 2020	1990 WTP Capacity (MGD)	Low Population Peak Day (MGD) 1990	Low Population Peak Day (MGD) 2000	Low Population Peak Day (MGD) 2010	Low Population Peak Day (MGD) 2020
ABILENE*	Total Demand	55.90	59.83	64.09	72.35	52.00	55.59	59.22	62.08	67.21
	Surplus/(Deficit)	(3.90)	(7.83)	(12.09)	(20.35)		(3.59)	(7.22)	(10.08)	(15.21)
ALBANY*	Total Demand	1.81	1.82	1.79	1.72	1.70	1.78	1.80	1.77	1.69
(incl.Moran)	Surplus/(Deficit)	(0.11)	(0.12)	(0.09)	(0.02)		(0.08)	(0.10)	(0.07)	0.01
ANSON*	Total Demand	1.27	1.33	1.37	1.52	1.40	1.26	1.27	1.27	1.31
	Surplus/(Deficit)	0.13	0.07	0.03	(0.12)		0.14	0.13	0.13	0.09
BAIRD*	Total Demand	0.67	0.76	0.85	0.93	0.46	0.67	0.74	0.72	0.78
	Surplus/(Deficit)	(0.21)	(0.30)	(0.39)	(0.47)		(0.21)	(0.28)	(0.26)	(0.32)
BALLINGER	Total Demand	2.06	2.42	1.97	1.98	2.80	2.06	1.97	1.93	1.85
	Surplus/(Deficit)	0.74	0.38	0.83	0.82		0.74	0.83	0.87	0.95
BRECKENRIDGE*	Total Demand	3.55	3.83	3.94	4.28	3.46	3.46	3.60	3.68	3.79
	Surplus/(Deficit)	(0.09)	(0.37)	(0.48)	(0.82)		0.00	(0.14)	(0.22)	(0.33)
BUFFALO GAP	Total Demand	0.13	0.15	0.16	0.18	0.46	0.13	0.14	0.15	0.17
	Surplus/(Deficit)	0.33	0.31	0.30	0.28		0.33	0.32	0.31	0.29

Table 2.2, Continued

Water Supply Entity		High Population Peak Day (MGD) 1990	2000	2010	2020	1990 WTP Capacity (MGD)	Low Population Peak Day (MGD) 1990	2000	2010	2020
CISCO*	Total Demand	3.06	2.96	2.86	2.99	4.50	2.93	2.63	2.37	2.38
	Surplus/(Deficit)	1.44	1.54	1.64	1.51		1.57	1.87	2.13	2.12
CLYDE	Total Demand	1.41	1.94	2.15	2.34	2.00	1.41	1.89	1.82	1.97
	Surplus/(Deficit)	0.59	0.06	(0.15)	(0.34)		0.59	0.11	0.18	0.03
COLEMAN	Total Demand	3.95	4.69	4.59	4.80	6.00	3.89	4.30	4.18	4.15
	Surplus/(Deficit)	2.05	1.30	1.41	1.20		2.11	1.70	1.82	1.85
CROSS PLAINS	Total Demand	0.42	0.43	0.49	0.53	0.65	0.42	0.42	0.41	0.45
	Surplus/(Deficit)	0.23	0.22	0.16	0.12		0.23	0.23	0.24	0.20
EASTLAND CO.	Total Demand	4.79	4.70	4.52	4.68	4.00	4.58	4.13	3.69	3.65
	Surplus/(Deficit)	(0.79)	(0.70)	(0.52)	(0.68)		(0.58)	(0.13)	0.31	0.35
HAMLIN*	Total Demand	2.26	2.30	2.36	2.66	1.62	2.26	2.20	2.18	2.29
	Surplus/(Deficit)	(0.64)	(0.68)	(0.74)	(1.04)		(0.64)	(0.58)	(0.56)	(0.67)
LAWN	Total Demand	0.31	0.34	0.38	0.44	0.22	0.31	0.32	0.35	0.38
	Surplus/(Deficit)	(0.09)	(0.12)	(0.16)	(0.22)		(0.09)	(0.14)	(0.13)	(0.16)
MILES	Total Demand	0.35	0.36	0.36	0.38	-	0.35	0.35	0.35	0.36
RISING STAR	Total Demand	0.35	0.34	0.32	0.31	-	0.33	0.30	0.27	0.25

Table 2.2, Continued

Water Supply Entity		High Population Peak Day (MGD) 1990	2000	2010	2020	1990 WTP Capacity (MGD)	Low Population Peak Day (MGD) 1990	2000	2010	2020
STAMFORD*	Total Demand	2.86	2.96	3.01	3.33	3.00	2.86	2.83	2.79	2.87
	Surplus/(Deficit)	0.14	0.04	(0.01)	(0.33)		0.14	0.17	0.21	0.13
SWEETWATER*	Total Demand	10.48	10.88	11.68	12.78	7.46	10.46	10.54	11.00	11.57
	Surplus/(Deficit)	(3.02)	(3.42)	(4.22)	(5.32)		(3.00)	(3.08)	(3.54)	(4.11)
WINTERS	Total Demand	1.92	1.95	1.86	1.84	2.00	1.92	1.89	1.81	1.72
	Surplus/(Deficit)	0.08	0.05	0.14	0.16		0.08	0.11	0.19	0.28
WOODSON*	Total Demand	0.17	0.19	0.18	0.17	0.16	0.17	0.19	0.17	0.16
	Surplus/(Deficit)	(0.01)	(0.03)	(0.02)	(0.01)		(0.01)	(0.03)	(0.01)	0.00

*Participants

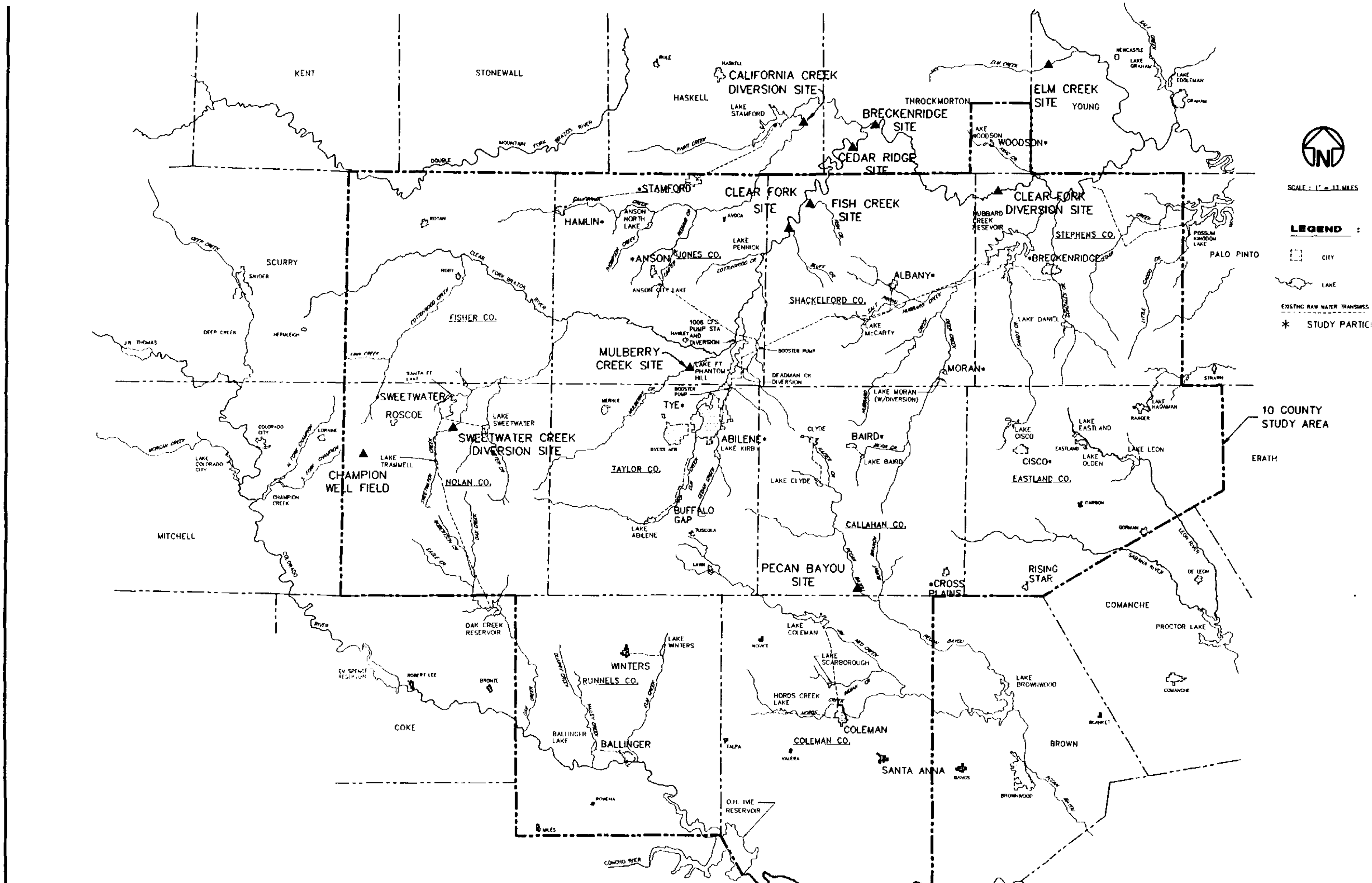
do not currently have the potable water production capacity to meet the demands of a high per capita municipal use year. It should be noted that the demands are based upon Texas Water Development Board projections of population and forecasts of potential per capita municipal use and historical peak-day to average-day ratios as shown in the water audits. The conservatism of these numbers, combined with the conservatism of the high municipal use figures which are appropriate for drought conditions, are appropriate for long-range planning. However, they may provide for inconsistencies with observed data for 1990 and beyond. Only Ballinger, Buffalo Gap, Cisco, Coleman, Cross Plains, and Winters currently have sufficient treatment capacity to meet the projected demands through the year 2020, assuming the high population projections. However, the plants used by Buffalo Gap and Cross Plains are not capable of treating surface water and would need significant expansions in order to treat raw surface water. The remaining entities have sufficient production capacity to meet current need, but will need to upgrade their facilities to meet the projected demands of 2020.

Using the low population projections, the entities of Abilene, Albany, Baird, Eastland Co., Hamlin, Lawn, Sweetwater, and Woodson currently do not have the treatment capacity to meet the estimated 1990 demands for high per capita use. Anson, Ballinger, Buffalo Gap, Cisco, Clyde, Coleman, Cross Plains, Stamford, and Winters have sufficient capacity to meet the demands projected throughout the 30 year study period, though Buffalo Gap and Cross Plains have plants that can treat only groundwater. Due to declining population projections under the low series, Albany, Eastland Co., and Woodson are projected to meet their 2020 demands despite having insufficient capacity for the estimated 1990 demands. The remaining entities, which are shown to currently have sufficient treatment capacity, are projected to outgrow their current production capacity prior to the year 2020.

2.4 Potential Additional Water Supply Sources

Numerous additional water supply sources were reviewed for potential use by the potable water supply entities within the 10-county area. These potential water sources included proposed new reservoirs, the purchase and diversion of raw water from existing reservoirs outside the study area, the diversion of available stream flows into a nearby existing reservoir, and proposed groundwater sources, as well as the possibility of utilizing reclaimed water. These potential additional supply sources are shown in Figure 2.1.

Of the numerous proposed projects, several could be discounted without further study due to economic considerations, lack of suitable water quality, or lack of available water rights. Others were ruled out due to marginal water quality or expected difficult and extended processes for obtaining appropriate water rights. Few appear to be strongly viable projects with good water quality and a potentially short development time. The potential projects considered to be worthwhile for further consideration are listed in Table 2.3. Also included in this



WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STU
FREESE AND NICHOLS | TODD ENGINEERING | JACOB AND MART
POTENTIAL RAW WATER SUPPLY SOURCES | FIGURE 2.1

Table 2.3

Summary of Viable New Supply Sources
Estimated Supply
(Acre-Feet/Year)

Project	Initial	After 30-Years	Potential Customers
1 Cedar Ridge Reservoir	20,600	n.a.	Abilene Sweetwater Stamford
2 Elm Creek Reservoir	5,470	4,588	WCTMWD member cities and customers
3 Fish Creek with Clear Fork Diversion	8,365	7,006	Abilene Sweetwater Stamford
4 Pecan Bayou	4,320	3,870	Baird Clyde Cisco Cross Plains Rising Star
5 Sweetwater Creek Div.	790	790	Sweetwater
6 Clear Fork Diversion to Hubbard Creek Res.	14,500	14,500	WCTMWD member cities and customers
7 California Creek Div. to Lake Stamford			Stamford
-100 cfs pumps	5,500	5,500	
-channel diversion	5,700	5,700	
8 Water Reclamation			
-Sweetwater	1,120	1,120	Sweetwater
-Abilene	5,000	5,000	Abilene
9 Champion Well Field	1,170	0	Sweetwater
10 Div. from O.H. Ivie Reservoir	15,000	15,000	Abilene & its customers
11 Lake Brownwood	8,200	3,400	Baird, Clyde, Cisco, Cross Plains, Rising Star

Table 2.3 continued

Project	Initial	After 30-Years	Potential Customers
12. Div. from E. V. Spence Reservoir	16,100	5,700	Sweetwater

table is a list of the potable water supply entities that could possibly benefit from the proposed project.

2.5 Water Conservation Plan and Drought Contingency Plan

The objective of a water conservation program is to permanently reduce the quantity of water required for each activity, insofar as is practical, through the implementation of efficient water use practices. A drought contingency program provides procedures for voluntary and mandatory actions to be put into effect to temporarily reduce the demand placed upon a water supply system during a water shortage emergency. Although conservation is not a new water supply, it is a means of making the existing supplies last longer.

Water conservation goals are usually selected and expressed in terms of the period of effect, the level of reduction desired, and the type of user demand impacted. A short-term reduction is usually limited to a year or less, generally employed in an emergency situation such as a drought. A long-term reduction is the result of a conservation program continuing for more than one year.

A water conservation plan specifies and explains the actions a water supplier will take to implement a water use reduction program. A detailed explanation of a water conservation plan is included as Appendix E of Volume III. In general, the plan includes nine major elements which are an education and information program, a water conservation plumbing code, a water conservation retrofit program, a conservation oriented water rate structure, a program for meter repair and replacement, water conserving landscaping, water audits and leak detection, recycling and reuse, and means of implementing and enforcing the plan.

A drought contingency plan is typically developed in advance and implemented for short durations of one to several years or less, dependent upon such things as climatic conditions. Appendix E of Volume III includes a detailed description of the elements of a drought contingency plan. The first step in developing a plan is to determine what will trigger the plan, as well as distinguishing between mild, moderate, or severe drought conditions. The major items which trigger drought conditions are low reservoir levels and/or reaching the systems treatment or distribution capacity. The next part of a drought contingency plan is to establish the steps in implementing the plan. The first step would be for mild drought conditions and would include voluntary conservation and an informational system. Upon determining that a moderate drought condition exists, the requirements for rationing would become mandatory. The final step for a severe drought condition would include a much more restricted use of water and a complete ban of water for some uses, such as vehicle washing.

The remaining elements of a drought contingency plan would include the development of an information and education system, a method of initiating and terminating the curtailments, and a method of modifying the plan as the need arises.

Appendix E of Volume III also includes conservation tips and a sample of a conservation/drought contingency plan ordinance.

3. SUMMARY OF VIABLE ALTERNATIVES

A wide range of alternatives to meet the water supply needs of the study area, both for water supply and potable water production, were reviewed. A compilation of the identified viable alternatives is summarized in Table 3.1. This table shows for each entity whether it has a surplus or a deficit for water supply or treatment capacity, the viable water supply alternatives, and the viable treatment alternatives. It is assumed that each entity will continue to supply its current customers. Therefore, the alternatives for each supply entity apply to each of its customers as well. For those whom an alternative was included to supply raw water or potable water to new customers, these potential customers are listed. For some entities, more than one viable alternative is listed. The choice will depend on considerations beyond the economic analysis of the alternatives, including, but not limited to water quality.

Several of the viable alternatives listed include the purchase of water from one of the member cities of West Central Texas Municipal Water District out of Hubbard Creek Reservoir. However, by the end of the study period, Hubbard Creek Reservoir is shown to have a yield approximately equal to its current contracted amount of supply for the four member cities. Since there is no dependable yield surplus to the contracted amounts, any water purchased, as described in the alternatives, would have to come out of a member city's current contracted allocation. The alternatives do not imply that additional

Table 3.1

Regional Water Supply Study
Summary of Viable Water Supply Alternatives

	Water Supply		Potable Water Production	
	Surplus/ Deficit**	Alternatives	Surplus/ Deficit**	Alternatives
ABILENE*	Surplus	Div. - O.H. Ivie Res., Potential New Customers: - Baird - Buffalo Gap - Cisco - Clyde - Eastland Co. WSD - Rising Star - Cross Plains - Stamford - Sweetwater	Deficit	Upgrade as needed, Potential New Customers: - Baird - Buffalo Gap - Cisco - Clyde - Eastland Co. WSD - Rising Star - Cross Plains - Stamford - Sweetwater
ALBANY*	Surplus	-	Deficit	Upgrade as needed.
ANSON*	Surplus	-	Surplus	Upgrade as needed.
BAIRD*	Deficit	-	Deficit	Purchase Potable water from Abilene

Table 3.1, Continued

	Water Supply		Potable Water Production	
	Surplus/ Deficit**	Alternatives	Surplus/ Deficit**	Alternatives
BALLINGER	Surplus	-	N/A	-
BRECKENRIDGE*	Surplus	-	Both	Upgrade as needed, Potential New Customers: - Woodson
BUFFALO GAP	Deficit	-	Deficit	Purchase Potable Water from Steamboat/Tuscola WSC (Abilene)
CISCO*	Deficit	Purchase Raw Water from: a) Abilene, Anson, or Albany (Hubbard Ck. Line) b) Coleman (Lake Coleman) c) BCWCID (Lake Brownwood) d) Div. - Battle Creek	Surplus	Upgrade as needed.
CLYDE	Deficit	-	Both	a) Upgrade WTP as needed. b) Purchase Potable Water from Abilene

Table 3.1, Continued

	Water Supply		Potable Water Production	
	Surplus/ Deficit**	Alternatives	Surplus/ Deficit**	Alternatives
COLEMAN	Surplus	- Potential New Customers: - Cisco - Cross Plains - Rising Star - Sweetwater	Surplus	Upgrade as needed.
CROSS PLAINS*	Deficit	-	Deficit	Purchase Potable Water from: a) Coleman b) Abilene c) BCWCID
EASTLAND CO.	Both		Both	Upgrade as needed
LAWN	Surplus	-	Deficit	Upgrade as needed.
MILES	Deficit	-	Deficit	Purchase Potable Water from: a) Ballinger b) Winters c) San Angelo

Table 3.1, Continued

	Water Supply		Potable Water Production	
	Surplus/ Deficit**	Alternatives	Surplus/ Deficit**	Alternatives
RISING STAR	Deficit	-	Deficit	Purchase Potable Water from: a) Coleman b) Abilene c) BCWCID
ROSCOE	Deficit	-	Deficit	Purchase Potable Water from Sweetwater
STAMFORD*	Deficit	a) Div. - California Ck. b) Purchase Raw Water from Abilene (Hubbard Creek)	Both	Upgrade as needed.
SWEETWATER*	Deficit	a) Div. - Sweetwater Ck. Purchase Raw Water from: a) Abilene b) Lake Coleman (Lake Coleman) c) CRMWD (E.V. Spence Res.)	Deficit	Upgrade as needed.
WINTERS	Surplus	-	Surplus	Upgrade as needed.

Table 3.1, Continued

	Water Supply		Potable Water Production	
	Surplus/ Deficit**	Alternatives	Surplus/ Deficit**	Alternatives
WOODSON	Deficit*	Purchase Raw Water from Abilene, Albany, Anson, Breckenridge (Hubbard Creek Res.)	Deficit	a) Upgrade as needed. b) Purchase Potable Water from Stephens Co. WSC (Breckenridge)

* Participant

** Surplus - Entity shows a surplus through 2020

Deficit - Entity shows a deficit through 2020

Both - Entity shows both a surplus and a deficit within study period dependable long-term water supply is available from Hubbard Creek Reservoir above the current contracted allocations.

If the City of Abilene supplies water to the customers listed in Table 3.1, the pipeline from the O.H. Ivie Reservoir or the water reclamation program will need to be operational sooner than would be required with only its existing customers. With its current customers, it was projected that the line would need to be operational by about the year 2020 under the high population projections and by approximately 2030 under the low projections. With the additional potential water customers, this time frame is moved to the years 2007 to 2012.

If the City were to implement the full water reclamation program outlined in the main text, which could reduce the potable water supply demand by as much as 5,000 ac-ft per year, the time frame for completion of the Ivie line could be pushed back by eight years.

4. ESTIMATED COSTS OF VIABLE ALTERNATIVES

4.1 Estimated Costs of Water Supply Alternatives

Of the numerous alternatives identified for water supply and treatment facilities for the potable water supply entities, several were selected for further review and preparation of estimated capital and annual costs for utilizing the alternative. The alternatives for which cost estimates were prepared are listed in Table 4.1 and shown in Figure 4.1. These alternatives listed are for water supply only. Some of the alternatives proposed to supply raw water to an entity, while others proposed to supply treated water. Table 4.1 also lists, for each of the alternatives, segment letters of the portions of the pipelines shown in Figure 4.1 that are used for that alternative. For example, Alternative No. 4 which is the alternative to supply treated water from Abilene to the Cities of Baird and Clyde is listed as included in pipeline segments D and E. In Figure 4.1, pipeline segments D and E can be seen to connect the City of Baird and on to the City of Clyde.

For each of the viable water supply alternatives listed in Table 4.1, an opinion of probable construction cost was prepared. These costs are tabulated in more detail in the main text and are summarized in Table 4.2. Included in these cost estimates are an assumption of 10 percent for engineering, geotechnical and administrative costs and 15 percent contingencies. The engineering costs are included in the capital cost items. Also included in the annual costs for each alternative are a debt service of 25 years at eight percent, pumping cost of 7.5¢/kwh, and

Table 4.1

Regional Water Supply Study
Viable Alternatives

System Number	Raw/Treated	Source	Customers	Figure 4.1 System Segment Numbers
1	Raw	Ivie Reservoir	Abilene-Grimes	A
2	Raw	California Creek	Stamford-Lake Stamford	B
3	Raw	Hubbard Creek Line	Stamford	C
4	Treated	Abilene	Baird & Clyde	D,E
5	Treated	Abilene	Clyde/Baird/Cross Plains/ Rising Star	D,E,F,G
6	Raw	Hubbard Cr. Line	Cisco	H
7	Treated	Brownwood WTP	Cross Plains/Rising Star	I,G
8	Treated	Coleman WTP	Cross Plains/Rising Star	J,G
9	Raw	Hubbard Cr. Res.	Woodson	R
10	Raw	Sweetwater Creek Div.	Sweetwater-Lake Sweetwater	K
11	Raw	Abilene	Sweetwater-Lake Sweetwater	M
12	Raw	Lake Coleman	Sweetwater-Oak Cr. Res.	N,L
13	Raw	Lake Spence	Sweetwater-Oak Cr. Res.	O
14	Raw	Lake Coleman	Cisco	P
15	Raw	Lake Brownwood	Cisco	Q
16	Raw	Battle Creek Div.	Cisco	S

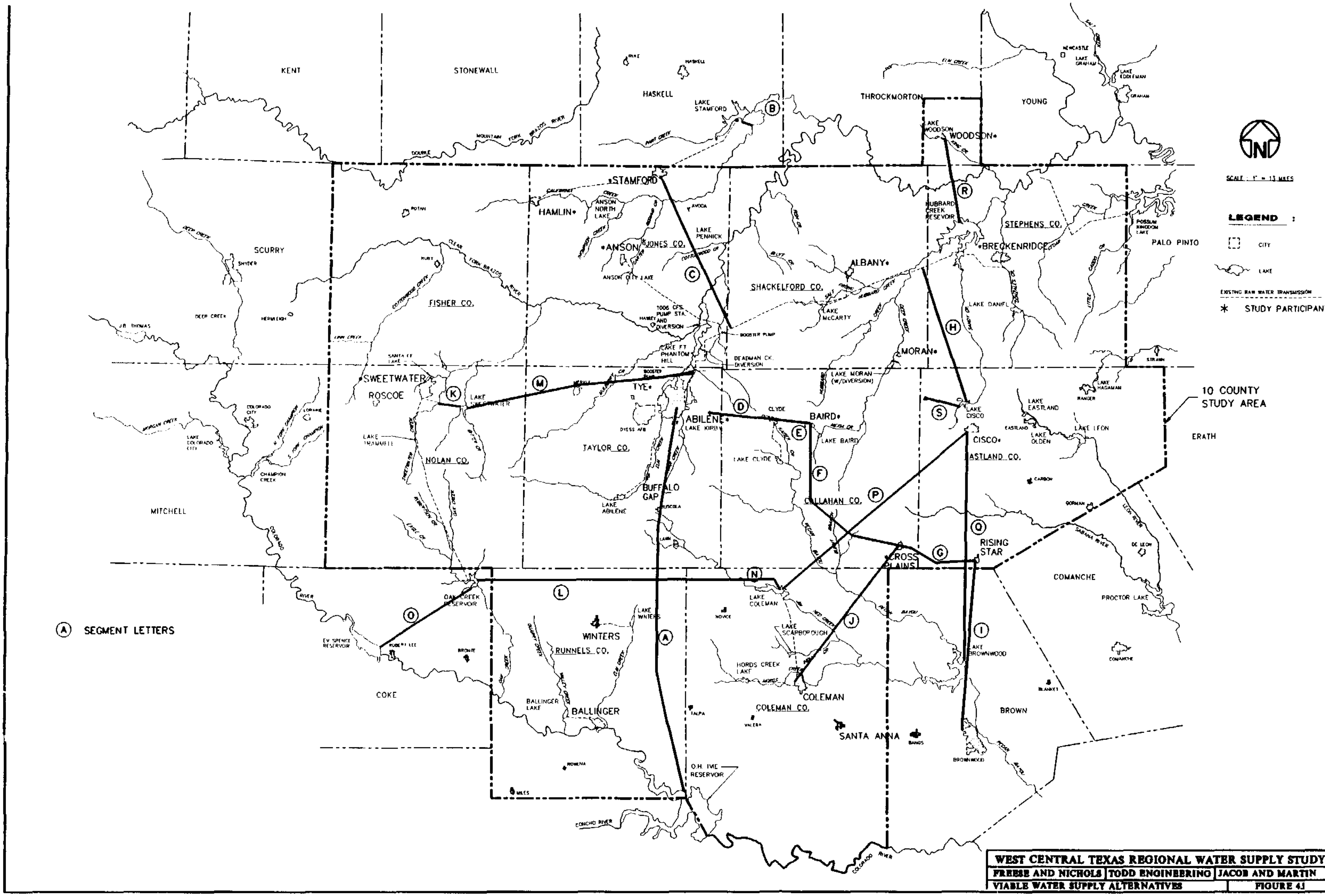

KENT
STONEWALL
HASKELL
THROCKMORTON
YOUNG
SCURRY
MITCHELL
COKE
COMANCHE
BROWN
ERATH
PALO PINTO
LAKE STAMFORD
LAKE WOODSON
WOODSON
STAMFORD
HAMLIN
ANSON
JONES CO.
LAKE PENNICK
ANSON CITY LAKE
FISHER CO.
SHACKELFORD CO.
ALBANY
LAKE McCARTY
HUBBARD CREEK RESEVOIR
BRECKENRIDGE
STEPHENS CO.
LAKE DANIEL
MORAN
SWEETWATER
ROSCOE
NOLAN CO.
LAKE TRAMMELL
TYE
ABILENE
LAKE KIRBY
TAYLOR CO.
BUFFALO GAP
LAKE ABILENE
LAKE FT. PHANTOM HILL
DEADMAN CK. DIVERSION
LAKE MORAN (W/DIVERSION)
CLYDE
BAIRD
LAKE BAIRD
LAKE CLYDE
CALLAHAN CO.
LAKE CISCO
CISCO
LAKE EASTLAND
LAKE OLDEN
LAKE LEON
EASTLAND CO.
RISING STAR
CROSS PLAINS
LAKE COLEMAN
LAKE SCARBOROUGH
HORDS CREEK LAKE
COLEMAN
COLEMAN CO.
SANTA ANNA
LAKE BROWNWOOD
BROWNWOOD
LAKE WINTERS
WINTERS
RUNNELS CO.
BALLINGER LAKE
BALLINGER
O.H. IVIE RESERVOIR
OAK CREEK RESERVOIR
E.V. SPENCE RESERVOIR
ROBERT LEE
CONCHO RIVER
COLORADO RIVER
PROCTOR LAKE
LAKE COLORADO CITY
CHAMPION CREEK
10 COUNTY STUDY AREA
A SEGMENT LETTERS
A B C D E F G H I J K L M N O P Q R S
N
LEGEND :
CITY
LAKE
EXISTING RAW WATER TRANSMISSION
* STUDY PARTICIPANT
WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
FREESE AND NICHOLS | TODD ENGINEERING | JACOB AND MARTIN
VIABLE WATER SUPPLY ALTERNATIVES
FIGURE 4.1

Table 4.2

Regional Water Supply Study
Summary of Estimated Costs of Viable Alternatives
(1991 Dollars)

System Number	Source	Customers	Annual Supply Ac-Ft/Yr	Pump Station and Pipeline Capacity MGD	Capital Costs	Annual Costs
1	Ivie Reservoir	Abilene-Grimes	15,000	20.000	$31,601,000	$4,490,543
2	Calif. Cr.	Stamford-Lake Stamford	5,800	97.000	17,523,000[3]	1,975,068
3	Hubbard Creek Line	Stamford	3,186	5.990	11,355,000[3]	1,178,223
4	Abilene[1]	Baird & Clyde	1,191	2.260[2]	2,905,000	332,787
5	Abilene[1]	Clyde/Baird/Cross Plains/ Rising Star	1,673	3.100[2]	9,584,000	1,053,589
6	Hubbard Cr. Line	Cisco	665	0.595	3,397,000	372,700
7	Brownwood WTP[1]	Cross Plains/Rising Star	482	0.840[2]	6,144,000	672,052
8	Coleman WTP[1]	Cross Plains/Rising Star	482	0.840[2]	5,786,000	614,152
9	Hubbard Cr. Res.	Woodson	67	0.190[2]	1,655,000[3]	174,280
10	Sweetwater Creek Dv.	Sweetwater-Lake Sweetwater	790	7.000	2,865,000	327,126
11	Abilene	Sweetwater-Lake Sweetwater	4,342	3.880	19,445,000[3]	2,416,771
12	Lake Coleman	Sweetwater-Oak Cr. Res.	4,342	3.880	25,924,000[3]	3,260,184
13	Lake Spence	Sweetwater-Oak Cr. Res.	4,342	3.880	15,390,000[3]	1,952,501
14	Lake Coleman	Cisco	665	0.595	6,741,500	742,312
15	Lake Brownwood	Cisco	665	0.595	6,407,000	705,313
16	Battle Creek Dv.	Cisco	500	7.199	3,676,000	406,846

Note: Costs for purchase of water and local treatment and distribution not included.
[1]Potable water supply alternative, remaining alternatives for raw water supply.
[2]Sized for peak-day demand.
[3]Capital costs include WTP expansion.

annual administrative costs of 10 percent of operating cost. The pumping costs assume full use of the water supply. The alternatives were designed based on the average demand or the peak day demand, as appropriate. If the lines delivered raw water to a storage reservoir, average-day values were used. If raw water was delivered to a treatment plant or treated water was delivered, peak-day values were used to size the line.

Additional notes regarding these alternatives include the following:

a) The proposed pipeline from O. H. Ivie Reservoir to Abilene has a selected route up to Highway 707 south of Abilene, for which the survey has been completed and field notes delivered. Portions of this route between Highway 707 and Ovalo have been purchased. The cost shown adds the estimated cost of extending the line to the Grimes WTP, for which no line location has been selected.

b) The Brown County Water Improvement District is considering supplying treated water to customers north of Lake Brownwood. If this is done, the estimated costs of BCWID supplying treated water to Cross Plains and Rising Star would be reduced, as a shorter pipeline would be needed to tap into the system.

4.2 Estimated Cost of Treatment Alternatives

Many of the potable water supply entities do not have sufficient water treatment capacity to meet projected high use demand either for current or projected customers. Opinions of probable construction cost for expanding the existing treatment facilities to meet projected high population, high use demands were prepared. These costs are summarized in Table 4.3 for current and potential customers. These expansions meet the maximum deficits listed in Table 2.2. The maximum value generally reflects the estimated 2020 deficit, but for entities with a declining demand, the largest deficit was used. Therefore, these costs estimate the maximum potential expansion needed for current customers.

Only Coleman, Abilene and the Brown County Water District were considered as a viable source for treated water for new customers. Their maximum expansion potential and the estimated costs are also listed in Table 4.3. The capital cost estimates do not include the potential cost of local water treatment plant upgrading that may be needed to meet TDH criteria. The costs reflected are strictly for water capacity.

Table 4.3

Regional Water Supply Study
Potential Water Treatment Plant Expansions and Estimated Costs

A) Current Customers

Plant	Existing Capacity (MGD)	Projected Maximum Demand (MGD)	Year of Maximum Demand	Expand (Deficit) (MGD)	Estimated Cost Millions
Abilene	52.00	72.35	2020	20.35	$19.414
Albany	1.70	1.82	2000	0.12	0.294
Anson	1.49	1.52	2020	0.12	0.294
Baird	0.46	0.93	2020	0.47	0.888
Breckenridge	3.46	4.28	2020	0.82	1.377
Cisco	4.50	2.99	2020	0.00	0.000
Clyde	2.00	2.34	2020	0.34	0.666
Coleman	6.00	4.80	2020	0.00	0.000
Eastland Co.	4.00	4.79	1990	0.79	1.542
Hamlin	1.62	2.66	2020	1.04	1.674
Stamford	3.00	3.33	2020	0.33	0.670
Sweetwater	7.46	12.78	2020	5.32	6.762
Winters	2.00	1.95	2000	0.00	0.000
Woodson	0.16	0.19	2000	0.03	0.084

B) Potential Customers

	Existing Capacity (MGD)	Projected 2020 Demand		
Abilene	52.00	72.35	24.64	$19.958
Baird		0.93		
Clyde		2.34		
Buffalo Gap		0.18		
Cross Plains		0.53		
Rising Star		0.31		
Total		76.64		
Coleman	6.00	4.80	0.08	$0.201
Cross Plains		0.53		
Rising Star		0.31		
Lawn		0.44		
Total		6.08		

Note: All new customers assume full peak-day demand met with treated water supply.

5. IMPLEMENTATION PLAN

5.1 Introduction

Each of the potable water supply entities discussed within the ten county study area face a different water supply and water treatment situation. As have been identified in the preceding chapters, several entities face current water supply deficits. These deficits tend to become larger over time as the demand increases while the available supply decreases. The estimated deficits of the different entities are summarized in Chapter 2 along with the surpluses. Potential alternatives to the water supply and water treatment deficits are summarized in Chapter 3. Estimated costs for the viable options are discussed in Chapter 4. Table 5.1 lists each of the entities, whether it has a deficit in either water supply or water treatment, and the year in which their deficit appears.

5.2 Implementation of Water Supply Alternatives

Eastland County is the only entity identified that shows a current water supply surplus that becomes a deficit by the end of the study period. However, this is only under the high population projections. Using the low population projections, Eastland Co. would still have surplus in the year 2020. Therefore, Eastland County would need to plan on having access to additional supply by about the year 2020, unless the actual population figures more closely match the low estimates.

Abilene shows a surplus under both the population projections, assuming current customers and supplies. However, the City is listed as

Table 5.1

Regional Water Supply Study
Summary of Deficits

	Water Supply			Potable Water Production		
	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.
Abilene*	Surplus			Deficit		
-Current Customers		2019	2029		current	current
-Potential Customers		2007	2012		current	current
Albany*	Surplus	-	-	Deficit	current	current
Anson*	Surplus	-	-	Both	2012	-
Baird*	Deficit	current	current	Deficit	current	current
Ballinger	Deficit	current	current	N/A	-	-
Breckenridge*	Surplus	-	-	Both	current	current
Buffalo Gap	Deficit	†	†	Deficit	-	-
Cisco*	Deficit	current	current	Surplus	-	-
Clyde	Deficit	current	current	Both	2003	2022
Coleman	Surplus	-	-	Surplus	-	-

Table 5.1, Continued

	Water Supply			Potable Water Production		
	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.
Cross Plains*	Deficit	†	†	Deficit	-	-
Eastland Co.	Both	2015	-	Both	current	current
Lawn	Surplus	-	-	Deficit	current	current
Miles	Deficit	†	†	Deficit	-	-
Rising Star	Deficit	†	†	Deficit	-	-
Roscoe	Deficit	current	current	Deficit	-	-
Stamford*	Deficit	current	current	Both	2008	-
Sweetwater*	Deficit	current	current	Deficit	current	current
Winters	Surplus	-	-	Surplus	-	-

Table 5.1, Continued

	Water Supply			Potable Water Production		
	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.
Woodson	Deficit*	current	current	Deficit	current	current

*Participant
**Surplus - Entity shows a surplus through 2020
Deficit - Entity shows a deficit through 2020
Both - Entity shows both a surplus and a deficit within study period
†Currently on groundwater. Deficit will occur when groundwater does not meet needs.

a viable supplier for numerous entities. If the City of Abilene were to supply these entities, they would develop a deficit in water supply prior to the year 2020. This would require that the City bring on line the water supply pipeline from O.H. Ivie Reservoir earlier than currently planned. This is discussed further in Chapter 3. If Abilene were to continue supplying only their current customers plus the cities of Clyde and Baird, with whom they have entered into a contract, it is projected that water from the Ivie pipeline would be needed between the years 2019 and 2029, using the high and low population projections as bounds. Development of the full water reclamation project as described in chapter 6, would delay this by about 10 years. If all of the entities for which Abilene is listed as a viable supplier, the Ivie line would need to be in place by 2007 to 2012, again using the high and low projections as bounds. Development of the water reclamation program could also delay this by eight years.

All other entities that show a current deficit in water supply show this deficit under both the high and low population projections and over the entire study period. Therefore, some means of solving the water supply deficit should be enacted as soon as is practical. For each of the deficit entities, one or more viable alternatives were identified and estimated costs developed. The most attractive of the alternatives should be pursued for development. Each of the viable alternatives listed for each deficit entity could be developed at the present time.

Sweetwater has viable alternatives available other than purchasing water from Abilene to reduce or eliminate its supply deficit. These include purchasing water from the CRMWD out of E.V.Spence Reservoir, purchasing water from Coleman out of Lake Coleman, developing the Sweetwater Creek diversion, and developing a water reclamation program. Some of these alternatives, discussed further in chapter 3, could be developed presently, prior to the purchase of water from Abilene.

The estimated time frames required for implementing the projects shown in Table 4.2 are shown in Figures 5.1 through 5.16.

5.3 Implementation of the Water Treatment Alternatives

As can be seen in Table 5.1, several of the water supply entities face current shortages in water treatment capacity, while others develop a shortage over the study period. For all of the determinations, high average per capita municipal use was assumed in order to best reflect the demands that would exist during a drought or dry season.

Some entities have one or more viable alternatives available that would provide for the purchase of treated water which would solve both the water supply deficit and the treatment capacity deficit. These include the Cities of Baird, Buffalo Gap, Clyde, Cross Plains, Miles, Rising Star, and Roscoe. For the remaining entities with capacity deficits, an expansion of the treatment facilities should be developed as needed at or before the time at which the deficit is listed. A listing of the needed expansion and the estimated costs are described in Chapter 4.

Each of the entities which will be performing treatment of surface

Figure 5.1

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 1

Needed: 2007-2029
Location: Ivie to Abilene
Capacity: 15,000 af/yr
Cost: $31,601,000

```
                                        #**********2003*********#**********2004*********#**********2005*********#**********2006*********#*******
                                         J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A
                                         ----------------------- ----------------------- ----------------------- ----------------------- -------

A. Final Engineering
   1. Issue and sell bonds                                 ======
   2. Survey                                                     ============
   3. Detailed design
      a. Pipe line                                               =======================
      b. Pump stations                                             =========================
   4. Owner review                                                                   ====
   5. Prepare specifications                                                           =======

B. Construction Phase
   1. Advertise for Construction                                                               ====
   2. Receive bids and award contracts                                                             ===
   3. Construction                                                                                     ==============================================
```

Figure 5.2

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 2

Needed: Now
Location: California Creek to Stamford/Hamlin
Capacity: 5,800 af/yr
Cost: $17,523,000

```
                                    #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                     J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                    ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Decision to proceed          X
   2. Deed composite mapping                           ===
   3. Easements                                          ========

B. Initial Engineering
   1. Decision to proceed          X
   2. Aerial photos                  ==
   3. Preliminary design             ======
   4. Cost estimate                      ===
   5. Permitting                     ==============

C. Financial
   1. Financial evaluation                   ====
   2. Evaluation by S&P and Moody's            ==

D. Final Engineering
   1. Issue and sell bonds                       ======
   2. Survey                                           ===
   3. Detailed design
      a. Diversion structure & pipeline                ============
      b. Pump station                                  ==========
   4. Owner review                                               ====
   5. Prepare specifications                                   ======

E. Construction Phase
   1. Advertise for Construction                                     ====
   2. Receive bids and award contracts                                   ===
   3. Construction                                                           ====================================
```

Figure 5.3

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 3

Needed: Now
Location: Hubbard Creek Line to Stamford/Hamlin
Capacity: 3,186 af/yr
Cost: $11,355,000

```
                                        #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                         J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                        ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)           ===============
   2. Decision to proceed                      x
   3. Deed composite mapping                                      ===
   4. Easements                                                     ========

B. Initial Engineering
   1. Decision to proceed                      x
   2. Aerial photos                             ==
   3. Preliminary design                        ========
   4. Cost estimate                                   ===

C. Financial
   1. Financial evaluation                              ====
   2. Evaluation by S&P and Moody's                       ==

D. Final Engineering
   1. Issue and sell bonds                                  ======
   2. Survey                                                      ===========
   3. Detailed design
      a. Pipe line                                                ================
      b. Pump stations (none needed)
   4. Owner review                                                          ====
   5. Prepare specifications                                                =======

E. Construction Phase
   1. Advertise for Construction                                                    ====
   2. Receive bids and award contracts                                                  ===
   3. Construction                                                                             ================================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 5.4

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 4

Needed: Now
Location: Treated Water From Abilene to Clyde/Baird
Capacity: 1,191 af/yr
Cost: $2,905,000

```
                                        #**********1991*********#**********1992*********#**********1993*********#**********1994*********
                                         J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                        ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Decision to proceed                      x
   2. Deed composite mapping                                                              ===
   3. Easements                                                                             =======

B. Initial Engineering
   1. Decision to proceed                      x
   2. Aerial photos (none needed)
   3. Preliminary design                    ====                  ========
   4. Cost estimate                                                     ===

C. Financial
   1. Financial evaluation                                                    ====
   2. Evaluation by S&P and Moody's                                             ==

D. Final Engineering
   1. Issue and sell bonds                                                        ======
   2. Survey                                                                      ====
   3. Detailed design
      a. Pipe line                                                                ============
      b. Pump station                                                               =========
   4. Owner review                                                                      =====
   5. Prepare specifications                                                            ======

E. Construction Phase
   1. Advertise for Construction                                                              ====
   2. Receive bids and award contracts                                                            ===
   3. Construction                                                                                    ========================
```

Note: Based on Billy Jacob's current schedule.
Contracts between Abilene/Clyde/Baird are signed.

Figure 5.5

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 5

Needed: Now
Location: Treated Water From Abilene to Clyde/Baird/Rising Star/Cross Plains
Capacity: 1,673 af/yr (482 af/yr for Cross Plains/Rising Star)
Cost: $9,584,000 ($6,679,000 in addition to System 4)

```
                                      #**********1992*********#**********1993*********#**********1994*********#********1995***********
                                       J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                      ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
  1. Negotiations (see note)          =========
  2. Cross Plains/Rising Star
     Decision to proceed                 x
  3. Deed composite mapping                                 ===
  4. Easements                                                ========

B. Initial Engineering
  1. Decision to proceed                 x
  2. Aerial photos                        ==
  3. Preliminary design                   ========
  4. Cost estimate                              ===

C. Financial
  1. Financial evaluation                         ====
  2. Evaluation by S&P and Moody's                  ==

D. Final Engineering
  1. Issue and sell bonds                             ======
  2. Survey                                                 ======
  3. Detailed design
     a. Pipe line                                           ==============
     b. Pump station                                          ============
  4. Owner review                                                       ====
  5. Prepare specifications                                           ======

E. Construction Phase
  1. Advertise for Construction                                             ====
  2. Receive bids and award contracts                                           ===
  3. Construction                                                                   ================================
```

Note: Clyde/Baird scheduled for completion in 1994. Negotiations of Cross Plains and Rising Star with Abilene need to be complete before selection of pipe size in 1992.

Figure 5.6

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 6

Needed: Now
Location: Hubbard Creek Line to Cisco
Capacity: 665 af/yr
Cost: $3,397,000

```
                                             #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                              J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                              ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)                ===============
   2. Decision to proceed                           x
   3. Deed composite mapping                                   ===
   4. Easements                                                  ========

B. Initial Engineering
   1. Decision to proceed                           x
   2. Aerial photos                                  ==
   3. Preliminary design                             ========
   4. Cost estimate                                        ===

C. Financial
   1. Financial evaluation                                   ====
   2. Evaluation by S&P and Moody's                            ==

D. Final Engineering
   1. Issue and sell bonds                                       ======
   2. Survey                                                         ====
   3. Detailed design
      a. Pipe line                                                   ============
      b. Pump station                                                   ========
   4. Owner review                                                           ====
   5. Prepare specifications                                               ======

E. Construction Phase
   1. Advertise for Construction                                                 ====
   2. Receive bids and award contracts                                               ===
   3. Construction                                                                       ==============================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 5.7
WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 7

Needed: Now
Location: Treated Water From BCWCID to Rising Star/Cross Plains
Capacity: 482 af/yr
Cost: $6,144,000

```
                                      #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                       J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                      ------------------------ ------------------------ ------------------------ ------------------------
A. Legal
   1. Negotiations (see note)         ===============
   2. Decision to proceed                    x
   3. Deed composite mapping                                    ===
   4. Easements                                                   ========

B. Initial Engineering
   1. Decision to proceed                    x
   2. Aerial photos                           ==
   3. Preliminary design                      ========
   4. Cost estimate                                 ===

C. Financial
   1. Financial evaluation                            ====
   2. Evaluation by S&P and Moody's                     ==

D. Final Engineering
   1. Issue and sell bonds                                ======
   2. Survey                                                    ======
   3. Detailed design
      a. Pipe line                                              ==============
      b. Pump station                                             ============
   4. Owner review                                                        ====
   5. Prepare specifications                                            ======

E. Construction Phase
   1. Advertise for Construction                                              ====
   2. Receive bids and award contracts                                            ===
   3. Construction                                                                    ==============================
```

Note: Negotiations with the supplying enity
could be from a few months to several years.

Figure 5.8

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 8

Needed: Now
Location: Treated Water From Coleman to Rising Star/Cross Plains
Capacity: 482 af/yr
Cost: $5,786,000

```
                                      #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                       J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                      ------------------------ ------------------------ ------------------------ ------------------------
A. Legal
   1. Negotiations (see note)         ===============
   2. Decision to proceed                    x
   3. Deed composite mapping                                    ===
   4. Easements                                                   ========

B. Initial Engineering
   2. Decision to proceed                    x
   2. Aerial photos                           ==
   3. Preliminary design                      ========
   4. Cost estimate                                 ===

C. Financial
   1. Financial evaluation                            ====
   2. Evaluation by S&P and Moody's                     ==

D. Final Engineering
   1. Issue and sell bonds                                ======
   2. Survey                                                    ======
   3. Detailed design
      a. Pipe line                                              ==============
      b. Pump station                                             ============
   4. Owner review                                                          ====
   5. Prepare specifications                                              ======

E. Construction Phase
   1. Advertise for Construction                                              ====
   2. Receive bids and award contracts                                            ===
   3. Construction                                                                    =============================
```

Note: Negotiations with the supplying enity
could be from a few months to several years.

Figure 5.9

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 9

Needed: Now
Location: Hubbard Creek Water For Woodson
Capacity: 67 af/yr
Cost: $1,655,000

```
                                        #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                         J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                        ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)           ================
   2. Decision to proceed                      x
   3. Deed composite mapping                                      ==
   4. Easements                                                     =====

B. Initial Engineering
   1. Decision to proceed                      x
   2. Aerial photos                             ==
   3. Preliminary design                        ========
   4. Cost estimate                                   ===

C. Financial
   1. Financial evaluation                              ====
   2. Evaluation by S&P and Moody's                       ==

D. Final Engineering
   1. Issue and sell bonds                                  ======
   2. Survey                                                      ==
   3. Detailed design
      a. Pipe line                                                ========
      b. Pump station                                               ========
   4. Owner review                                                      ====
   5. Prepare specifications                                            =====

E. Construction Phase
   1. Advertise for Construction                                              ====
   2. Receive bids and award contracts                                            ===
   3. Construction                                                                    ================
```

Note: Negotiations with the supplying enity
could be from a few months to several years.

Figure 5.10

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 10

Needed: Now (only partial solution)
Location: Sweetwater Creek to Lake Sweetwater
Capacity: 790 af/yr
Cost: $2,865,000

```
                                    #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                     J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                    ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Decision to proceed          x
   2. Deed composite mapping                          ==
   3. Easements                                         ====

B. Initial Engineering
   1. Decision to proceed          x
   2. Aerial photos                 ==
   3. Preliminary design            ======
   4. Cost estimate                     ===
   5. Permitting                    ============

C. Financial
   1. Financial evaluation                ====
   2. Evaluation by S&P and Moody's           ==

D. Final Engineering
   1. Issue and sell bonds                      ======
   2. Survey                                          ==
   3. Detailed design
      a. Diversion structure & pipe line              =======
      b. Pump station                                   =======
   4. Owner review                                          ====
   5. Prepare specifications                                =====

E. Construction Phase
   1. Advertise for Construction                                  ====
   2. Receive bids and award contracts                                ===
   3. Construction                                                        ===================
```

Figure 5.11

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 11

Needed: Now
Location: Raw Water Line from Abilene NE WTP to Lake Sweetwater
Capacity: 4,342 af/yr
Cost: $19,445,000

```
                                      #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                       J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                      ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations                    ===============
   2. Decision to proceed                    x
   3. Deed composite mapping                                ====
   4. Easements                                               =========

B. Initial Engineering
   1. Decision to proceed                    x
   2. Aerial photos                           ==
   3. Preliminary design                      ==========
   4. Cost estimate                                 ====

C. Financial
   1. Financial evaluation                            ====
   2. Evaluation by S&P and Moody's                     ==

D. Final Engineering
   1. Issue and sell bonds                              ======
   2. Survey                                                  ======
   3. Detailed design
      a. Pipe line                                            ==============
      b. Pump stations                                           ==========
   4. Owner review                                                       ====
   5. Prepare specifications                                           =======

E. Construction Phase
   1. Advertise for Construction                                               ====
   2. Receive bids and award contracts                                           ===
   3. Construction                                                                   ==========================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 5.12

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 12

Needed: Now
Location: Raw Water Line from Lake Coleman to Oak Creek Res. (Sweetwater)
Capacity: 4,342 af/yr
Cost: $25,924,000

```
                                    #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                      J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                    ------------------------ ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)       ===============
   2. Decision to proceed                   x
   3. Deed composite mapping                              ====
   4. Easements                                             =========

B. Initial Engineering
   1. Decision to proceed                   x
   2. Aerial photos                          ==
   2. Preliminary design3                    ===========
   4. Cost estimate                                 ===

C. Financial
   1. Financial evaluation                           ====
   2. Evaluation by S&P and Moody's                    ==

D. Final Engineering
   1. Issue and sell bonds                               ======
   2. Survey                                                   ======
   3. Detailed design
      a. Pipe line                                             ===================
      b. Pump stations                                           ===============
   4. Owner review                                                           ====
   5. Prepare specifications                                               =======

E. Construction Phase
   1. Advertise for Construction                                                   ====
   2. Receive bids and award contracts                                               ===
   3. Construction                                                                       ==========================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 5.13

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 13

Needed: Now
Location: Raw Water Line from Lake Spence to Oak Creek Res. (Sweetwater)
Capacity: 4,342 af/yr
Cost: $15,390,000

```
                                     #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                      J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                     ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)        ===============
   2. Decision to proceed                   x
   3. Deed composite mapping                           ====
   4. Easements                                          =======

B. Initial Engineering
   1. Decision to proceed                   x
   2. Aerial photos                          ==
   3. Preliminary design                     =========
   4. Cost estimate                                ===

C. Financial
   1. Financial evaluation                           ====
   2. Evaluation by S&P and Moody's                    ==

D. Final Engineering
   1. Issue and sell bonds                               ======
   2. Survey                                                 ====
   3. Detailed design
      a. Pipe line                                           ============
      b. Pump stations                                         ============
   4. Owner review                                                   ====
   5. Prepare specifications                                         =======

E. Construction Phase
   1. Advertise for Construction                                             ====
   2. Receive bids and award contracts                                         ===
   3. Construction                                                                 ============================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 5.14

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 14

Needed: Now
Location: Raw Water Line from Lake Coleman to Cisco
Capacity: 665 af/yr
Cost: $6,741,500

```
                                    #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                     J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                    ------------------------ ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)       ================
   2. Decision to proceed                  x
   3. Deed composite mapping                                  ====
   4. Easements                                                 ========

B. Initial Engineering
   1. Decision to proceed                  x
   2. Aerial photos                         ==
   3. Preliminary design                    ==========
   4. Cost estimate                                 ===

C. Financial
   1. Financial evaluation                          ====
   2. Evaluation by S&P and Moody's                   ==

D. Final Engineering
   1. Issue and sell bonds                              ======
   2. Survey                                                  ======
   3. Detailed design
      a. Pipe line                                            ================
      b. Pump stations                                          ==============
   4. Owner review                                                        ====
   5. Prepare specifications                                              ======

E. Construction Phase
   1. Advertise for Construction                                                ====
   2. Receive bids and award contracts                                            ===
   3. Construction                                                                    =====================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 5.15

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 15

Needed: Now
Location: Raw Water Line from Lake Brownwood to Cisco
Capacity: 665 af/yr
Cost: $6,407,000

```
                                        #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                         J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                        ------------------------ ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)           ===============
   2. Decision to proceed                      x
   3. Deed composite mapping                                  ====
   4. Easements                                                 ========

B. Initial Engineering
   1. Decision to proceed                      x
   2. Aerial photos                             ==
   3. Preliminary design                        ==========
   4. Cost estimate                                     ===

C. Financial
   1. Financial evaluation                              ====
   2. Evaluation by S&P and Moody's                       ==

D. Final Engineering
   1. Issue and sell bonds                                  ======
   2. Survey                                                      ======
   3. Detailed design
      a. Pipe line                                                ================
      b. Pump stations                                              ==============
   4. Owner review                                                            ====
   5. Prepare specifications                                                ======

E. Construction Phase
   1. Advertise for Construction                                                  ====
   2. Receive bids and award contracts                                                ===
   3. Construction                                                                        ====================
```

Note: Time for negotiations with the suppling entity could be from a few months to several years.

Figure 5.16

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 16

Needed: Now
Location: From Battle Creek to Lake Cisco
Capacity: 500 af/yr
Cost: $3,676,000

	#********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
	J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
A. Legal	
1. Decision to proceed	x
2. Deed composite (none needed)	
3. Easements (none needed)	
B. Initial Engineering	
1. Decision to proceed	x
2. Aerial photos (none needed)	
3. Preliminary design	======
4. Cost estimate	===
C. Financial	
1. Financial evaluation	====
2. Evaluation by S&P and Moody's	==
D. Final Engineering	
1. Issue and sell bonds	======
2. Survey	==
3. Detailed design	
a. Diversion structure	========
b. Pump station	=====
4. Owner review	====
5. Prepare specifications	====
E. Construction Phase	
1. Advertise for Construction	====
2. Receive bids and award contracts	===
3. Construction	==================

water will need to review the changes in treatment regulations dictated by the 1986 Safe Drinking Water Act. The potential effects of the regulations is discussed thoroughly in main text. None of the costs that may be incurred for update of the existing facilities to meet the new regulations are included in the estimated costs of expansion listed in Chapter 4.

5.4 Summary of Legal Issues

One of the tasks in this report was to review legal issues as identified by West Central Municipal Water District. A list of questions were developed in conjunction with the District and these were submitted to the law office of Davidson, Troilo and Booth for responses. Appendix D in Volume III includes a letter dated July 10, 1991, which provides an opinion in three parts. The first part deals with answers to 18 legal questions which were developed in the planning effort, the second deals with general observations and recommendations, and the third deals with qualifications and assumptions.

The following is a summary of the key points from this letter. However, it should be noted that the response in Volume III should be referred to for a full and proper interpretation of the legal issues.

- Water rights are defined, and limited, to the conditions of the certificate of adjudication. The water use is also limited by existing water supply contracts.
- Title to state water in Texas belongs to the state according to

common understanding. Generally, under the usufruct doctrine, the state retains title to public or state water insofar as the molecules are concerned and the appropriator has a right to use the water in accordance with the certificate of adjudication. Water supply contracts such as those the District has with its customers provide that title passes from the supplier to the customer at a specified delivery point. This provision is designed to clarify the legal liabilities involved in operations and means that the District retains control and liability for damages, etc., up to the delivery point and then the customer assumes the control and liability.

- The District's contracts with its member cities pertaining to Hubbard Creek Reservoir each provide that the "city agrees to purchase water for its own use and for distribution to all of the customers served by the city's distribution system."
- The Stacy "O.H. Ivie Reservoir" contracts between the District and Abilene provide that all water from Stacy is for Abilene's use. There are no contractual limitations on Abilene's use of Stacy water, except that the contracts cannot be assigned to others.
- Water rights to use state water have been adjudicated and are not subject to future adjudication under the Texas Water Code. All such water rights are subject to cancellation, in whole or in part, for 10 years nonuse of water or failure to construct

facilities required to be built under the particular adjudicated water right. These Water Code provisions contain certain limitations and defenses to cancellation.

- In the absence of contracts which address ownership or use of additional yield created by conjunctive or system operations of multiple reservoirs, any net increase in yield would be owned and controlled by the entity(ies) developing the system operation. The method used to finance conjunctive use facilities ordinarily will determine use of increased yields in the contracts made to secure issuance of tax or revenue bonds.
- Development of a regional water supply feasibility study and report in the planning process involves developing the technical data relating to areas of water supply demand, presently available water supplies, potential developable future water supplies and economic feasibility. Such a study also involves consideration of interlocal governmental relationships and legal constraints. Where necessary, assumptions must be made that interlocal governmental relationships can be resolved and existing contractual restraints can be resolved by mutual agreement. The assumptions should be made that other legal constraints can be avoided or legislation enacted to authorize development of regional water supplies, if constrained by existing laws.

5.5 Role of the West Central Texas Municipal Water District

The West Central Texas Municipal Water District (WCTMWD), which operates Hubbard Creek Reservoir and supplies raw water to its member cities of Abilene, Anson, Albany, and Breckenridge, is listed only as an indirect supplier for some of the viable water supply alternatives. This is because the entire long-term yield in Hubbard Creek Reservoir is apportioned by contract to the member cities. However several of the alternatives called for the purchase of raw water from one of the member cities. The existing contracts with the member cities preclude the sale of raw water by the receiving entity. These cities can currently only sell potable water. It has been assumed, for the purposes of this report, that the member cities of WCTMWD, if needed in order to supply a new entity with raw water, would be able to renegotiate their contracts with the WCTMWD in order that WCTMWD could supply the new entity with raw water without increasing the actual contracted amount supplied by WCTMWD.

The District could also play a major role in the development of needed supply alternatives. Their potential would include assistance in financing, development, implementation, and operation of water supply alternatives. Their assistance would be beneficial to many of the smaller entities because of their size, financial capabilities, and experience in developing and managing water resources.

In evaluating the potential role of WCTMWD, the role of the various state agencies may have strong influence. State efforts to encourage sharing present resources as completely as possible in order to delay more expensive alternatives to future years suggests that the surplus suppliers of WCTMWD member cities will be under increasing pressure to be shared with neighboring communities having water supply deficits. Additionally, a regional effort should be made to maintain realistic water costs. Water should not be priced below cost nor contracted at fixed rates for time periods beyond the sellers ability to adequately determine costs and water needs. WCTMWD, to the extent that circumstances place additional duties on the District (WCTMWD), should be aware of these cost of water concerns and seek to avoid untenable situations. In the present need situations named in the report, WCTMWD could be asked to become a contract party. Any such action should be presupported by Board action. Since a general board policy regarding water resources management has been considered, final policy action may become widely considered and bind the Board by precedent. Therefore, an initial step for the WCTMWD in the near future is to complete the future oriented policy choices developed in the water management (audit) committee. Other roles may evolve on request of member cities or cities/entities with water needs.

WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT
IN CONJUNCTION WITH THE
TEXAS WATER DEVELOPMENT BOARD

REGIONAL WATER SUPPLY PLAN

VOLUME II

1991

Freese And Nichols, Inc.
Jacob And Martin, Inc.
Todd Engineering, Inc.

REGIONAL WATER SUPPLY PLAN

VOLUME TWO - REPORT

PREPARED FOR

WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT

IN CONJUNCTION WITH THE

TEXAS WATER DEVELOPMENT BOARD
AND PARTICIPATING ENTITIES

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1. INTRODUCTION

1.1 Scope of Study

The West Central Texas area faces a variety of water supply concerns that are typical of semi-arid regions. These concerns center around the need to provide sufficient quantities of water with suitable quality to people spread over a large area. Providing this water on a continuous basis requires foresight and careful planning. Identifying and developing reliable future sources of water will be critical to maintain the quality of life of communities in the area as well as enabling economic growth and development.

In August 1989, a group of 17 cities and other water supply entities within a 10-county area, sponsored by the West Central Texas Municipal Water District, authorized Freese and Nichols, Todd Engineering, and Jacob and Martin to perform a regional water supply study. The project was funded by the participating water supply entities and a grant from the Texas Water Development Board. The purposes of the study were:

a) review current and future raw water supply needs of the area,

b) identify and recommend future raw water supply alternatives for the 10-county area on both a local and regional basis to meet the projected needs through the year 2020,

c) review current and future requirements for the existing water treatment plants,

d) identify and recommend treatment facility alternatives for the potable water supply entities on both a local and regional basis to meet the projected needs through the year 2020,

e) provide estimated schedules and information needed for implementation of the treatment facility alternatives,

f) develop a general water conservation plan that could be adopted to the needs of the participating entities,

g) evaluate legal, financial, and water rate implications of the regional water supply and treatment alternatives,

h) present an evaluation of the effects of the 1986 Safe Drinking Water Act on the existing and proposed water treatment facilities, and

i) prepare evaluations of the proposed Battle Creek Diversion for the City of Cisco and the routing of the O.H. Ivie Reservoir pipeline to the City of Abilene.

The 10-county area of west central Texas encompassed by the study included the following counties:

Callahan
Coleman
Eastland
Fisher
Jones
Nolan
Runnels
Shackelford
Stephens
Taylor

The participants in this study included the following water supply entities.

City of Abilene
City of Albany
City of Anson

City of Baird
City of Breckenridge
City of Cisco
City of Cross Plains
City of Hamlin
Hawley Water Supply Corporation
City of Moran
Shackelford Water Supply Corporation
City of Stamford
City of Sweetwater
Tuscola, Taylor County Fresh Water Supply District No.1
City of Tye
West Central Texas Municipal Water District
City of Woodson

1.2 Existing Systems

All of the potable water supply entities identified in the 10-county study area are listed in Table 1.1. The table focuses on the existing treatment facilities, but also includes sources that utilize groundwater. Some customers are listed as having part of their supply from two separate entities. Also listed in the table are each entity's source of raw water and the customers to whom they provide potable water. These existing systems are shown in Figures 1.1 and 1.2. Figure 1.1 shows the existing cities and surface water supply reservoirs. Figure 1.2 shows the boundaries of the identified rural water supply corporations. In both, the study participants are designated by an asterisk.

1.3 Study Approach

The potable water supply entities, both those that utilize water treatment facilities and groundwater sources, were used as a focal point

Table 1.1

West Central Texas Regional Water Supply Study
Existing Potable Water Supply Entities
Current Supplies and Customers

Water Supply Entity	Potable Water Customers	Raw Water Source
Abilene*	Abilene Merkel Tye* Feed Lots Pride Refining Potosi WSC View-Caps WSC Sun WSC Steamboat/Tuscola WSC* Blair WSC Hamby WSC Hawley WSC (Part)*	Lake Fort Phantom Hill Hubbard Creek Reservoir Lake Abilene
Albany*	Albany Moran* Shackelford WSC* Moran SWSC	Hubbard Creek Reservoir Lake McCarty
Anson*	Anson Hawley WSC (Part)*	Hubbard Creek Reservoir South Anson Lake
Baird*	Baird	Baird Lake
Ballinger	Ballinger N. Runnels WSC (Part) Rowena WSC	Lake Ballinger
Breckenridge*	Breckenridge Stephens Co. WSC Woodson (Part)	Hubbard Creek Reservoir Lake Daniel
Buffalo Gap	Buffalo Gap	Buffalo Gap Well Field
Cisco*	Cisco Westbound WSC (Part)	Lake Cisco Battle Creek Diversion
Clyde	Clyde Eula WSC	Lake Clyde

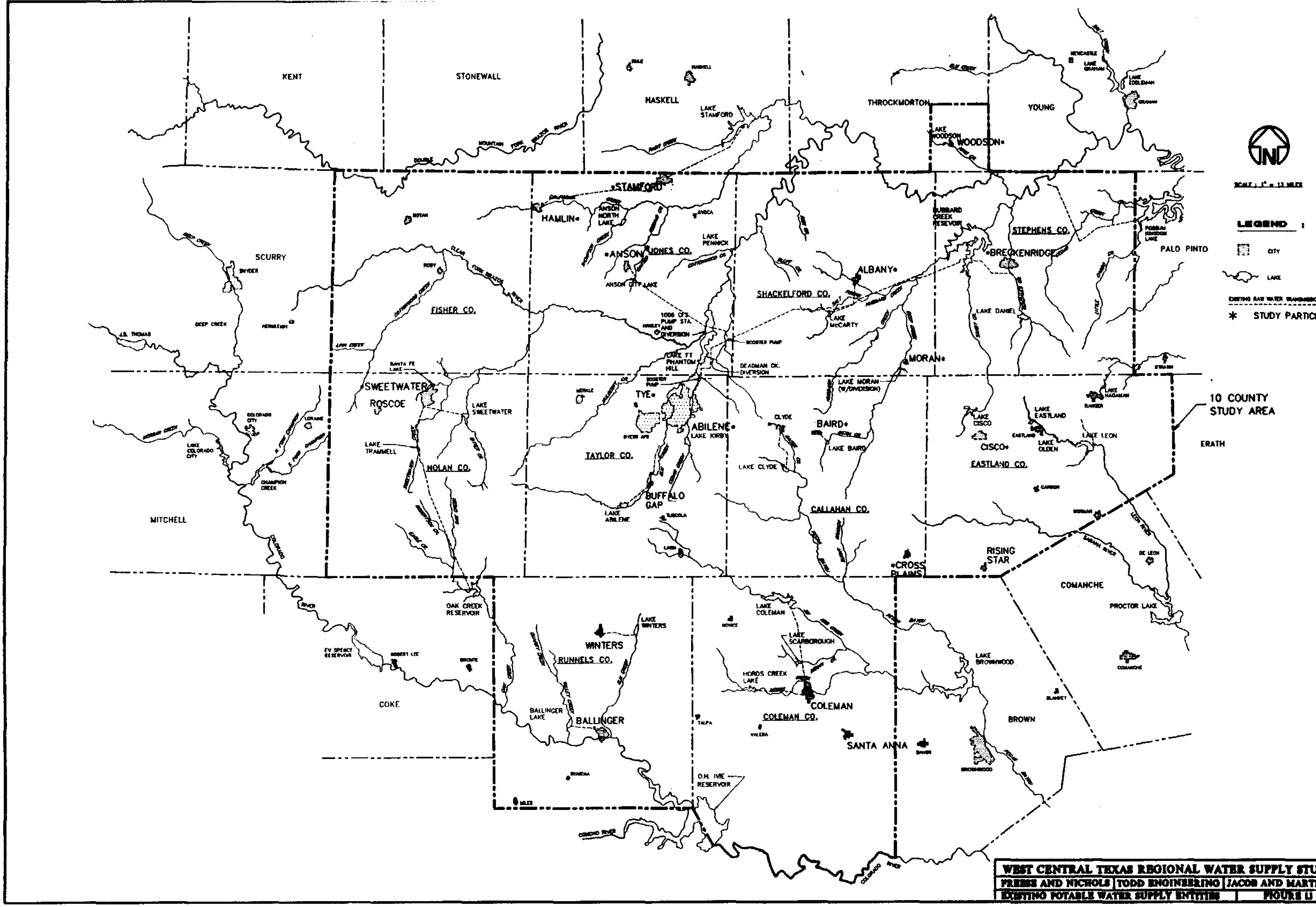
Table 1.1, Continued

Water Supply Entity	Potable Water Customers	Raw Water Source
Coleman	Coleman Lawn† Coleman Co/Burkett WSC	Lake Coleman
Cross Plains*	Cross Plains	Trinity Aquifer
Eastland Co.	Eastland Ranger Carbon Morton Valley WSC Westbound WSC (Part) Staff WSC Olden WSC	Lake Leon Lake Eastland
Hamlin*	Hamlin (Part) Moore Feed Lots West Hamlin WSC Flat Top WSC South Hamlin WSC	South Lake City of Stamford
Miles	Miles	Miles Well Field
Rising Star	Rising Star	Rising Star Well Field
Roscoe	Roscoe (Part)	Roscoe Well Field
Santa Anna	Santa Anna	Lake Santa Anna Brown Co. WCID#1
Stamford*	Stamford Lueders Avoca Community Private (near Hamlin) Hamlin (Part)† Sagerton WSC Ericksdahl WSC Paint Creek WSC	Lake Stamford

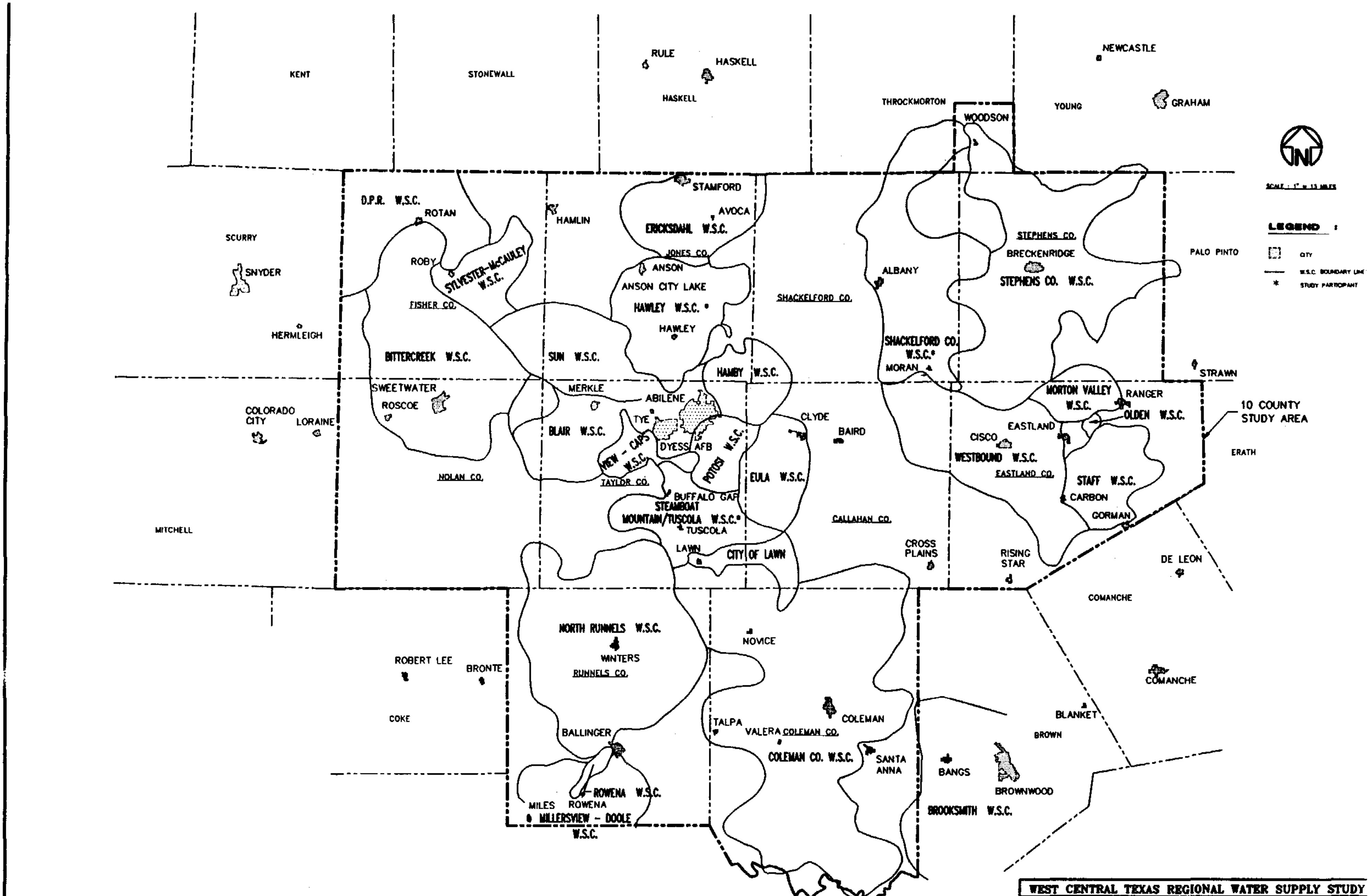
Table 1.1, Continued

Water Supply Entity	Potable Water Customers	Raw Water Source
Sweetwater*	Sweetwater Trent Roby Roscoe (Part) Blackwell Bronte Chadborne Ranch Blackwell-Nolan FWSD Bitter Creek WSC Sylvester-McCauley WSC	Oak Creek Reservoir Lake Trammel Lake Sweetwater Getty (Texaco) Well Field
Winters	Winters N. Runnels WSC (Part)	Lake Winters
Woodson*	Woodson (Part)	Lake Woodson

*Study Participant
†Raw Water Customer



WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STU
FREESE AND NICHOLS | TODD ENGINEERING | JACOB AND MARTI
EXISTING POTABLE WATER SUPPLY ENTITIES
FIGURE
LEGEND :
CITY
LAKE
STUDY PARTICIPA
10 COUNTY STUDY AREA
KENT
STONEWALL
HASKELL
THROCKMORTON
YOUNG
SCURRY
MITCHELL
COKE
PALO PINTO
ERATH
COMANCHE
BROWN
FISHER CO.
JONES CO.
SHACKELFORD CO.
STEPHENS CO.
NOLAN CO.
TAYLOR CO.
CALLAHAN CO.
EASTLAND CO.
RUNNELS CO.
COLEMAN CO.
STAMFORD
HAMLIN
ANSON
ALBANY
BRECKENRIDGE
WOODSON
MORAN
SWEETWATER
ROSCOE
TYE
ABILENE
BAIRD
CISCO
BUFFALO GAP
CROSS PLAINS
RISING STAR
WINTERS
BALLINGER
COLEMAN
SANTA ANNA
LAKE STAMFORD
LAKE PENNICK
ANSON CITY LAKE
HUBBARD CREEK RESERVOIR
LAKE DANIEL
LAKE McCARTY
LAKE FT PHANTOM HILL
DEADMAN CK. DIVERSION
LAKE MORAN (W/DIVERSION)
LAKE SWEETWATER
LAKE TRAMMELL
LAKE KIRBY
LAKE ABILENE
LAKE CLYDE
LAKE BAIRD
LAKE CISCO
LAKE EASTLAND
LAKE OLDEN
LAKE LEON
OAK CREEK RESERVOIR
LAKE WINTERS
BALLINGER LAKE
O.H. IVIE RESERVOIR
LAKE COLEMAN
LAKE SCARBOROUGH
HORDS CREEK LAKE
LAKE BROWNWOOD
PROCTOR LAKE
LAKE HAGAMAN
COLORADO CITY
CHAMPION CREEK
DEEP CREEK
J.B. THOMAS
CONCHO RIVER
COLORADO RIVER



WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY		
FREESE AND NICHOLS	TODD ENGINEERING	JACOB AND MARTIN
RURAL WATER SYSTEM SERVICE AREAS		FIGURE 1.2

for the study. Total estimated demands and dependable supplies were developed for each existing entity. Once projected surpluses and deficits of water supply were identified, local and regional alternatives were developed for both water supply and treatment entities. The projections of future water requirements in the 10-County study area were based on projections made by the Texas Water Development Board (TWDB) dated October 1989 and July 3, 1990. The TWDB's estimates of future populations and water needs extended beyond the study period to the year 2040 and are organized by counties and by major river basins. Within each county, municipal uses are also estimated individually for the principal cities. For the purposes of this study, the TWDB projections for both the low and the high population series assuming high per capita use with additional conservation were used. These projections are discussed in detail in Chapter 3.

Chapter 4 describes the existing groundwater sources, raw water supply systems, and water treatment facilities. Descriptions of the yields of the existing supply sources projected over the study period and the portions of these estimated yields available for potable water use are given. Yields were derived from the latest reports available. Information on the participants' treatment plant facilities and a discussion of the effects of the 1986 Safe Drinking Water Act upon existing treatment facilities are provided, while additional data is shown in Appendix D.

A comparison of the projected water demands over the study period with the existing available supply is presented in Chapter 5. This includes both raw water supplies and treatment plant capacities.

The identified potential new raw water sources included the development of new reservoirs, the construction of diversions, the development of new groundwater wells, the use of reclaimed water, and the diversion of available water from existing reservoirs not currently utilized within the study area. Water conservation was also reviewed. The findings are discussed in Chapter 6. In addition, an evaluation was made of the diversion from the City of Cisco's permitted diversion point on Battle Creek as a potential supplement to the quantity of water available from Lake Cisco.

After identifying the problem areas from a supply and treatment standpoint, possible local and regional solutions were identified and evaluated. These evaluations included both the raw water supply and the potable water production. These alternatives are discussed in Chapters 7 and 8 for water supply and potable water production alternatives, respectively. For the study area, the available groundwater is being used by a few cities and for irrigation. However due to the concerns about dependability, quality and the lack of suitable recharge, groundwater is not considered a sound solution for long term potable water supply. For all entities that currently depend on groundwater, alternatives were developed that assumed groundwater would not be available, though the timing of the replacement with surface water is left open in the implementation recommendations in order to allow for full utilization of the groundwater resource. For planning purposes, it was assumed that the groundwater sources would not be available by the year 2020, as 2020 deficits were used to size supply and treatment alternatives.

After a screening of the identified alternatives, a summary of the viable alternatives is presented in Chapter 9. Chapter 10 provides a summary of the estimated costs of the recommended alternatives. Chapter 11 presents an implementation plan for the viable alternatives. A separately bound volume entitled, "Summary of Findings", presents a summary of the findings.

The appendices include information on the water audit, references, detailed water use summaries, diagrams of the treatment facilities of the study participants, legal and financing issues as they relate to existing and potential new supplies, a general water conservation plan, and the evaluation of the proposed pipeline routes from the O.H. Ivie Reservoir to the City of Abilene.

2. PREVIOUS PLANNING STUDIES

As a part of this study, a review of previous planning studies and reports addressing water resources in the planning area was made. In all, 61 reports were reviewed. Included in Appendix B are an Inventory of Reports, a Summary of Subjects Addressed, and a Summary of Abstracts for the categories of reports for three different groups of reports. The first is the portion of the reports that were completed prior to 1978. The second group consists of reports completed after 1978. The third list is for supplementary reports reviewed. These lists also serve as a list of references used for the report.

Below is a summary of the entities for whom the reviewed reports had been prepared.

Entity	Number of Reports Reviewed
Abilene	17
Albany	1
Anson	1
Baird	2
Breckenridge	1
Clyde	1
Cisco	1
Coleman	1
Cross Plains	1
Colorado River MWD	2
Eastland County WSD	2
Hamlin	1
Merkel	1
Moran	3
Stamford	7
Sweetwater	8
Texas Dept. of Water Resources	1
TU Electric	1
Tye	1
West Central Texas MWD	6
West Central Texas COG	2
Total	61

3. WATER REQUIREMENTS

3.1 Introduction

The first steps in a regional water supply study of this magnitude are to estimate the future population of the area and to project its demands for water supply. Both of these elements are essential in order to develop realistic alternatives for future additional supply.

Through its history, West Central Texas has experienced relatively erratic growth and development, largely due to the area's dependence on its rich abundance of oil and its related industries. With the recent decline in the oil industry, the growth of the region has again been slowed significantly, with some areas actually experiencing decreases in population. Another impact of the drop in oil production in the area is a 50 percent decline in water usage for mining needs from 1980-85. Overall, the majority of water usage in the region has consistently been for municipal and irrigation consumption.

For review purposes, the water demands were developed on a county-wide basis as well as for each water supply entity. A summary of the historical trends in the area is presented, followed by information on future projections. Detailed information regarding population and water use figures by counties and municipalities are contained in Appendix C.

3.2 Historical Population Figures

Historically, the 10-county region has experienced moderate growth, with a 9.1 percent increase in its total population from 1960-1985. However, the population showed a significant drop between 1960 and 1970 and has since rebounded. The largest increase, 58.8 percent over the 25-year period, was noticed in Callahan County, while Fisher County experienced the largest decrease, a 28.9 percent drop in population. In 1985, the 10-county region's estimated population was 234,558 people. Table 3.1 depicts the 1960, 1970, 1980 and 1985 population for each county in the study area.

In 1985, Taylor County comprised 52 percent of the region's population with an estimated 122,237 people, centered in the area's largest municipality, the City of Abilene. It had an estimated 109,169 people in 1985. Due mainly to the dramatic decrease in oil production in the area, these historical population trends should not continue for the region, as the population levels and growth rates are expected to stabilize.

3.3 Historical Water Use Figures

Table 3.2 summarizes the historical municipal water use patterns for 1974, 1977, 1980 and 1985 in the region, according to Texas Water Development Board figures. The data indicate an overall increase of only 3.2 percent in water usage for the region over the 11-year period, though both 1977 and 1980 experienced higher use than 1985. The year 1980 was unusually dry for much of the state, thus leading to higher per capita use of water during that year.

Between 1974 and 1985, the area experienced a 10.3 percent decline in per capita municipal water use, from 156 gallons per capita per day (gpcd) down to 140 gpcd. The per capita use in 1977 and 1980 for

Table 3.1

Historical Study Area Population

County	1960	1970	1980	1985
Callahan	7,929	8,205	10,992	12,593
Coleman	12,458	10,288	10,439	10,622
Eastland	19,526	18,092	19,480	20,727
Fisher	7,861	6,341	5,891	5,592
Jones	19,303	16,109	17,266	18,198
Nolan	18,963	16,220	17,359	17,644
Runnels	15,016	12,108	11,872	12,521
Shackelford	3,990	3,323	3,915	3,986
Stephens	8,885	8,414	9,926	10,438
Taylor	101,028	97,853	110,932	122,237
Total	215,009	196,953	218,072	234,558

Source: Texas Water Development Board

Table 3.2

Historical Study Area Municipal Water Use

(Acre-Feet)

County	1974	1977	1980	1985
Callahan	1,163	1,423	1,508	1,674
Coleman	1,473	2,043	2,128	2,038
Eastland	3,603	4,225	4,296	4,098
Fisher	928	935	876	866
Jones	2,965	3,026	4,341	2,322
Nolan	2,778	3,727	4,743	3,234
Runnels	2,151	2,193	1,707	1,627
Shackelford	520	638	763	635
Stephens	1,430	1,571	1,985	1,595
Taylor	18,752	20,449	26,262	18,807
Total	35,763	40,230	48,609	36,896

Source: Texas Water Development Board

comparison were 170 and 200 gpcd, respectively. In 1985, Taylor County, with the City of Abilene, experienced the highest water usage, 18,807 acre-feet, which represents over 50 percent of the total water used in the region. The historical population, total municipal water use, and per capita water use are shown in Figures 3.1 and 3.2.

3.4 Regional Population Projections

There are two sets of population projections published by the Texas Water Development Board (TWDB), designated as the "high series" and the "low series". These provide reasonable upper and lower bounds on the population projections. According to projections provided by the TWDB, the region as a whole is expected to grow between 0.6 and 1.3 percent per year over the next thirty years. Table 3.3 provides a summary of the high and low series population projections for the counties in the study area through the year 2020. Appendix C contains additional detailed population projections for each county as well as the larger municipalities within those counties. Figure 3.3 illustrates the population projections along with the historical population totals.

The low population projection series indicates a moderate overall average annual growth rate over the 30-year planning period of 0.72 percent. The projected county growth rates vary from a low of a 0.14 percent average annual decline in Eastland County to a 1.6 percent average annual growth in Callahan County. The high population series shows a slightly higher overall growth rate of 1.2 percent. It shows the same low of a 0.14 percent average annual decline, but in Shackelford

Historical Population
10 County Area

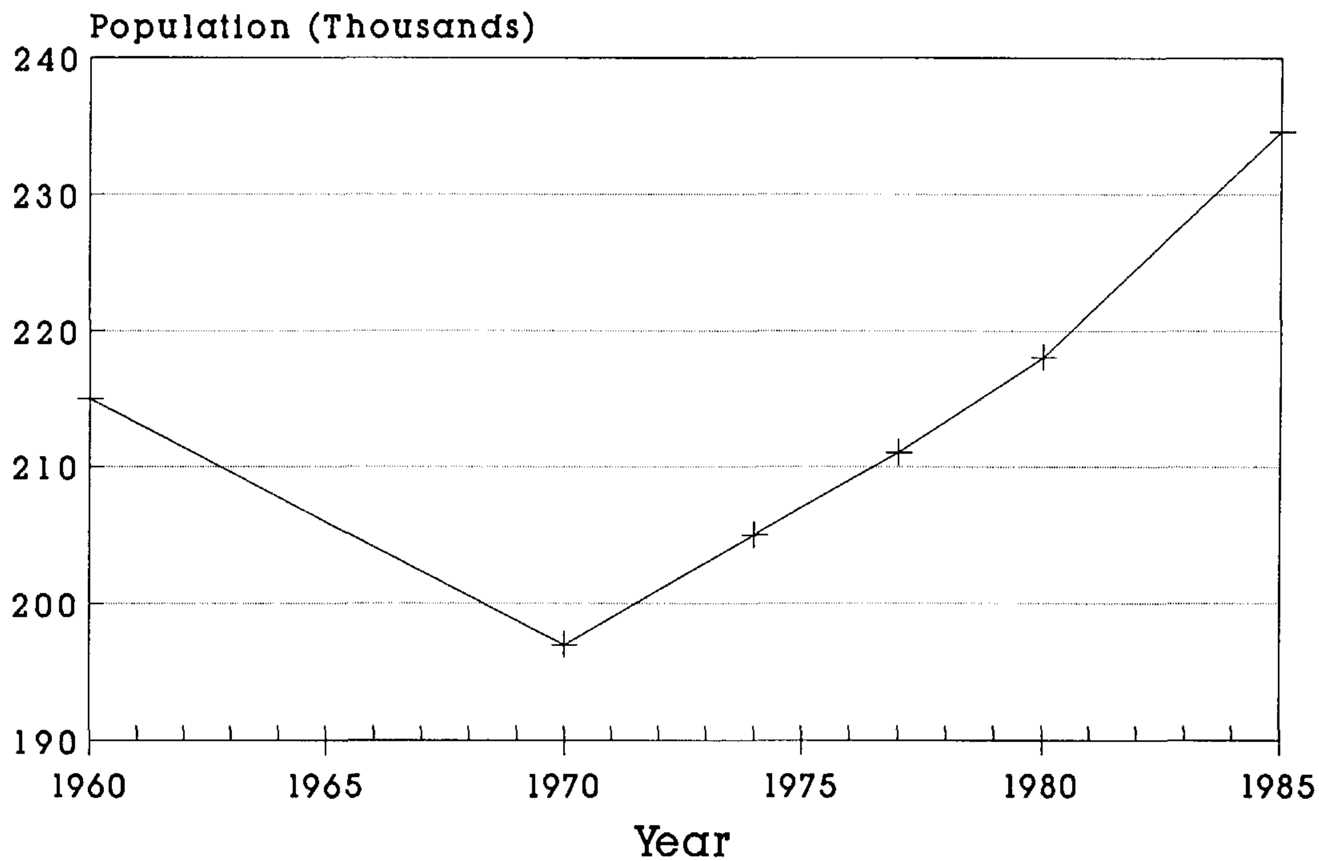


Figure 3.1

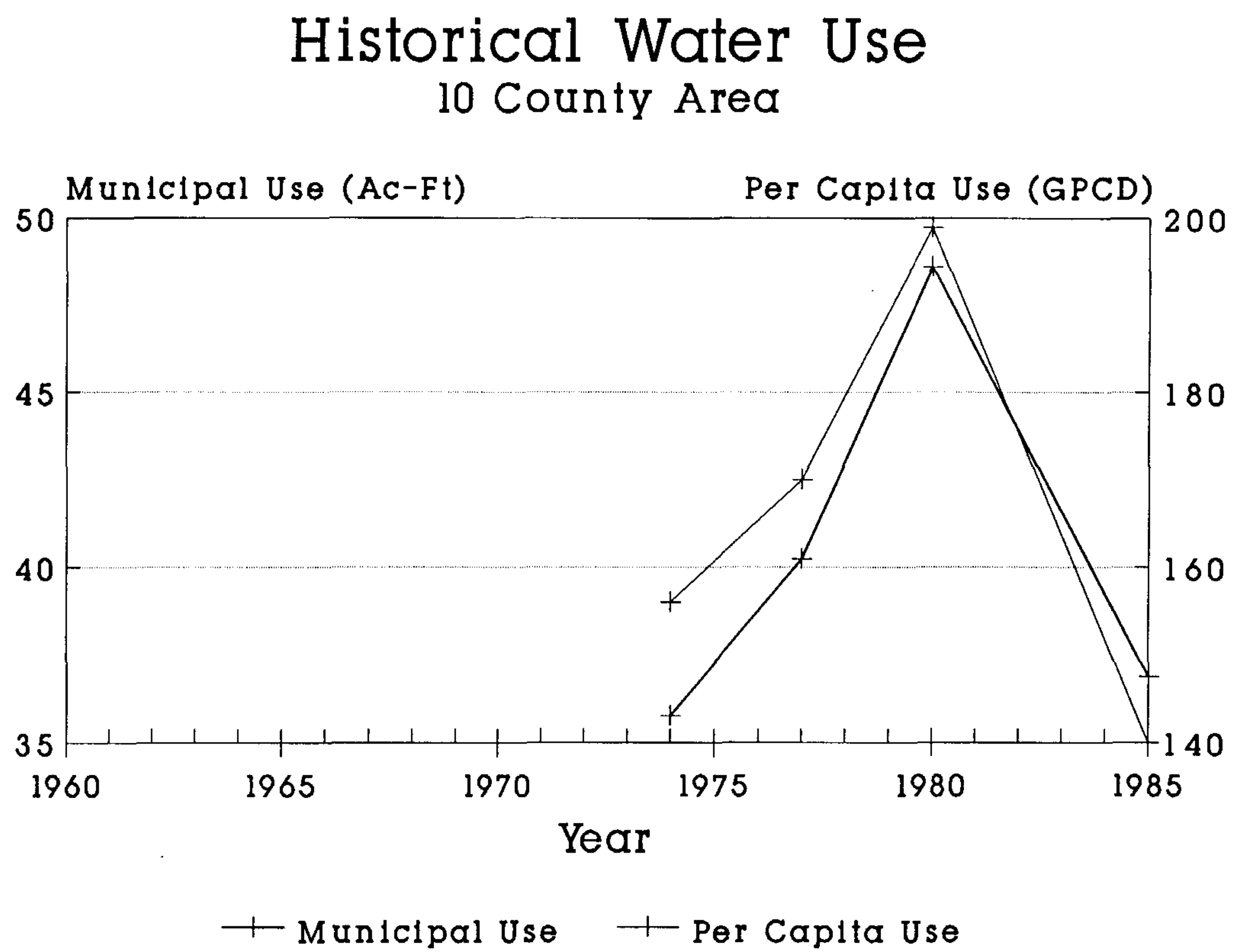

Historical Water Use
10 County Area
Municipal Use (Ac-Ft)
Per Capita Use (GPCD)
50
45
40
35
200
180
160
140
1960
1965
1970
1975
1980
1985
Year
Municipal Use
Per Capita Use

Figure 3.2

Table 3.3

Summary of Population Projections

Low Population Series:

County	Population 1990	2000	2010	2020
Callahan	13,301	15,136	17,300	19,547
Coleman	9,609	9,607	9,657	9,897
Eastland	19,422	19,244	19,077	19,302
Fisher	5,360	5,315	5,366	5,469
Jones	17,359	18,156	19,010	20,626
Nolan	17,317	17,949	18,974	20,717
Runnels	11,689	11,692	11,704	11,873
Shackelford	3,455	3,470	3,424	3,308
Stephens	9,897	10,660	11,428	12,318
Taylor	125,650	135,586	146,134	160,054
Total	233,059	246,815	262,074	283,111

High Population Series:

County	1990	2000	2010	2020
Callahan	13,316	15,524	20,431	23,193
Coleman	9,765	10,469	10,611	11,456
Eastland	20,303	21,856	23,342	24,757
Fisher	5,386	5,564	5,687	5,854
Jones	17,401	19,010	20,557	23,949
Nolan	17,353	18,613	20,372	23,462
Runnels	11,691	12,040	12,086	12,798
Shackelford	3,518	3,534	3,489	3,373
Stephens	10,162	11,346	12,233	13,900
Taylor	126,421	137,123	151,545	174,390
Total	235,316	255,079	280,353	317,132

Source: Texas Water Development Board

Historical & Projected Population
10 County Area

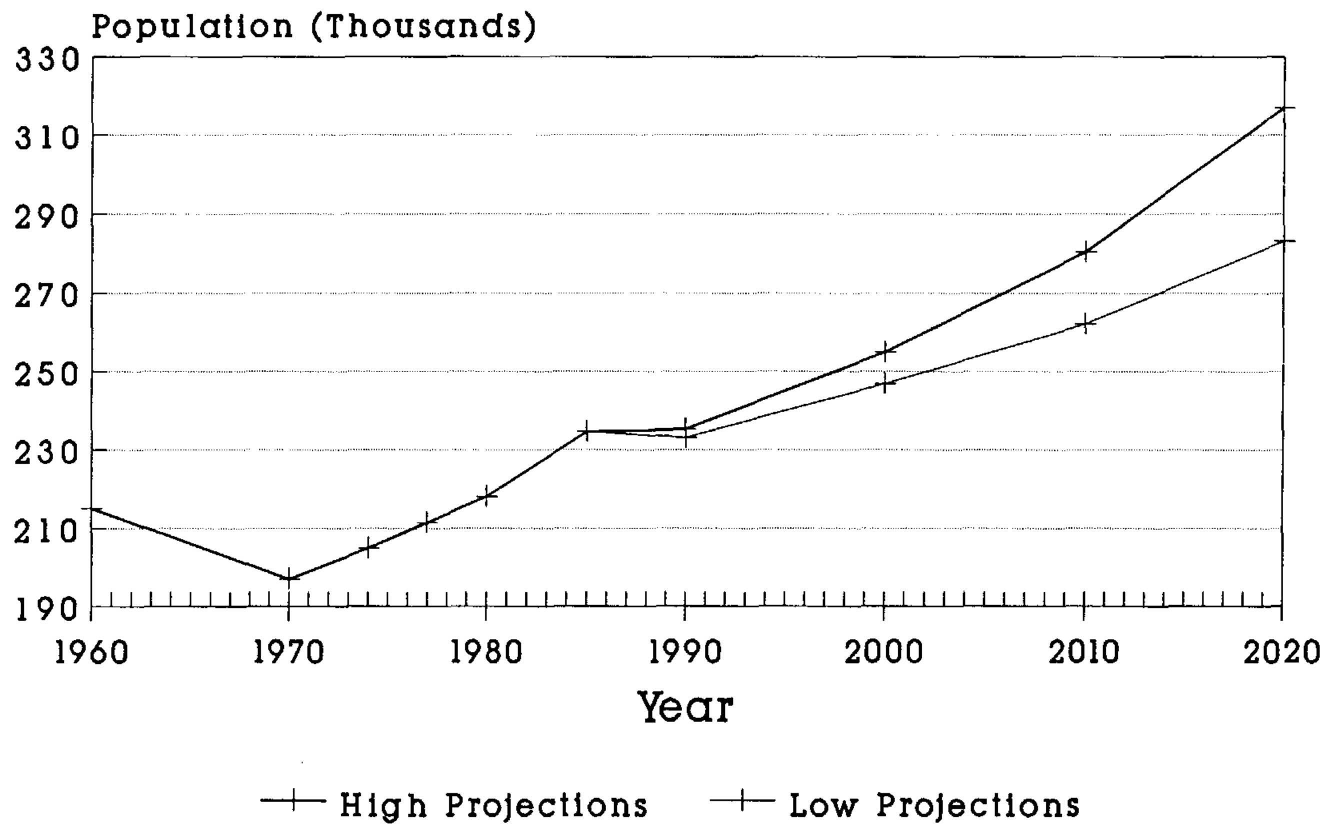


Figure 3.3

County, and a high of 2.5 percent average annual growth in Callahan County. The above average growth rate in Callahan County may be due to the projected future growth of the City of Abilene carrying over into this adjacent county. Appendix C contains additional information on municipalities located in the study area.

Initial estimates available from the 1990 Census indicate that the TWDB projections may be somewhat conservatively high, by as much as 5 to 10 percent. However, since these figures have not been finalized, the TWDB figures were used for development of the study as they would still be appropriate for long-range planning.

3.5 Regional Water Use Projections

Municipal water use in the region is expected to increase, on the average, 0.50 percent per year or 16 percent total, over the next three decades. During the same period, water use for manufacturing needs is expected to rise by 111 percent, from 4,200 acre-feet in 1990 to 8,900 acre-feet in 2020. In 2020, however, municipal water usage in the region will be the highest percentage of water use at 43 percent of the total, or 60,900 acre-feet. The water demand for irrigation purposes is projected to be slightly lower at 36.7 percent, or 52,500 acre-feet in 2020. Water demand for mining should decline to around 1.0 percent of the total water used, or 1,300 acre-feet by 2020.

Table 3.4 depicts municipal water use projections assuming the high population series with two alternative conditions, designated as "average

Historical and Projected Water Use
10 County Area

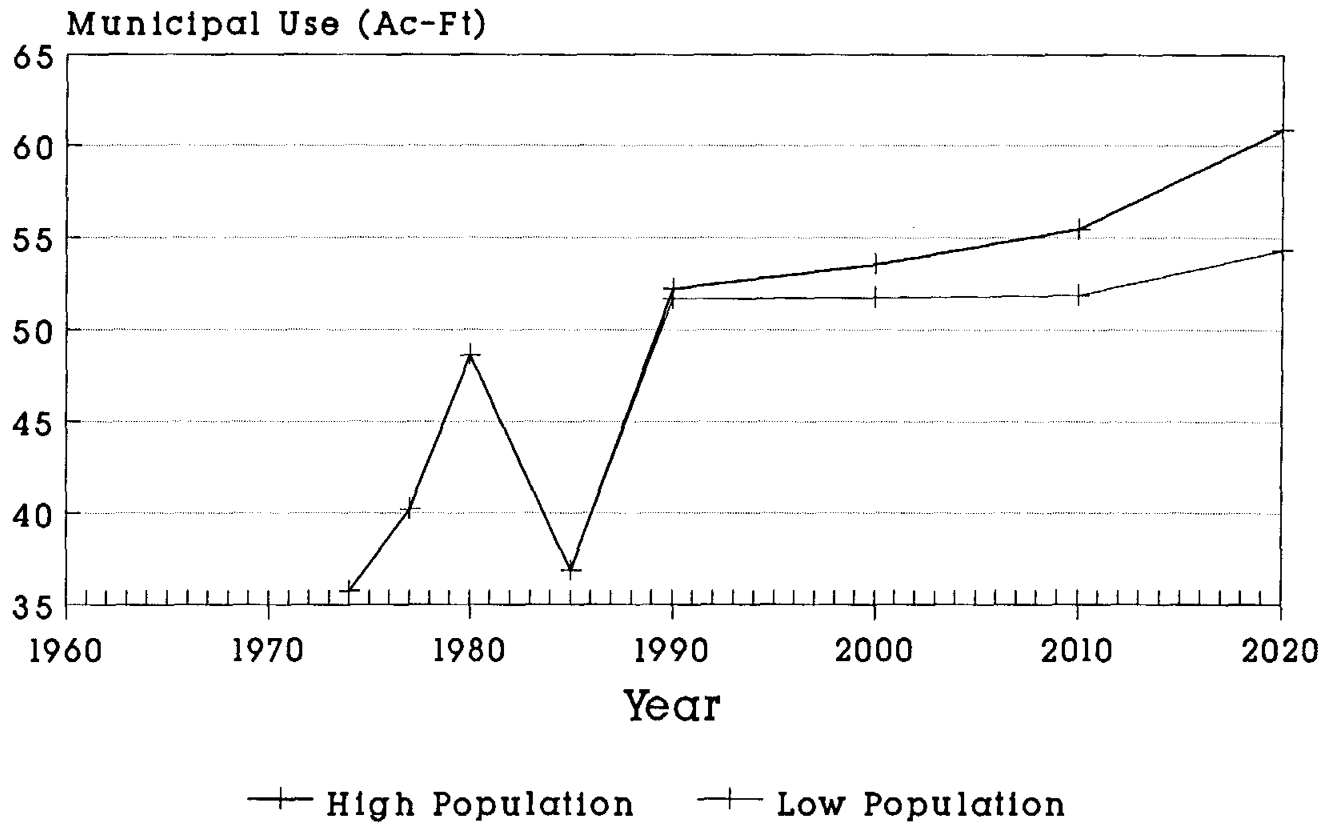


Figure 3.4

Table 3.4

Municipal Water Use Projections
High Population Series

Average per Capita Use Rate:
(With Conservation)

County	Total Annual Water Usage (Acre-Feet) 1990	2000	2010	2020
Callahan	1,826	2,017	2,480	2,734
Coleman	1,941	1,974	1,894	1,986
Eastland	4,260	4,264	4,231	4,360
Fisher	917	899	869	869
Jones	2,918	3,017	3,085	3,487
Nolan	3,980	4,027	4,172	4,630
Runnels	1,826	1,782	1,692	1,720
Shackelford	608	580	546	512
Stephens	1,701	1,801	1,838	2,025
Taylor	22,566	23,245	24,328	27,200
Total	42,543	43,606	45,136	49,523

High per Capita Use Rate:
(With Conservation)

County	Total Annual Water Usage (Acre-Feet) 1990	2000	2010	2020
Callahan	2,311	2,550	3,145	3,464
Coleman	2,225	2,263	2,169	2,275
Eastland	4,988	4,973	4,915	5,065
Fisher	1,189	1,165	1,128	1,127
Jones	3,734	3,862	3,949	4,464
Nolan	4,626	4,680	4,848	5,378
Runnels	2,270	2,213	2,100	2,126
Shackelford	742	707	666	625
Stephens	2,200	2,329	2,377	2,619
Taylor	27,946	28,802	30,164	33,727
Total	52,231	53,544	55,461	60,870

per capita use" and "high per capita use". The average use is appropriate for normal years, depicting average per capita municipal demand. However, during drouths, water requirements tend to be more than in normal years, and the high per capita use rates should be expected. This can be noted in the historical water use that occurred in 1980, as shown in Figure 3.4. For long range planning, the adequacy of supply should be measured against potential demands in times of critical drouth. Therefore, for all water supply comparison and alternatives, only the high per capita use rates were utilized, though both the low and high population series were reviewed. The water use rates were derived by the TWDB and reflect a 15 percent drop in total municipal per capita use demand due to conservation efforts by the year 2020. Regionally, Table 3.4 indicates overall increases over the 30-year planning period of 16.4 percent and 16.5 percent, for the average and high per capita use rates.

Table 3.5 lists the municipal water use projections for the 10-county area, assuming the same average and high use rates, but with the low population series. The same 15 percent reduction in per capita municipal demand is assumed due to conservation. Figure 3.4 shows the projected water use, assuming both the high and low series population projections plotted along with the historical water use.

Comparing the high and low population series reveals the following results. Callahan County is projected to increase its municipal water demand 49.7 percent by 2020 and Taylor County is second with an

Table 3.5

Municipal Water Use Projections
Low Population Series

Average per Capita Use Rates:
(With Conservation)

County	Total Annual Water Usage (Acre-Feet) 1990	2000	2010	2020
Callahan	1,825	1,968	2,101	2,305
Coleman	1,910	1,812	1,723	1,715
Eastland	4,078	3,760	3,466	3,409
Fisher	913	858	820	812
Jones	2,910	2,880	2,852	3,003
Nolan	3,972	3,883	3,885	4,090
Runnels	1,825	1,729	1,638	1,595
Shackelford	576	548	511	480
Stephens	1,657	1,692	1,717	1,794
Taylor	22,428	22,984	23,459	24,964
Totals	42,094	42,114	42,172	44,167

High per Capita Use Rates:
(With Conservation)

County	Total Annual Water Usage (Acre-Feet) 1990	2000	2010	2020
Callahan	2,309	2,486	2,661	2,919
Coleman	2,189	2,077	1,974	1,965
Eastland	4,773	4,382	4,026	3,959
Fisher	1,183	1,113	1,064	1,053
Jones	3,725	3,688	3,652	3,845
Nolan	4,617	4,512	4,517	4,748
Runnels	2,269	2,149	2,035	1,972
Shackelford	707	674	629	590
Stephens	2,143	2,189	2,220	2,320
Taylor	27,775	28,479	29,086	30,955
Totals	51,690	51,749	51,864	54,326

approximate 20.5 percent increase. Shackelford County is expecting the largest decrease in demand, 15.8 percent. Other counties projected to experience declines in municipal water use are Fisher at 5.2 percent and Runnels at 5.8 percent.

Table 3.6 identifies the regional distribution of water use by type for the period 1990-2020. Municipal and irrigation water usage remain the highest types of use across the region at 41 and 43 percent respectively, in 1990 and 43 and 37 percent, respectively, in 2020. Manufacturing is expected to increase dramatically at 111 percent, or by 4,685 acre-feet per year by 2020, while irrigation needs are projected to fall off slightly during the planning period, by about 3.6 percent.

Using municipal demands based on the high population series and high per capita use rate projections with added conservation, the total annual water use of all types in the region is expected to increase. Coleman County shows the largest percentage increase in total water usage, with an average annual rate of 3.6 percent per year. This unusually high rate when compared with the region is due to a rather large projected increase in the county's steam electric usage. Aside, from Coleman County, Callahan County represents the second highest rate at 1.0 percent per year. Overall, the region is projected to experience a .41 percent annual growth rate in water usage over the 30-year planning period. However, in four counties, total water use should tend to decrease during the planning period. Counties showing a projected drop in water usage include Fisher, Runnels, Shackelford, and Stephens. Table 3.7 lists the

Table 3.6

10-County Water Use Projections by Type of Use

(Acre-Feet/Year)

Type of Use	1990	2000	2010	2020
Municipal*	52,231	53,544	55,461	60,870
Manufacturing	4,232	5,765	7,180	8,917
Irrigation	54,425	53,111	52,788	52,468
Livestock	10,152	11,733	11,733	11,733
Steam Electric	1,390	1,500	1,500	7,500
Mining	4,656	2,371	1,849	1,323
Total (Region)	127,086	128,024	130,511	142,811

*High Population, high per capita use with conservation

Table 3.7

Total Annual Water Use Projections
(Acre-Feet per Year)

County	1990	2000	2010	2020
Callahan	4,423	4,823	5,420	5,741
Coleman	5,761	5,984	5,893	12,003
Eastland	22,654	22,877	22,887	23,120
Fisher	6,454	6,291	6,320	6,414
Jones	16,076	16,171	16,168	16,608
Nolan	9,812	10,016	10,297	11,001
Runnels	14,126	13,810	13,619	13,574
Shackelford	2,121	2,119	2,064	2,010
Stephens	7,464	5,882	5,617	5,545
Taylor	38,195	40,051	42,226	46,795
Total (Region)	127,086	128,024	130,511	142,811

total water use, by county, assuming the high population series with the high use rate for municipal demand.

The projections for Stephens County shows a decrease in total water use of 25.7% over the study period. This decrease is due largely to a reduction in projected water use for mining and irrigation. The municipal usage, mainly in the City of Breckenridge, actually increases by approximately 22% over the study period. The current contractual obligations of the West Central Texas Municipal Water District to the member cities allocates the full yield of Hubbard Creek and the water used for mining is from the temporary surplus of the allocated amounts over the current use. As the cities use increases to the contracted amounts, the water available for mining will be decreased, which is reflected in the projections.

3.6 Local Water Use Projections

The water use projections presented in the preceding section for each county and for the 10-county region were reorganized in order to develop projections of the potable water demands for each existing potable water supply entity. Entities that are located in the 10-county area, but purchase their water supply from a source outside of the study area, were not included. The demands are only the potable water needs, including all projected municipal demand as well as the estimated industrial demands that utilize potable water. Raw water uses that are not treated or used as potable supply are not included. These would include irrigation, cooling water for power plants, and other raw water uses. These demands will be totaled in Chapter 4 as a reduction in the raw water supply available for potable use.

The potable water demand projections are listed in Table 3.8 for the high population series and in Table 3.9 for the low population series. Both assume a high per capita municipal use rate with a 15 percent reduction in municipal water use for conservation, as projected by the Texas Water Development Board. The projected industrial demands for potable water were kept the same for both high and low population estimates. Roscoe's projected demands are included as potable supply demands, listed as a customer of Sweetwater, as the potential for continued groundwater use is unknown.

3.7 Projected Demands on Water Treatment Facilities

The projected potable water supply demands listed in Tables 3.8 and 3.9 for the high and low population projections were adjusted to reflect the peak day demand for potable water. These values would reflect the demands facing the existing water treatment facilities.

The results are shown in Tables 3.10 and 3.11 for the high and low population projections, respectively. The values were derived from peak day/average day ratios assumed for each water supply entity. These ratios were derived from historical data provided in the water audits and are listed in Tables 3.10 and 3.11 as well. The sum of the peak day demands for the 10- county area are projected to range from 97.72 MGD in 1990 to 120.55 MGD in 2020 using the demands based on the high population projections. The sum of the peak day demands should vary from 96.83 MGD in 1990 to 109.00 MGD in 2020 under the low population projections.

Table 3.8

Regional Water Supply Study
Projected Local Potable Water Demand
High Population Series

Water Supply Entity	Customers:	Potable Water Demand (Ac-Ft/Yr) 1990	2000	2010	2020
ABILENE*	Abilene	25,944	26,841	28,224	31,566
	Merkel	601	619	653	733
	Tye	332	343	362	406
	Feed Lots	135	130	130	130
	Pride Refining	290	290	290	290
	Potosi WSC	258	316	331	346
	View-Caps WSC	181	234	260	287
	Sun WSC	205	235	244	255
	Steamboat/Tuscola WSC	217	256	271	286
	Blair WSC	47	60	66	72
	Hamby WSC	135	165	174	182
	Hawley WSC (Part)	231	276	289	302
	Industrial	2,734	3,749	4,608	5,673
	Total Demand	31,310	33,514	35,902	40,528
ALBANY*	Albany	564	538	517	485
	Shackelford WSC	140	162	166	167
	Moran SWSC	33	42	48	48
	Total Demand	737	742	731	700
ANSON*	Anson	567	571	586	661
	Hawley WSC (Part)	144	172	181	189
	Total Demand	711	743	767	850
BAIRD*	Baird	428	485	541	593
	Total Demand	428	485	541	593
BALLINGER	Ballinger	1,004	964	915	892
	N. Runnels WSC (Part)	14	14	13	13
	Rowena WSC	60	60	60	58
	Industrial	78	98	119	144
	Total Demand	1,156	1,136	1,107	1,107

Table 3.8, Continued

Water Supply Entity	Customers:	Potable Water Demand (Ac-Ft/Yr) 1990	2000	2010	2020
BRECKENRIDGE*	Breckenridge	1,687	1,785	1,823	1,996
	Stephens Co. WSC	196	244	255	265
	Industrial	11	15	19	23
	Total Demand	1,894	2,044	2,097	2,284
BUFFALO GAP	Buffalo Gap	59	65	72	82
	Total Demand	59	65	72	82
CISCO*	Cisco	1,047	984	931	959
	Westbrook WSC (Part)	50	62	66	70
	Industrial	46	58	71	87
	Total Demand	1,143	1,104	1,068	1,116
CLYDE	Clyde	538	658	735	806
	Eula WSC	93	212	227	242
	Total Demand	631	870	962	1,048
COLEMAN	Coleman	1,485	1,510	1,447	1,518
	Lawn†	140	153	169	194
	Coleman Co/Burkett WSC	280	580	596	612
	Industrial	7	11	14	18
	Total Demand	1,912	2,254	2,226	2,342
CROSS PLAINS*	Cross Plains	269	278	311	341
	Total Demand	269	278	311	341
EASTLAND CO.	Eastland	1,570	1,515	1,433	1,476
	Ranger	1,068	1,002	947	976
	Carbon	100	100	100	100
	Morton Valley WSC	77	79	80	82
	Westbrook WSC (Part)	60	70	72	75
	Staff WSC	134	168	181	195
	Olden WSC	57	72	78	89
	Total Demand	3,066	3,006	2,891	2,993

Table 3.8, Continued

Water Supply Entity	Customers:	Potable Water Demand(Ac-Ft/Yr) 1990	2000	2010	2020
HAMLIN*	Hamlin	784	798	819	923
	Moore Feed Lots	16	16	16	16
	West Hamlin WSC	29	30	30	34
	Flat Top WSC	6	6	6	7
	South Hamlin WSC	10	10	11	12
	Total Demand	845	860	882	992
MILES	Miles	105	108	109	115
	Total Demand	105	108	109	115
RISING STAR	Rising Star	157	154	145	141
	Total Demand	157	154	145	141
STAMFORD*	Stamford	946	971	976	1,099
	Lueders	51	51	48	45
	Avoca Community	58	60	66	72
	Private (near Hamlin)	16	17	17	17
	Hamlin (Total)†	845	860	882	992
	Sagerton WSC	33	39	42	47
	Ericksdahl WSC	82	77	76	76
	Paint Creek WSC	79	94	108	115
	Industrial	20	20	20	20
	Total Demand	2,130	2,189	2,235	2,483
SWEETWATER*	Sweetwater	3,683	3,650	3,795	4,053
	Trent	55	60	60	60
	Roby	160	157	152	152
	Roscoe	256	266	276	295
	Blackwell	67	67	67	67
	Bronte	455	455	455	455
	Chadborne Ranch	14	14	14	14
	Blackwell-Nolan FWSD	81	113	144	176
	Bitter Creek WSC	386	373	392	412
	Sylvester-McCauley WSC	72	81	83	85
	Industrial	578	794	1,030	1,314
	Total Demand	5,807	6,030	6,468	7,083

Table 3.8, Continued

Water Supply Entity	Customers:	Potable Water Demand(Ac-Ft/Yr) 1990	2000	2010	2020
WINTERS	Winters	733	720	683	666
	N. Runnels WSC (Part)	200	212	204	202
	Industrial	26	33	40	48
	Total Demand	959	965	927	912
WOODSON*	Woodson	59	67	63	60
	Total Demand	59	67	63	60
	Total Potable Demand	52,533	55,754	58,622	64,778

*Participant
†Raw Water Customer

Table 3.9

Regional Water Supply Study
Projected Local Potable Water Demand
Low Population Series

Water Supply Entity	Customers:	Potable Water Demand (Ac-Ft/Yr) 1990	2000	2010	2020
ABILENE*	Abilene	25,787	26,532	27,207	28,958
	Merkel	597	612	629	672
	Tye	330	340	349	373
	Feed Lots	134	129	125	119
	Pride Refining	288	287	280	266
	Potosi WSC	256	312	319	317
	View-Caps WSC	180	231	251	263
	Sun WSC	204	232	235	234
	Steamboat/Tuscola WSC	216	253	261	262
	Blair WSC	47	59	64	66
	Hamby WSC	134	163	168	167
	Hawley WSC (Part)	230	273	279	277
	Industrial	2,734	3,749	4,608	5,673
	Total Demand	31,137	33,172	34,774	37,648
ALBANY*	Albany	553	528	507	475
	Shackelford WSC	137	162	166	167
	Moran SWSC	33	42	48	48
	Total Demand	723	732	721	690
ANSON*	Anson	565	546	542	569
	Hawley WSC (Part)	143	164	167	163
	Total Demand	708	710	709	732
BAIRD*	Baird	428	472	458	500
	Total Demand	428	472	458	500
BALLINGER	Ballinger	1,004	936	886	827
	N. Runnels WSC (Part)	14	14	13	12
	Rowena WSC	60	58	58	54
	Industrial	78	98	119	144
	Total Demand	1,156	1,106	1,076	1,037

Table 3.9, Continued

Water Supply Entity	Customers:	Potable Water Demand (Ac-Ft/Yr) 1990	2000	2010	2020
BRECKENRIDGE*	Breckenridge	1,643	1,677	1,703	1,768
	Stephens Co. WSC	191	229	238	235
	Industrial	11	15	19	23
	Total Demand	1,845	1,921	1,960	2,026
BUFFALO GAP	Buffalo Gap	59	64	69	75
	Total Demand	59	64	69	75
CISCO*	Cisco	1,002	866	761	747
	Westbrook WSC (Part)	48	55	54	55
	Industrial	46	58	71	87
	Total Demand	1,096	979	886	889
CLYDE	Clyde	537	642	622	679
	Eula WSC	93	207	192	204
	Total Demand	630	849	814	883
COLEMAN	Coleman	1,461	1,386	1,317	1,311
	Lawn†	138	140	154	168
	Coleman Co/Burkett WSC	275	532	542	529
	Industrial	7	11	14	18
	Total Demand	1,881	2,070	2,027	2,025
CROSS PLAINS*	Cross Plains	268	271	263	287
	Total Demand	268	271	263	287
EASTLAND CO.	Eastland	1,501	1,334	1,171	1,151
	Ranger	1,021	882	774	761
	Carbon	96	88	82	78
	Morton Valley WSC	74	70	65	64
	Westbrook WSC (Part)	57	62	59	58
	Staff WSC	128	148	148	152
	Olden WSC	54	63	64	69
	Total Demand	2,931	2,647	2,363	2,334

Table 3.9, Continued

Water Supply Entity	Customers:	Potable Water Demand (Ac-Ft/Yr) 1990	2000	2010	2020
HAMLIN*	Hamlin	782	762	757	794
	Moore Feed Lots	16	15	15	14
	West Hamlin WSC	29	29	28	29
	Flat Top WSC	6	6	6	6
	South Hamlin WSC	10	10	10	10
	Total Demand	843	821	815	853
MILES	Miles	105	105	106	107
	Total Demand	105	105	106	107
RISING STAR	Rising Star	150	135	119	110
	Total Demand	150	135	119	110
STAMFORD	Stamford	944	927	901	946
	Lueders	51	49	44	39
	Avoca Community	58	57	61	62
	Private (near Hamlin)	16	16	16	15
	Hamlin†	843	821	815	853
	Sagerton WSC	33	37	39	40
	Ericksdahl WSC	82	74	70	65
	Paint Creek WSC	79	90	100	99
	Industrial	20	20	20	20
	Total Demand	2,125	2,091	2,066	2,140
SWEETWATER	Sweetwater	3,675	3,520	3,535	3,579
	Trent	55	58	56	53
	Roby	159	150	143	142
	Roscoe	256	256	257	260
	Blackwell	67	65	62	59
	Bronte	454	439	424	402
	Chadborne Ranch	14	14	13	12
	Blackwell-Nolan FWSD	81	109	134	155
	Bitter Creek WSC	385	360	365	364
	Sylvester-McCauley WSC	72	78	77	75
	Industrial	578	794	1,030	1,314
	Total Demand	5,796	5,842	6,097	6,416

Table 3.9, Continued

Water Supply Entity	Customers:	Potable Water Demand (Ac-Ft/Yr) 1990	2000	2010	2020
WINTERS	Winters	732	699	662	618
	N. Runnels WSC (Part)	200	206	198	187
	Industrial	26	33	40	48
	Total Demand	958	938	900	853
WOODSON	Woodson	58	64	59	54
	Total Demand	58	64	59	54
	Grand Total Demand	52,054	54,168	55,467	58,806

*Participant
†Raw Water Customer

Table 3.10

Regional Water Supply Study
Projected Treatment Plant Demands
High Population Series

Water Supply* Entity	Customers:	Peak Day/ Avg. Day Ratio	High Population Peak Day (MGD) 1990	2000	2010	2020
ABILENE*	Abilene	2.00	46.32	47.92	50.39	56.36
	Merkel	2.00	1.07	1.11	1.17	1.31
	Tye	2.00	0.59	0.61	0.65	0.72
	Feed Lots	2.00	0.24	0.23	0.23	0.23
	Pride Refining	2.00	0.52	0.52	0.52	0.52
	Potosi WSC	2.00	0.46	0.56	0.59	0.62
	View-Caps WSC	2.00	0.32	0.42	0.46	0.51
	Sun WSC	2.00	0.37	0.42	0.44	0.46
	Streamboat/Tuscola WSC	2.00	0.39	0.46	0.48	0.51
	Blair WSC	2.00	0.08	0.11	0.12	0.13
	Hamby WSC	2.00	0.24	0.29	0.31	0.32
	Hawley WSC (Part)	2.00	0.41	0.49	0.52	0.54
	Industrial	2.00	4.88	6.69	8.22	10.12
	Total Demand		55.90	59.83	64.09	72.35
ALBANY*	Albany	2.75	1.38	1.32	1.27	1.19
	Shackleford WSC	2.75	0.34	0.40	0.41	0.41
	Moran SWSC	2.75	0.08	0.10	0.12	0.12
	Total Demand		1.81	1.82	1.79	1.72

Table 3.10, Continued

Water Supply* Entity	Customers:	Peak Day/ Avg. Day Ratio	High Population Peak Day (MGD) 1990	2000	2010	2020
ANSON*	Anson	2.00	1.01	1.02	1.05	1.18
	Hawley WSC (Part)	2.00	0.26	0.31	0.32	0.34
	Total Demand		1.27	1.33	1.37	1.52
BAIRD*	Baird	1.75	0.67	0.76	0.85	0.93
	Total Demand		0.67	0.76	0.85	0.93
BALLINGER	Ballinger	2.00	1.79	1.72	1.63	1.59
	N. Runnels WSC (Part)	2.00	0.02	0.02	0.02	0.02
	Rowena WSC	2.00	0.11	0.11	0.11	0.10
	Industrial	2.00	0.14	0.17	0.21	0.26
	Total Demand		2.06	2.02	1.97	1.98
BRECKENRIDGE*	Breckenridge	2.10	3.16	3.35	3.42	3.74
	Stephens Co. WSC	2.10	0.37	0.46	0.48	0.50
	Industrial	2.10	0.02	0.03	0.04	0.04
	Total Demand		3.55	3.83	3.94	4.28
BUFFALO GAP	Buffalo Gap	2.50	0.13	0.15	0.16	0.18
	Total Demand		0.13	0.15	0.16	0.18

Table 3.10, Continued

Water Supply* Entity	Customers:	Peak Day/ Avg. Day Ratio	High Population Peak Day (MGD) 1990	2000	2010	2020
CISCO*	Cisco	3.00	2.80	2.64	2.49	2.57
	Westbound WSC (Part)	3.00	0.13	0.17	0.18	0.19
	Industrial	3.00	0.12	0.16	0.19	0.23
	Total Demand		3.06	2.96	2.86	2.99
CLYDE	Clyde	2.50	1.20	1.47	1.64	1.80
	Eula WSC	2.50	0.21	0.47	0.51	0.54
	Total Demand		1.41	1.94	2.15	2.34
COLEMAN	Coleman	2.50	3.31	3.37	3.23	3.39
	Coleman Co/Burkett WSC	2.50	0.62	1.29	1.33	1.37
	Industrial	2.50	0.02	0.02	0.03	0.04
	Total Demand		3.93	4.69	4.59	4.80
CROSS PLAINS*	Cross Plains	1.75	0.42	0.43	0.49	0.53
	Total Demand		0.42	0.43	0.49	0.53

Table 3.10, Continued

Water Supply* Entity	Customers:	Peak Day/ Avg. Day Ratio	High Population Peak Day (MGD) 1990	2000	2010	2020
EASTLAND CO.	Eastland	1.75	2.45	2.37	2.24	2.31
	Ranger	1.75	1.67	1.57	1.48	1.52
	Carbon	1.75	0.16	0.16	0.16	0.16
	Morton Valley WSC	1.75	0.12	0.12	0.12	0.13
	Westbound WSC (Part)	1.75	0.09	0.11	0.11	0.12
	Staff WSC	1.75	0.21	0.26	0.28	0.30
	Olden WSC	1.75	0.09	0.11	0.12	0.14
	Total Demand		4.79	4.70	4.52	4.68
HAMLIN*	Hamlin	3.00	2.10	2.14	2.19	2.47
	Moore Feed Lots	3.00	0.04	0.04	0.04	0.04
	West Hamlin WSC	3.00	0.08	0.08	0.08	0.09
	Flat Top WSC	3.00	0.02	0.02	0.02	0.02
	South Hamlin WSC	3.00	0.03	0.03	0.03	0.03
	Total Demand		2.26	2.30	2.36	2.66
LAWN	Lawn	2.50	0.31	0.34	0.38	0.44
MILES	Miles	3.75	0.35	0.36	0.36	0.38
RISING STAR	Rising Star	2.50	0.35	0.34	0.32	0.31

Table 3.10, Continued

Water Supply* Entity	Customers:	Peak Day/ Avg. Day Ratio	High Population Peak Day (MGD) 1990	2000	2010	2020
STAMFORD*	Stamford	2.50	2.11	2.17	2.18	2.45
	Lueders	2.50	0.11	0.11	0.11	0.10
	Avoca Community	2.50	0.13	0.13	0.15	0.16
	Private (near Hamlin)	2.50	0.04	0.04	0.04	0.04
	Sagerton WSC	2.50	0.07	0.09	0.09	0.10
	Ericksdahl WSC	2.50	0.18	0.17	0.17	0.17
	Paint Creek WSC	2.50	0.18	0.21	0.24	0.26
	Industrial	2.50	0.04	0.04	0.04	0.04
	Total Demand		2.86	2.96	3.01	3.33
SWEETWATER*	Sweetwater	2.00	6.58	6.52	6.78	7.24
	Trent	2.00	0.10	0.11	0.11	0.11
	Roby	2.00	0.29	0.28	0.27	0.27
	Roscoe (Part)	2.50	0.57	0.59	0.62	0.66
	Blackwell	2.00	0.12	0.12	0.12	0.12
	Bronte (U.C.R.A.)	2.00	0.81	0.81	0.81	0.81
	Chadborne Ranch	2.00	0.02	0.02	0.02	0.02
	Blackwell-Nolan FWSD	2.00	0.14	0.20	0.26	0.31
	Bitter Creek WSC	2.00	0.69	0.67	0.70	0.74
	Sylvester-McCauley WSC	2.00	0.13	0.14	0.15	0.15
	Industrial	2.00	1.03	1.42	1.84	2.35
	Total Demand		10.48	10.88	11.68	12.78

Table 3.10, Continued

Water Supply* Entity	Customers:	Peak Day/ Avg. Day Ratio	High Population Peak Day (MGD) 1990	2000	2010	2020
WINTERS	Winters	2.25	1.47	1.45	1.37	1.34
	N. Runnels WSC (Part)	2.25	0.40	0.43	0.41	0.41
	Industrial	2.25	0.05	0.07	0.08	0.10
	Total Demand		1.92	1.95	1.86	1.84
WOODSON*	Woodson	3.25	0.17	0.19	0.18	0.17
	Total Demand		0.17	0.19	0.18	0.17

*Participant
†Currently a raw water customer

Table 3.11

Regional Water Supply Study
Projected Treatment Plant Demands
Low Population Series - High Use Rate

Water Supply Entity	Customers:	Peak Day/ Avg. Day Ratio	Low Population Peak Day (MGD) 1990	2000	2010	2020
ABILENE*	Abilene	2.00	46.04	47.37	48.58	51.70
	Merkel	2.00	1.07	1.09	1.12	1.20
	Tye	2.00	0.59	0.61	0.62	0.67
	Feed Lots	2.00	0.24	0.23	0.22	0.21
	Pride Refining	2.00	0.51	0.51	0.50	0.47
	Potosi WSC	2.00	0.46	0.56	0.57	0.57
	View-Caps WSC	2.00	0.32	0.41	0.45	0.47
	Sun WSC	2.00	0.36	0.41	0.42	0.42
	Streamboat/Tuscola WSC	2.00	0.39	0.45	0.47	0.47
	Blair WSC	2.00	0.08	0.11	0.11	0.12
	Hamby WSC	2.00	0.24	0.29	0.30	0.30
	Hawley WSC (Part)	2.00	0.41	0.49	0.50	0.49
	Industrial	2.00	4.88	6.69	8.22	10.12
	Total Demand		55.59	59.22	62.08	67.21
ALBANY*	Albany	2.75	1.36	1.30	1.24	1.17
	Shackleford WSC	2.75	0.34	0.40	0.41	0.41
	Moran SWSC	2.75	0.08	0.10	0.12	0.12
	Total Demand		1.78	1.80	1.77	1.69

Table 3.11, Continued

Water Supply Entity	Customers:	Peak Day/ Avg. Day Ratio	Low Population Peak Day (MGD) 1990	2000	2010	2020
ANSON*	Anson	2.00	1.01	0.97	0.97	1.02
	Hawley WSC	2.00	0.26	0.29	0.30	0.29
	Total Demand		1.26	1.27	1.27	1.31
BAIRD*	Baird	1.75	0.67	0.74	0.72	0.78
	Total Demand		0.67	0.74	0.72	0.78
BALLINGER	Ballinger	2.00	1.79	1.67	1.58	1.48
	N. Runnels WSC (Part)	2.00	0.02	0.02	0.02	0.02
	Rowena WSC	2.00	0.11	0.10	0.10	0.10
	Industrial	2.00	0.14	0.17	0.21	0.26
	Total Demand		2.06	1.97	1.93	1.85
BRECKENRIDGE*	Breckenridge	2.10	3.08	3.14	3.19	3.31
	Stephens Co. WSC	2.10	0.36	0.43	0.45	0.44
	Industrial	2.10	0.02	0.03	0.04	0.04
	Total Demand		3.46	3.60	3.68	3.79
BUFFALO GAP	Buffalo Gap	2.50	0.13	0.14	0.15	0.17
	Total Demand		0.13	0.14	0.15	0.17

Table 3.11, Continued

Water Supply Entity	Customers:	Peak Day/ Avg. Day Ratio	Low Population Peak Day (MGD) 1990	2000	2010	2020
CISCO*	Cisco	3.00	2.68	2.32	2.04	2.00
	Westbrook WSC (Part)	3.00	0.13	0.15	0.14	0.15
	Industrial	3.00	0.12	0.16	0.19	0.23
	Total Demand		2.93	2.63	2.37	2.38
CLYDE	Clyde	2.50	1.20	1.43	1.39	1.52
	Eula WSC	2.50	0.21	0.46	0.43	0.45
	Total Demand		1.41	1.89	1.82	1.97
COLEMAN	Coleman	2.50	3.26	3.09	2.94	2.93
	Coleman Co/Burkett WSC	2.50	0.61	1.19	1.21	1.18
	Industrial	2.50	0.02	0.02	0.03	0.04
	Total Demand		3.89	4.30	4.18	4.15
CROSS PLAINS*	Cross Plains	1.75	0.42	0.42	0.41	0.45
	Total Demand		0.42	0.42	0.41	0.45

Table 3.11, Continued

Water Supply Entity	Customers:	Peak Day/ Avg. Day Ratio	Low Population Peak Day (MGD) 1990	2000	2010	2020
EASTLAND CO.	Eastland	1.75	2.34	2.08	1.83	1.80
	Ranger	1.75	1.60	1.38	1.21	1.19
	Carbon	1.75	0.15	0.14	0.13	0.12
	Morton Valley WSC	1.75	0.12	0.11	0.10	0.10
	Westbrook WSC (Part)	1.75	0.09	0.10	0.09	0.09
	Staff WSC	1.75	0.20	0.23	0.23	0.24
	Olden WSC	1.75	0.09	0.10	0.10	0.11
	Total Demand		4.58	4.13	3.69	3.65
HAMLIN*	Hamlin	3.00	2.09	2.04	2.03	2.13
	Moore Feed Lots	3.00	0.04	0.04	0.04	0.04
	West Hamlin WSC	3.00	0.08	0.08	0.07	0.08
	Flat Top WSC	3.00	0.02	0.02	0.01	0.02
	South Hamlin WSC	3.00	0.03	0.03	0.03	0.03
	Total Demand		2.26	2.20	2.18	2.29
LAWN	Lawn	2.50	0.31	0.32	0.35	0.28
MILES	Miles	3.75	0.35	0.35	0.35	0.36
RISING STAR	Rising Star	2.50	0.33	0.30	0.27	0.25

Table 3.11, Continued

Water Supply Entity	Customers:	Peak Day/ Avg. Day Ratio	Low Population Peak Day (MGD) 1990	2000	2010	2020
STAMFORD*	Stamford	2.50	2.11	2.07	2.01	2.11
	Lueders	2.50	0.11	0.11	0.10	0.09
	Avoca Community	2.50	0.13	0.13	0.14	0.14
	Private (near Hamlin)	2.50	0.04	0.04	0.04	0.03
	Sagerton WSC	2.50	0.07	0.08	0.09	0.09
	Ericksdahl WSC	2.50	0.18	0.16	0.16	0.15
	Paint Creek WSC	2.50	0.18	0.20	0.22	0.22
	Industrial	2.50	0.04	0.04	0.04	0.04
	Total Demand		2.86	2.83	2.79	2.87
SWEETWATER*	Sweetwater	2.00	6.56	6.28	6.31	6.39
	Trent	2.00	0.10	0.10	0.10	0.09
	Roby	2.00	0.28	0.27	0.26	0.25
	Roscoe	2.50	0.57	0.57	0.57	0.58
	Blackwell	2.00	0.12	0.12	0.11	0.11
	Bronte	2.00	0.81	0.78	0.76	0.72
	Chadborne Ranch	2.00	0.02	0.02	0.02	0.02
	Blackwell-Nolan FWSD	2.00	0.14	0.19	0.24	0.28
	Bitter Creek WSC	2.00	0.69	0.64	0.65	0.65
	Sylvester-McCauley WSC	2.00	0.13	0.14	0.14	0.13
	Industrial	2.00	1.03	1.42	1.84	2.35
	Total Demand		10.46	10.54	11.00	11.57

Table 3.11, Continued

Water Supply Entity	Customers:	Peak Day/ Avg. Day Ratio	Low Population Peak Day (MGD) 1990	2000	2010	2020
WINTERS	Winters	2.25	1.47	1.40	1.33	1.24
	N. Runnels WSC (Part)	2.25	0.40	0.41	0.40	0.38
	Industrial	2.25	0.05	0.07	0.08	0.10
	Total Demand		1.92	1.89	1.81	1.72
WOODSON*	Woodson	3.25	0.17	0.19	0.17	0.16
	Total Demand		0.17	0.19	0.17	0.16

*Participant

4. EXISTING WATER SUPPLY SYSTEMS

4.1 Introduction

Twenty-two potable water supply entities have been identified in the ten-county area. Four depend entirely on groundwater and have no treatment plant. These are Buffalo Gap, Cross Plains, Miles, and Rising Star. The remaining eighteen entities depend either partially or completely on surface water supplies and do have water treatment plants. The Cities of Roscoe and Sweetwater obtain significant portions of their supply from both groundwater and surface water.

The surface water supplies in the area tend to be relatively small reservoirs, developed separately for each city. The two largest reservoirs, Hubbard Creek and Lake Fort Phantom Hill are the exceptions. Hubbard Creek Reservoir provides raw water for the member cities of the West Central Texas Municipal Water District, which are Abilene, Anson, Albany, and Breckenridge. Lake Fort Phantom Hill is currently the primary raw water source for the City of Abilene. A list of all of the potable water supply entities, their sources of raw water, and the customers whom they serve is given in Chapter 1, Table 1.1.

4.2 Existing Water Supplies

The 18 potable water supply entities that utilize surface water currently depend on a total of 28 surface water reservoirs. These reservoirs are located in both the Brazos and Colorado River Basins. Nineteen are located in the Brazos Basin, and nine are in the Colorado Basin. The majority of the information obtained for the reservoirs was from existing reports and studies listed in Chapter 2. A brief description of each reservoir is given below. The permitted withdrawals and available safe yields of the reservoirs are discussed later. The City of Abilene currently has a contract with the Colorado River Municipal Water District for 15,000 ac-ft of raw water per year from the recently completed O.H. Ivie Reservoir. However, since the City does not currently use water from the source, it is not included as part of existing supplies. It will be discussed in more detail in the chapters on alternative solutions.

Lake Abilene. Lake Abilene is owned by the City of Abilene. It is located in Taylor County, about 15 miles southwest of Abilene, on Big Elm Creek, which is a tributary of the Clear Fork of the Brazos River. The dam was completed in 1921 with an initial capacity of 11,868 acre-feet of storage. In 1957, a portion of the service spillway was removed due to erosion damage at the "toe" of the dam. This modification reduced the storage capacity to its present capacity of 7,900 acre-feet. The original capacity of 11,868 acre-feet is the authorized capacity of the lake, but there are no plans to restore it to that storage capacity. The City of Abilene feeds water by gravity from this lake to the existing Lake Abilene Water Treatment Plant, utilizing this source as much as possible. It is anticipated that the City will continue to use this source in this same manner for the foreseeable future.

Anson City Lake and North Lake. Anson City and North Lake are small reservoirs owned by the City of Anson. They are located on Thompson

Creek and Carter Creek, respectively, and have no dependable yield. They are not currently used for municipal water supply.

Lake Baird. Lake Baird is a small reservoir located on Mexia Creek. It is owned by the City of Baird and is city's sole source of municipal water supply.

Lake Ballinger. Lake Ballinger is owned by the City of Ballinger and is located on Valley Creek. It provides the raw water supply for Ballinger and its customers.

Lake Cisco. Lake Cisco is owned by the City of Cisco and is located on Sandy Creek, a tributary of the Clear Fork Brazos River. The lake has a permitted capacity of 45,000 acre-feet, although the latest estimates indicate a current capacity of approximately 8,800 acre-feet.

Lake Clyde. Lake Clyde is owned by the City of Clyde and is located in Callahan County on the North Prong Pecan Bayou, which is part of the Colorado River Basin. Completed in 1970, the lake's permitted capacity is 5,748 acre-feet and is utilized for recreational purposes as well as a municipal water source.

Lake Coleman. Lake Coleman is located on Jim Ned Creek in Coleman County and was completed in 1966. It was initially permitted to impound 40,000 acre-feet. The lake is owned by the City of Coleman and provides water supply for the Cities of Coleman and Lawn.

Lake Daniel. Lake Daniel is located on Gonzales Creek, approximately eight miles south of the City of Breckenridge. The reservoir, which has a drainage area of 115 square miles, was constructed in 1949. It supplied all of the water used by Breckenridge until 1970, when the City began to get part of its requirements from Hubbard Creek Reservoir. The lake has a permitted capacity of 11,400 acre-feet, although the latest estimate of capacity is 9,515 acre-feet.

Lake Eastland. Lake Eastland is a small reservoir located on the Leon River northwest of Eastland. It is owned by the City of Eastland, but is not used for water supply as it was found to have no dependable yield.

Lake Fort Phantom Hill. Lake Fort Phantom Hill is located approximately nine miles north of the City of Abilene and is owned and operated by the City. In addition to capturing natural runoff from the lake's 470 square mile drainage area on Elm Creek, Abilene diverts water into the lake from the Clear Fork of the Brazos and from the adjacent Deadman Creek watershed. Lake Fort Phantom Hill was built in 1938 and has a permitted storage capacity of 73,960 acre-feet. The permitted diversions from the Clear Fork of the Brazos and Deadman Creek total a maximum of 30,690 acre-feet per year.

This lake is currently operated in conjunction with Hubbard Creek Reservoir. This coordinated use of these sources was found to increase the overall yield of Lake Fort Phantom Hill by a significant amount, by taking additional water from Fort Phantom Hill and replacing it as needed with Hubbard Creek water. The net change in yield utilized by the City of Abilene is projected to be 8,890 acre-feet per year by the year 2030.

Hords Creek Lake. Hords Creek Lake is owned by the City of Coleman and the U.S. Army Corps of Engineers maintains the associated dam. The total capacity of the reservoir is 8,120 acre-feet.

Hubbard Creek Reservoir. Hubbard Creek Reservoir is located on Hubbard Creek, approximately 6.5 miles northwest of Breckenridge. The dam, completed in 1962, was constructed by the West Central Texas Municipal Water District to provide water to its member cities as their requirements increase beyond the dependable supplies of their own reservoirs. The Cities of Abilene, Albany, Anson, and Breckenridge comprise the member cities of the District. As discussed previously under the description of Lake Fort Phantom Hill, when Hubbard Creek Reservoir and Lake Fort Phantom Hill are operated as a coordinated system there is a potential overall increase in yield of 8,890 acre-feet per year in the year 2030.

Lake Kirby. Lake Kirby is located on Cedar Creek, which is a tributary of the Clear Fork of the Brazos River. This lake is owned and operated by the City of Abilene. The lake has a permitted capacity of 8,500 acre-feet. Since the lake has no dependable yield, it is currently used for golf course irrigation, reducing the demands on the potable supply system, and as an emergency backup supply.

Lake Leon. Lake Leon is owned by the Eastland County Water Supply District which is authorized to impound 28,000 acre-feet of water on the Leon River, a tributary of the Brazos River.

Lake McCarty. Lake McCarty is a small water supply reservoir owned and operated by the City of Albany. It is located on the Salt Prong of

Hubbard Creek and is used as the City's first source of water supply.

Oak Creek Reservoir. Oak Creek Reservoir is included in the Upper Colorado River segment of the Colorado River Basin in Coke and Nolan Counties. The reservoir's permitted capacity is 30,000 acre-feet. The reservoir is owned and operated by the City of Sweetwater and used for both municipal and industrial water supply.

Lake Pennick. Lake Pennick is a small reservoir on Cottonwood Creek east of Anson. It has no dependable yield and is not used for water supply.

Lake Santa Anna. Lake Santa Anna is owned by the City of Santa Anna. Though the lake is still used for water supply, it has no dependable yield and is not the city's sole source of water.

Lake Santa Fe. Lake Santa Fe is a small reservoir owned by the Sweetwater Country Club. It has no dependable yield and is not used for water supply.

Lake Scarborough. Lake Scarborough is a small reservoir owned by the City of Coleman. Located on Indian Creek, it has no dependable yield and is not used for water supply.

South Hamlin Lake. South Hamlin Lake is a small reservoir located on a tributary of California Creek. The lake, owned by the City of Hamlin, has no dependable yield and is not used for water supply.

Lake Stamford. Owned and operated by the City of Stamford, the lake is located in Haskell County on Paint Creek, a tributary of the Clear Fork of the Brazos River. The City constructed a dam with a sluiceway on the creek in late 1952 to form an authorized 60,000 acre-feet capacity although the present capacity is reported to be 49,900 acre-feet. A number of surrounding cities, individuals, and water supply corporations benefit from the water supply provided by Lake Stamford. The lake is also used as a cooling water source for a West Texas Utilities Co. power plant.

Lake Sweetwater. Located at the convergence of Bitter Creek and Cottonwood Creek in Nolan County, Lake Sweetwater is owned by the City of Sweetwater. Construction was completed in 1930, and the impoundment capacity was 11,900 acre-feet; however, due to siltation, the reservoir now impounds approximately 9,640 acre-feet. Lake Sweetwater is maintained as a backup source for meeting peak demand periods during summer months. Sweetwater's other municipal sources include Lake Trammel and Oak Creek Reservoir.

Lake Trammell. Lake Trammell is located on Sweetwater Creek south of the City of Sweetwater. The reservoir is owned and used by Sweetwater for municipal water supply.

Lake Winters. Lake Winters is an 8,347-acre-foot reservoir located on Elm Creek about five miles east of Winters. It is the sole water supply source for the City of Winters.

Lake Woodson. Lake Woodson, owned by the City of Woodson, is located on King Creek in Throckmorton County. Though the lake has no dependable yield, it is still used for municipal water supply for the City of Woodson.

Estimates of the dependable, or safe, yields of the reservoirs described above are listed in Table 4.1. The yields were derived from the available reports, which are described in Chapter 2 and in Appendix B. Several of the reservoirs had only a firm yield listed in the available reports. The firm yield of a reservoir is the annual withdrawal that can be taken from a reservoir during the critical period, while leaving no water stored in the reservoir at the end of the critical period. The safe yield of the reservoir is the annual withdrawal that can be taken that would leave a quantity of water equal to one year's use stored in the reservoir at the end of the critical period. This can be estimated from the firm yield by multiplying the firm yield by T/(1+T), where T is the critical period in years. This method does not take into account the extra evaporation losses that would occur if the safe yield is being used, as higher lake levels with larger surface areas would exist throughout the critical period. However, it provides a reasonable estimate of the safe yield and is more conservative than the firm yield. This was done for all reservoirs for which only a firm yield was listed. For these reservoirs, the estimated critical periods are listed in Table 4.1.

For each of the reservoirs, an estimated safe yield was found for two different times, as yields of surface water reservoirs tend to decrease over time due to siltation reducing the storage capacity. From these values, estimates of the safe yields of each reservoir were made for the years 1990, 2000, 2010, and 2020, using linear interpolation over

Table 4.1

Regional Water Supply Study
Estimated Safe Yields of Existing Reservoirs

Reservoir	Year	Yield	F/S	Year	Yield	F/S	Crit. Per.	Estimated Safe Yields 1990 (AF/YR)	2000 (AF/YR)	2010 (AF/YR)	2020 AF/YR)
Lake Abilene (w/ depletion allow.)	1980	1,110	S	2030	820	S		1,052	994	936	878
Anson City Lake								0	0	0	0
Anson North Lake								0	0	0	0
Lake Baird	1970	560	S	2000	560	S		0	0	0	0
Lake Ballinger	0	1,596	S	2040	1,596	S		1,596	1,596	1,596	1,596
Lake Cisco	1990	600	F	2020	500	F	9	540	510	480	450
Lake Clyde	1970	589	F	2020	500	F	9	498	482	466	450
Lake Coleman	1985	10,200	F	2035	9,400	F	7	8,855	8,715	8,575	8,435
Lake Daniel (w/ depletion allow.)	1980	1,300	S	2030	0	S		1,040	780	520	260
Lake Eastland								0	0	0	0

Table 4.1, Continued

Reservoir	Year	Yield	F/S	Year	Yield	F/S	Crit. Per.	Estimated Safe Yields 1990 (AF/YR)	2000 (AF/YR)	2010 (AF/YR)	2020 AF/YR)
Fort Phantom Hill (w/ div. from Clear Fork & Deadman Creeks) (w/ depletion allow.) (w/ Coordinated Use)	1980	17,930	S	2030	15,750	S		17,494	17,058	16,622	16,186
Hords Creek Lake (w/ depletion allow.)	1985	774	F	2010	774	F	7	677	677	677	677
Hubbard Creek Res. (w/ depletion allow.)	1980	26,700	S	2030	21,300	S		25,620	24,540	23,460	22,380
Lake Kirby								0	0	0	0
Lake Leon	1990	4,700	F	2020	3,100	F	7	4,113	3,646	3,179	2,713
Lake McCarty (w/ depletion allow.)	1980	190	S	2030	0	S		152	114	76	38
Oak Creek Res.	1980	4,000	S	2020	3,600	S		3,900	3,800	3,700	3,600
Lake Pennick								0	0	0	0

Table 4.1, Continued

Reservoir	Year	Yield	F/S	Year	Yield	F/S	Crit. Per.	Estimated Safe Yields 1990 (AF/YR)	2000 (AF/YR)	2010 (AF/YR)	2020 AF/YR)
Lake Santa Anna								0	0	0	0
Lake Santa Fe								0	0	0	0
Lake Scarborough								0	0	0	0
South Hamlin Lake								0	0	0	0
Lake Stamford	1990	830	S	2020	297	S		830	652	475	297
Lake Sweetwater	1980	600	S	2020	440	S		560	520	480	440
Lake Trammell	1980	130	S	2010	116	S		125	121	116	111
Lake Winters	0	1,360	S	2040	1,360	S		1,360	1,360	1,360	1,360
Lake Woodson								0	0	0	0

time. These values are also listed in Table 4.1.

The next step in the analysis was to determine the quantity of water supply that would be available for potable use on an annual basis from each of the reservoirs. Table 4.2 lists each of the identified reservoirs, their permitted diversion rates by type of use, and the estimated supply for potable use. For the purposes of the table, available potable supply is defined as the lesser of a) available water rights, b) estimated demand, or c) the available yield less estimated raw water demands. For Lake Ballinger and Lake Coleman, the available yield is greater than the sum of the available potable supply for each permitted use. For these two reservoirs, an additional line was added, "Add'l Municipal", which designates the portion of the yield that could be available for potable municipal supply if the water rights were transferred properly from one use to another. For each reservoir, the estimated safe yield for the length of the study period was used as a starting point. These values, the calculations of which are shown in Table 4.1, are listed in Table 4.2 along with the potable supply available. For all of the reservoirs, the estimated safe yield is less than the permitted diversion, as the critical period that has occurred is longer and more severe than that which was anticipated at the time of construction.

For the reservoirs that are permitted for other raw water uses in addition to municipal water use, an estimate was made of the demands of each type of use permitted for the study period. These projections were

Table 4.2

Regional Water Supply Study
Available Supplies of Existing Reservoirs for Potable Water Use

Reservoir	Owner of Water Rights	Type of Use	Amount Approp. (AF/YR)	Available Potable Supply and Yield 1990 (AF/YR)	2000 (AF/YR)	2010 (AF/YR)	2020 (AF/YR)
Lake Abilene	City of Abilene	Municipal	1,675	1,052	994	936	878
			Yield	1,052	994	936	878
Anson City Lake	City of Anson	Recreation	n.a.	0	0	0	0
Anson North Lake	City of Anson	Municipal	542	0	0	0	0
Lake Baird	City of Baird	Municipal	550	0	0	0	0
Lake Ballinger	City of Ballinger	Municipal	1,000	1,000	1,000	1,000	1,000
	City of Ballinger	Irrigation	685	0	0	0	0
		Add'l Municipal		596	596	596	596
		Total	1,685	1,000	1,000	1,000	1,000
			Yield	1,596	1,596	1,596	1,596
Lake Cisco (inc Battle Ck Div)	City of Cisco	Municipal	4,971	484	454	424	394
	City of Cisco	Industrial	56	56	56	56	56
		Total	5,027	540	510	480	450
			Yield	540	510	480	450
Lake Clyde	City of Clyde	Municipal	1,000	498	482	466	450
			Yield	498	482	466	450

Table 4.2, Continued

Reservoir	Owner of Water Rights	Type of Use	Amount Approp. (AF/YR)	Available Potable Supply and Yield 1990 (AF/YR)	2000 (AF/YR)	2010 (AF/YR)	2020 (AF/YR)
Lake Coleman	City of Coleman	Municipal	4,500	4,500	4,500	4,500	4,500
	City of Coleman	Industrial	4,500	7	11	14	18
	City of Coleman	Irrigation	500	0	0	0	0
		Add'l Municipal		4,348	4,204	4,061	3,917
		Total	9,500	8,855	8,715	8,575	8,435
			Yield	8,855	8,715	8,575	8,435
Lake Daniel	City of Breckenridge	Municipal	2,100	1,040	780	520	260
			Yield	1,040	780	520	260
Lake Eastland	City of Eastland	Municipal	600	0	0	0	0
Fort Phantom Hill (w/ coordinated use)	City of Abilene	Municipal	28,690	20,570	19,359	18,504	17,443
	West Texas Utilities	Industrial†	2,500	1,300	1,500	1,500	1,500
	City of Abilene	Irrigation	1,000	0	0	0	0
	City of Abilene	Industrial	4,000	2,754	3,769	4,628	5,693
		Total	36,190	24,624	24,628	24,632	24,636
			Yield	24,624	24,628	24,632	24,636
Hords Creek Lake	City of Coleman	Municipal	2,240	677	677	677	677
			Yield	677	677	677	677

Table 4.2, Continued

Reservoir	Owner of Water Rights	Type of Use	Amount Approp. (AF/YR)	Available Potable Supply and Yield 1990 (AF/YR)	2000 (AF/YR)	2010 (AF/YR)	2020 (AF/YR)
Hubbard Creek Res. Demands from High Population Series	West Central Texas MWD	Municipal	21,011	12,437	8,608	4,626	(1,593)
	City of Abilene	Contract	17,360	8,244	10,412	12,854	17,360
	City of Albany	Contract	1,881	585	628	655	662
	City of Anson	Contract	2,061	711	743	767	850
	City of Breckenridge	Contract	2,487	843	1,249	1,558	2,001
	West Central Texas MWD	Mining†	6,000	1,000	1,000	1,000	1,000
	West Central Texas MWD	Domestic†	2,000	900	1,000	1,100	1,200
	West Central Texas MWD	Industrial	1,200	0	0	0	0
	West Central Texas MWD	Irrigation†	2,000	900	900	900	900
		Total	56,000	25,620	24,540	23,460	22,380
			Yield	25,620	24,540	23,460	22,380
Hubbard Creek Res. Demands from Low Population Series	West Central Texas MWD	Municipal	21,011	12,676	9,116	5,949	1,499
	City of Abilene	Contract	17,360	8,071	10,070	11,726	14,654
	City of Albany	Contract	1,881	571	618	645	652
	City of Anson	Contract	2,061	708	710	709	732
	City of Breckenridge	Contract	2,487	794	1,126	1,421	1,743
	West Central Texas MWD	Mining†	6,000	1,000	1,000	1,000	1,000
	West Central Texas MWD	Domestic†	2,000	900	1,000	1,100	1,200
	West Central Texas MWD	Industrial	1,200	0	0	0	0
	West Central Texas MWD	Irrigation†	2,000	900	900	900	900
		Total	56,000	25,620	24,540	23,460	22,380
			Yield	25,620	24,540	23,460	22,380

Table 4.2, Continued

Reservoir	Owner of Water Rights	Type of Use	Amount Approp. (AF/YR)	Available Potable Supply and Yield 1990 (AF/YR)	2000 (AF/YR)	2010 (AF/YR)	2020 (AF/YR)
Lake Kirby	City of Abilene	Municipal	3,765	0	0	0	0
		Industrial	1,235	0	0	0	0
		Total	5,000	0	0	0	0
			Yield	0	0	0	0
Lake Leon	Eastland Co. WSD	Municipal	5,450	4,113	3,646	3,179	2,713
		Industrial	350	0	0	0	0
		Irrigation	500	0	0	0	0
		Total	6,300	4,113	3,646	3,179	2,713
			Yield	4,113	3,646	3,179	2,713
Lake McCarty	City of Albany	Municipal	600	152	114	76	38
			Yield	152	114	76	38
Oak Creek Res.	City of Sweetwater	Municipal	6,000	2,490	2,390	2,290	2,190
	City of Sweetwater	Industrial†	4,000	1,410	1,410	1,410	1,410
		Total	10,000	3,900	3,800	3,700	3,600
			Yield	3,900	3,800	3,700	3,600
Lake Pennick	City of Stamford	Recreation	n.a.	0	0	0	0
Lake Santa Fe	Sweetwater Country Club	Irrigation	40	0	0	0	0

Table 4.2, Continued

Reservoir	Owner of Water Rights	Type of Use	Amount Approp. (AF/YR)	Available Potable Supply and Yield 1990 (AF/YR)	2000 (AF/YR)	2010 (AF/YR)	2020 (AF/YR)
Lake Scarborough	City of Coleman	Municipal	769	0	0	0	0
South Hamlin Lake	City of Hamlin	Municipal	n.a.	0	0	0	0
Lake Stamford	City of Stamford	Municipal	3,880	(170)	(348)	(525)	(703)
	West Texas Utilities	Industrial†	5,000	1,000	1,000	1,000	1,000
		Total	10,000	830	652	475	297
			Yield	830	652	475	297
Lake Sweetwater	City of Sweetwater	Municipal	2,730	560	520	480	440
	City of Sweetwater	Industrial	960	0	0	0	0
	City of Sweetwater	Irrigation	50	0	0	0	0
		Total	3,740	560	520	480	440
			Yield	560	520	480	440
Lake Trammell	City of Sweetwater	Municipal	2,000	125	121	116	111
			Yield	125	121	116	111
Lake Winters	City of Winters	Municipal	1,360	1,334	1,327	1,320	1,312
	City of Winters	Industrial	395	26	33	40	48
		Total	1,755	1,360	1,360	1,360	1,360
			Yield	1,360	1,360	1,360	1,360

Table 4.2, Continued

Reservoir	Owner of Water Rights	Type of Use	Amount Approp. (AF/YR)	Available Potable Supply and Yield 1990 (AF/YR)	2000 (AF/YR)	2010 (AF/YR)	2020 (AF/YR)
Lake Woodson	City of Woodson	Municipal		0	0	0	0

Note:

Available potable supply is defined as the lesser of
a) Available Water Rights,
b) Estimated Demand,
c) Available Yield less raw water demands.
*Add'l Municipal available if water rights for other uses are changed.
†Raw water uses.

based on information developed by the Texas Water Development Board. For Hubbard Creek, the demands of the member cities are included, listing their type of use as by contract. The maximum contracted amounts, are shown under the amount appropriated column. For this reason, Hubbard Creek Reservoir is listed twice, once with the high population demand estimates and once with the low. The projected demands of the member cities, developed in Chapter 3 and shown in Tables 3.8 and 3.9, are listed in the estimated supply columns for the study period. Hubbard Creek is the only reservoir for which this approach had an impact.

The water supply available for potable use by the owner of the reservoir is the portion of the available yield that is remaining after the raw water demands are met. For Lake Stamford, the available potable supply is negative. This implies that the estimated raw water uses of West Texas Utilities are greater than the estimated safe yield. Though a negative supply has little practical meaning, for planning purposes, negative available supplies will be counted as a deficit towards meeting the projected demands.

For the member cities of the West Central Texas Municipal Water District (WCTMWD), their projected demands are listed assuming that the full available supply of their individual lakes are used first. For both Lake Fort Phantom Hill and Hubbard Creek Reservoir, the adjusted yield with coordinated use of the reservoirs by the City of Abilene is listed. The net gain in yield is added to Lake Fort Phantom Hill's yield. For all reservoirs, the permitted amount was used as an upper limit for the available supply.

Table 4.2 provides an estimate of the amount of water supply that is available from the identified reservoirs for potable use through the study period. The results are combined for each of the potable water supply entities which own a source of raw water in Table 4.3. For the member cities from WCTMWD, their contractual amounts are listed as available potable supply. For the owners of the reservoirs, the available potable water supply is listed. For each entity, a sum of the available potable water supplies is given for the total potable water supply available.

For the potable water supply entities that utilize groundwater, a withdrawal rate is listed in Table 4.3 as the estimated available raw water supply, if one was available. Values were available for the Getty (Texaco) well field used by Sweetwater and the Trinity Aquifer, used by Cross Plains. These were assumed to be zero in the year 2020 so that the sizing of supply alternatives would include replacement of the groundwater supply. For the others, values of zero are listed. Therefore, the cities of Buffalo Gap, Miles, and Rising Star are shown to have zero available potable water supplies.

Table 4.3

Regional Water Supply Study
Available Water Supply for Potable Use

- Acre-Feet/Year -

Water Supply Entity	Raw Water Supply Source	Supply Available for Potable Use 1990	2000	2010	2020
ABILENE*	Lake Fort Phantom Hill	23,324	23,128	23,132	23,136
	Hubbard Creek Res.	17,360	17,360	17,360	17,360
	Lake Abilene	1,052	994	936	878
	Total Available	41,736	41,482	41,428	41,374
ALBANY*	Hubbard Creek Res.	1,881	1,881	1,881	1,881
	Lake McCarty	152	114	76	38
	Total Available	2,033	1,995	1,957	1,919
ANSON*	Hubbard Creek Res.	2,061	2,061	2,061	2,061
	South Anson Lake	0	0	0	0
	Total Available	2,061	2,061	2,061	2,061
BAIRD*	Baird Lake	0	0	0	0
BALLINGER	Lake Ballinger	1,596	1,596	1,596	1,596
BRECKENRIDGE*	Hubbard Creek Res.	2,487	2,487	2,487	2,487
	Lake Daniel	1,040	780	520	260
	Total Available	3,527	3,267	3,007	2,747
BUFFALO GAP	Buffalo Gap Wellfield	0	0	0	0
CISCO*	Lake Cisco	540	510	480	450
CLYDE	Lake Clyde	498	482	466	450
COLEMAN (incl.Lawn)	Lake Coleman	8,855	8,715	8,573	8,435
CROSS PLAINS*	Trinity Aquifer	165	165	165	0

Table 4.3, Continued

Water Supply Entity	Raw Water Supply Source	Supply Available for Potable Use 1990	2000	2010	2020
EASTLAND CO.	Lake Leon	4,113	3,646	3,179	2,713
	Lake Eastland	0	0	0	0
	Total Available	4,113	3,646	3,179	2,713
MILES	Miles Well Field	0	0	0	0
RISING STAR	Rising Star Well Field	0	0	0	0
STAMFORD*	Lake Stamford	(170)	(348)	(525)	(703)
SWEETWATER*	Oak Creek Res.	2,490	2,390	2,290	2,190
	Lake Trammel	125	121	116	111
	Lake Sweetwater	560	520	480	440
	Getty Well Field	840	840	840	0
	Total Available	4,015	3,871	3,726	2,741
WINTERS	Lake Winters	1,360	1,360	1,360	1,360
WOODSON*	Lake Woodson	0	0	0	0

*Denotes a participant in the study.
Water supply based on safe yields.

4.3 Existing Potable Water Production Facilities

There are currently 19 existing water treatment plants in the 10-County Regional Water Study Area. A list of these facilities is shown in Table 4.4.

The rated capacities of the listed water treatment plants are shown in Table 4.5. Also listed for the participants are the figure numbers where a schematic of the plant is shown in Appendix D.

It is beyond the scope of this study to evaluate the existing conditions of these water treatment plants and their ability to meet current water treatment standards; however, based on discussions with the Texas Department of Health, the plants at Moran, Lawn, Albany, and Anson have some degree of difficulty meeting current treatment standards.

Table 4.4

Existing Water Treatment Plants

County	Owner	Water Source
Callahan	Baird*	Baird Lake
	Clyde	Lake Clyde
Coleman	Coleman	Lake Coleman
	Santa Anna	Lake Santa Anna Lake Brownwood
Eastland	Cisco*	Lake Cisco
	Eastland Co. WSD #1	Lake Leon
Jones	Anson*	Hubbard Creek Res. South Anson Lake
	Hamlin*	Lake Stamford
	Stamford*	Lake Stamford
Nolan	Blackwell-Nolan Co. FWSD #1	City of Sweetwater
	Sweetwater*	Oak Creek Lake Lake Sweetwater Lake Trammell
Runnels	Ballinger	Lake Ballinger
	Winters	Lake Winters
Shackelford	Albany*	Hubbard Creek Res. Lake McCarty
	Moran*	Lake Moran
Stephens	Breckenridge*	Hubbard Creek Res. Lake Daniel
Taylor	Abilene*	Lake Fort Phantom Hill Lake Abilene
	Lawn	Lake Coleman
Throckmorton	Woodson*	Lake Woodson

*Denotes a participant in the study.

Table 4.5

Capacities of Existing Water Treatment Plants

City	Plant Capacity MGD	Schematic Figure No.
Abilene:		
Lake Abilene WTP	3.000	G.1
Northeast WTP	24.000	G.2
Grimes WTP	25.000	G.3
Total	52.000	
Albany	1.700	G.4
Anson	1.400	G.5
Baird	0.455	G.6
Ballinger	2.800	-
Breckenridge	3.457	G.7
Buffalo Gap	0.460	-
Cisco	4.500	G.8
Clyde	2.000	-
Coleman	6.000	-
Cross Plains	0.650	-
Eastland Co.	4.000	-
Hamlin	1.620	G.9
Lawn	0.216	-
Moran	0.512	G.10
Stamford	3.000	G.11
Sweetwater	7.460	G.12
Winters	2.000	-
Woodson	0.144	G.13

4.4 Review of 1986 Safe Drinking Water Act Amendments

This section covers the information assembled in the evaluation of the impacts of the SDWA Amendments of 1986 on the study participants.

History

Most of the current regulations are based on old 1962 U.S. Public Health standards. Authority and responsibility for applying these regulations over all water supplies in the United States were given to the USEPA in the original Safe Drinking Water Act legislation of 1974.

The 1986 Amendments to the Safe Drinking Water Act (SDWA) focus on four major areas of evaluation.

1. Water Quality
2. Turbidity
3. Disinfection
4. Monitoring

USEPA's implementation of the above requirements was broken down further as follows:

1. Volatile Organic Chemical (VOC's)
2. Synthetic Organic Chemicals (SOC's) and Inorganic Chemicals (IOC's)
3. Surface Water Treatment Rule
4. Coliform Rule
5. Lead and Copper
6. Radionuclides
7. Disinfectant By-Products

All of the above requirements were to have regulations developed and effective by 1993. Some of the regulations have been completed, but EPA is behind schedule on others. It is estimated that all of the revisions and new standards are to be completed by 1995.

In order to review the impact on the study participants, they were categorized based on water supply source (surface vs. groundwater) and size. Information on the existing treatment systems was assembled and is shown in Figures G.1 through G.13.

Current Status of Regulations and Participant Impact

A summary of the current status of the SDWA regulations and the noted impact on the study participants is as follows:

1. Volatile Synthetic Organic Chemicals (VOC's)

The VOC regulations apply to all community water supply systems of all sizes. The implementation of regulations is based on the system size. For systems larger than 10,000 persons, the regulations became effective in January 1989; for those between 3,300 and 10,000, the regulations were in effect in January 1990. Systems less than 3,300 will not be required to comply until December 1991. The State of Texas is responsible for the testing of the compounds. Testing has been completed for the systems greater than 3,300 persons, but has not been completed for cities with a population less than 3,300.

The contaminants listed in the VOC regulations fall into four categories: 1) Regulated VOC's, 2) Unregulated VOC's which are required to be monitored, 3) Unregulated VOC's which are required to be monitored in Texas, and 4) Unregulated VOC's added to the list by the Texas Department of Health. The groupings of contaminants in each category are shown in Table 4.6. None of the water systems participating in this study who have been tested were out of compliance with the regulations. Of the contaminants listed, the only ones which have been found in levels greater than the proposed maximum contaminant level (MCL) are those in the unregulated groups. No regulations exist for these contaminants, so the systems are not in violation of the SDWA. However, it is anticipated that regulations will be developed for many of the contaminants on the monitored list.

A summary of the effects of the VOC regulations on the WCT Regional Water Supply participants is shown on Table 4.11.

Repeat monitoring of all systems will be required using a schedule based on water source (SW vs GW), system size, and whether VOC's were detected in the initial round of monitoring or it is determined by TDH that the water supply is vulnerable to contamination.

For systems who rely on surface water and for whom VOC's were not detected in the initial monitoring and are not vulnerable, repeat monitoring is required only at TDH discretion. The study participants should check with the TDH to determine their status.

Table 4.6

Safe Drinking Water Act Amendment of 1986
Regulated & Monitored Contaminants
Phase I

Contaminant	Proposed MCL (ug/l)
Regulated Volatile Organic Chemicals (VOC's)	
Trichloroethylene	5.0
Carbon Tetrachloride	5.0
1,2-Dichloroethane	5.0
Vinyl Chloride	2.0
Benzene	5.0
p-Dichlorobenzene	75.0
1,1-Dichloroethylene	7.0
1,1,1-Trichloroethane	200.0
Unregulated VOC's Required to be Monitored	
Bromobenzene	1.0
Bromodichloromethane	1.0
Bromoform	1.0
Bromomethane	2.0
Chlorobenzene	1.0
Chlorodibromomethane	1.0
Chloroethane	2.0
Chloroform	1.0
Chloromethane	2.0
o-Chlorotoluene	1.0
p-Chlorotoluene	1.0
Dibromomethane	1.0
m-Dichlorobenzene	1.0
o-Dichlorobenzene	1.0
trans-1,2-Dichloroethylene	1.0
cis-1,2-Dichloroethylene	1.0
Dichloromethane	1.0
1,1-Dichloroethane	1.0
1,1-Dichloropropene	1.0
1,3-Dichloropropene	1.0
1,2-Dichloropropane	1.0
1,3-Dichloropropane	1.0
2,2-Dichloropropane	1.0
Ethylbenzene	2.0

Table 4.6, Continued

Contaminant	Proposed MCL (ug/l)
Styrene	2.0
1,1,2-Trichloroethane	1.0
1,1,1,2-Tetrachloroethane	1.0
1,1,2,2-Tetrachloroethane	1.0
Tetrachloroethylene	1.0
1,2,3-Trichloropropane	1.0
Toluene	1.0
p-Xylene	2.0
o-Xylene	2.0
m-Xylene	2.0
Unregulated VOC's for which Monitoring is Required at State of Texas Discretion	
Bromochloromethane	1.0
Dichlorodifluoromethane	2.0
Flurotrichloromethane	1.0
Unregulated VOC's Added by Texas Department of Health	
Methyl Iso Butyl Ketone	4.0
Acetone	20.0
Methyl Methacrylate	10.0
Methyl-t-Butyl Ether	4.0
Methyl Ethyl Ketone	4.0
Tetrahydrofuran	10.0

2. <u>Synthetic Organic Chemicals (SOC's) and Inorganic Chemicals (IOC's)</u>

The SOC's and IOC's MCL development was broken down into two phases. The phases are designated Phase II and Phase V. The first group is listed in Table 4.7. Of the 38 contaminants in this phase, 33 were issued as final standards on December 31, 1990, and the remaining five are expected to be finalized in July 1991. The rules don't go into effect until July 30, 1992. The requirements are similar to those of Phase I. Initial monitoring is required for the 38 contaminants by all water supply systems. The schedule for implementation is based on system size, with the July 30, 1992 date applying to systems serving more than 10,000 persons. For medium-sized (3,300-9,999) and small systems, the effective dates are July 30, 1993 and July 30, 1995, respectively. Repeat monitoring is required and treatment is necessary for removal of SOC's and IOC's which are out of compliance.

The 10 volatile SOC's regulated under Phase II were required to be monitored (as an unregulated contaminant) during Phase I monitoring. None of the systems tested were out of compliance with the volatile SOC's.

The second grouping has had MCL's proposed for 24 contaminants but is not expected in final form until March 1992. The contaminants in Phase V are listed in Table 4.8 with their proposed MCL's. The implementation requirements, other than schedule, will be similar to those for the Phase II group.

Table 4.7

Safe Drinking Water Act Amendment of 1986
Regulated Contaminants
Phase II

Contaminant	Proposed MCL (mg/l)	Notes
Inorganics		
Asbestos	7	10^6 fibers (>10um long)/liter
Barium	5	
Cadmium	0.005	
Chromium	0.1	
Mercury	0.002	
Nitrate	10	(as N)
Nitrite	1	(as N)
Selenium	0.05	
Volatile Organic Contaminants		
o-Dichlorobenzene	0.6	
cis-1,2-Dichloroethylene	0.07	
trans-1,2-Dichloroethylene	0.07	
1,2-Dichloropropane	0.005	
Ethylbenzene	0.7	
Monochlorobenzene	0.1	
Styrene	0.005	
Tetrachloroethylene	0.005	
Toluene	2	
Xylene	10	
Polymers		
Acrylamide	treatment tech.	
Epichlorohydrin	treatment tech.	
Pesticides & PCB's		
Alachlor	0.002	
Aldicarb	0.01	
Aldicarb Sulfone	0.04	
Aldicarb Sulfoxide	0.01	
Atrazine	0.003	
Carbofuran	0.04	

Table 4.7, Continued

Contaminant	Proposed MCL (mg/l)	Notes
Chlordane	0.002	
2,4 D	0.07	
Dibromochloropropane (DBCP)	0.0002	
Heptachlor	0.0004	
Heptachlor epoxide	0.0002	
Lindane	0.0002	
Methoxychlor	0.4	
PCB's (as decachlorobiphenyls)	0.0005	
Pentachlorophenol	0.2	
Toxaphene	0.005	
2,4,5-TP(Silvex)	0.05	

Table 4.8

Safe Drinking Water Act Amendment of 1986
Regulated & Monitored Contaminants
Proposed Regulated Contaminants
Phase V

Contaminant	Proposed MCL (ug/l)
Proposed MCLG's for Inorganic Chemicals	
Antimony	3.0
Beryllium	0.0
Cyanide	200.0
Nickel	100.0
Sulfate	400 mg/L
Thallium	0.5
Proposed MCLG's for Organic Chemicals	
Adipates [Di(ethylexyl)apidate]	500.0
Dalapon	200.0
Dichloromethane (Methylene Chloride)	0.0
Dinoseb	7.0
Diquat	20.0
Endothall	100.0
Endrin	2.0
Glyphosate	700.0
Hexachlorobenzene	0.0
Hexachlorocyclopentadiene (HEX)	50.0
Oxamyl (Vydate)	200.0
PAH's [Benzo(a)pyrene]	0.0
Phthalates [Di(ethylhexyl)phthalate]	0.0
Picloram	500.0
Simazine	1.0
1,2,4-Trichlorobenzene	9.0
1,1,2-Trichloroethane	3.0
2,3,7,8-TCDD (Dioxon)	0.0

3. Surface Water Treatment Rule

The new Texas Surface Water Treatment (TSWTR) became effective on December 31, 1990. The compliance deadline for the TSWTR is July 1, 1993, meaning all improvements or changes required to meet the rules must be in place by that date. These rules apply to surface waters and to "groundwaters under the direct influence of surface water." The TSWTR require all applicable public water systems to remove or inactivate disease-causing organisms by filtration or disinfection or both. All surface water based public water systems in the study already provide filtration. To comply with the TSWTR will require these water systems to demonstrate:

- Ability to inactivate the disease-causing organisms to the appropriate levels by disinfection. In order to establish the effectiveness of the disinfection processes, tracer studies will have to be conducted for all surface water treatment plants using chloramines and either a tracer study or disinfection evaluation for all others. Data must be submitted to the Texas Department of Health by January 1, 1993 so that the necessary improvements can be made by July. Since the tracer studies are conducted at maximum flow rates the tests should be completed during or before the summer of 1992 for best results. For small plants that do not rely only on chloramines for disinfection and where the tracer studies are impractical or prohibitively expensive, the water system may, with prior approval of the Texas Department of Health (TDH), use calculated values for demonstrating compliance. Prior approval is required and the calculations must be submitted by a Registered Professional Engineer via an engineering report.

- Ability to monitor discrete levels of turbidity at least every four hours while the system is serving water to the public. Samples are to be taken after filtration. It is suggested each filter be able to be monitored independently. It is suggested the water systems contact the TDH to request approval of the higher turbidity lever allowed by the SWTR for systems using conventional or direct filtration. For systems serving fewer than 500 persons the State, at its discretion, may reduce the requirement to one grab sample per day.
- Ability to staff the SWTP on a 24-hour basis with a certified operator for any period during which the plant is producing water.
- Ability to continuously monitor disinfectant residual concentration in the water entering the distribution system. For systems serving fewer than 3,300 persons, grab samples are allowed.

It is believed that the WCT participants who treat surface water will have little difficulty in meeting the Surface Water Treatment Rule. This is based on interpretation of the State of Texas position on the effectiveness of conventional water treatment in reducing viruses and cysts, and the current water treatment in reducing viruses and cysts, and the current practice of disinfection. It will require, though, that the systems conduct tracer studies to verify the detention times in their basins and then modify the disinfectant chemical feed point(s) and dosage(s), as needed. In some cases, rehabilitation to correct short-circuiting or other physical improvements may be required. The TDH will be identifying groundwater supplies which are under the direct influence of surface water. Water supply systems based on such groundwaters will be required to comply with the SWTR. The TDH has not yet begun this program.

A summary of the systems to be impacted is shown on Table 4.11.

4. Coliform Rule

The coliform regulations were approved in June 1989 and became effective in Texas on January 1, 1991. The new rules drastically revise the MCL for the total coliforms, measuring compliance based on an analysis of the presence or absence of coliform as opposed to the previous density standard. The coliform rules do not affect the treatment plant (unless it is determined that inadequate treatment is the cause of the failure). Water systems were required to submit a written site sampling plan for state approval and to have implemented a testing program throughout the distribution system. The magnitude of the testing program is a function of the water system size, and whether the water source is surface water or groundwater.

All systems already should have submitted a written sampling siting plan and begun monitoring for compliance.

5. Lead and Copper Rule

The final rule for lead and copper came out on May 7, 1991. Monitoring for these contaminants must begin by January 1992 for large systems (50,000 and above), July 1992 for medium size systems (3,300 to 49,999), and July 1993 for small systems. Corrosion control systems will need to be in place for these systems by January 1997, July 1997, and January 1998, respectively. If the lead and copper levels are determined to be excessive in the source water, treatment will be required.

If the levels continue to be excessive, a systematic program for removal of service lines constructed with lead will be required.

A review of the water quality data of the study participants suggest there is not a problem with lead or copper in the raw or treated water. If a problem develops, it will be in the distribution system.

The final rule for lead and copper did not contain a requirement for sampling at the tap as was previously expected. However, legislation has been introduced to require USEPA to include sampling at the tap for lead and copper.

6. Radionuclides

The EPA is completing draft regulations for radionuclides. A

Federal Register notice is being developed to propose regulations for MCLG's (maximum contaminant level goals) and MCL's for the contaminants listed in Table 4.9. The proposed rules are expected to be published in July 1991. As with the Phase I and Phase II rules, a monitoring program is required with treatment of the water if maximum contaminant values are exceeded.

Table 4.11 lists those water systems which were in compliance with the radionuclides regulated prior to 1986. No data are presently available on the others listed.

7. Disinfection/Disinfectant By-Product

The objective of the SWTR described above is to reduce the microbiological contaminants that cause acute health risk. All of the WCT participants accomplish this by disinfecting with chlorine or chloramines. This disinfection practice creates new chemical contaminants, which are suspected to have long-term (chronic) disease-causing potential. These contaminants are referred to as Disinfectant By-Products (DBP's). A preliminary list of DBP's which will be regulated is shown in Table 4.10.

The proposed regulations provided for requirements for disinfection treatment processes for all public water systems using groundwater and maximum contaminant levels (MCL's) or treatment technique requirements for disinfectants and disinfection byproducts (DBP's) for all public water supplies. These rules are not

Table 4.9

Safe Drinking Water Act Amendment of 1986
Regulated & Monitored Contaminants
Phase III

Radionuclides Proposed for Regulation

Gross Alpha Particle Activity
Beta Particle and Photon Radioactivity
Natural Uranium
Radium 226 and 228
Radon

Table 4.10

Safe Drinking Water Act Amendment of 1986
Regulated & Monitored Contaminants
Phase IV

Disinfection By-Products Considered for Development of MCL's

Aldahydes
Bromate
Bromide
Bromodichloromethane
Bromoform
Chlorate
Chlorinated Acetic Acids
Chlorinated Ketones
Chlorite
Chloroform
Chloronated Alcohols
Chlorophenols
Chloropicrin
Chanogen Chloride
Dibromochloromethane
Halocetomitriles
Iodate
Iodite

TABLE 4.11

SUMMARY TABLE
SDWA AMMENDMENTS AFFECTS ON WCT
REGIONAL WATER SUPPLY STUDY PARTICIPANTS

			Regulated and Monitored Contaminants							
Participant	Type of Water Supply	Treatment Type	(1) Surface Water Treatment Rule	(2) Coliform Rule	(3) Copper & Lead Rule	(4) Phase I VOC's	Phase II SOC's & IOC's	(5) Phase III Radinuclides	(6) Phase IV DBP's	(7) Phase V Addn. SOC's & IOC's
Abilene	SW	(3) Solids Contact	■	■		x1				
Albany	SW	Conv.	■	■	■					
Anson	SW	Conv.	■	■	■			■		
Baird	SW	Conv.	■	■	■	x1		■		
Breckenridge	SW	Conv.	■	■						
Cisco	SW	Conv.	■	■		x				
Crossplains	SW	N/A	xN/A	■						
Hamlin	SW	Conv.	■	■	■					
Hawly WSC	(N/A - Purchases treated water)		N/A	■						
Moran	SW	Conv.	■	■				■		
Shackelford WSC	(N/A - Purchases treated water)		N/A	■						
Stamford	SW	Conv.	■	■	■	x1				
Sweetwater	SW	Solids Contact	■	■		x1				
Tuscalusa, Taylor	(N/A - Purchases treated water)		N/A	■						
County WSD				■						
Tye	(N/A - Purchases treated water)		N/A	■						
WCT MWD	(N/A - Provides no treatment)		N/A	■						
Woodson								■		

Notes:

1. Cities with a ■ appear to be able to comply with Surface Water Treatment Rule by making the following modifications: (1) Monitor turbidity constantly, (2) feed chlorine then ammonia at the head of the plant, (3) have tracer study performed or calculated and (4) have continuous chlorine residual analyzers added.
2. Does not affect treatment plant (unless it is determined inadequate treatment is cause of failure). Cities and WSC's will be required to submit a written site sampling plan for state approval and implement testing program throughout the distribution system.
3. Cities and WSC's with a ■ appear to satisfy MCL's. Available data on lead is on a detection limit of 0.02 mg/L which is greater than the proposed MCL. For cities with no ■, data has not yet been received.
4. State has not completed Phase I testing for all cities under 3300 population. On those tested, indicated by a ■, all regulated contaminants appear to be in compliance. On those tested, indicated by an "x", a regulated contaminant is exceeded. Those indicated by "x1" have a monitored contaminant which was exceeded.
5. Final MCL's have not yet been established. Cities designated by a ■ are in compliance with those radionuclides regulated prior to 1986.
6. Contaminants and MCL's for regulated Disinfection By-products have not been established at this time.
7. MCL's for additional SOC's and IOC's have not been established.

Table 4.12

Safe Drinking Water Act Amendment of 1986
Regulated & Monitored Contaminants
Proposed Regulated Contaminants
Phase V

Contaminant	Proposed MCL (ug/l)
Proposed MCLG's for Inorganic Chemicals	
Antimony	3.0
Beryllium	0.0
Cyanide	200.0
Nickel	100.0
Sulfate	400 mg/L
Thallium	0.5
Proposed MCLG's for Organic Chemicals	
Adipates [Di(ethylexyl)apidate	500.0
Dalapon	200.0
Dichloromethane (Methylene Chloride)	0.0
Dinoseb	7.0
Diquat	20.0
Endothall	100.0
Endrin	2.0
Glyphosate	700.0
Hexachlorobenzene	0.0
Hexachlorocyclopentadiene (HEX)	50.0
Oxamyl (Vydate)	200.0
PAH's [Benzo(a)pyrene]	0.0
Phthalates [Di(ethylhexyl)phthalate]	0.0
Picloram	500.0
Simazine	1.0
1,2,4-Trichlorobenzene	9.0
1,1,2-Trichloroethane	3.0
2,3,7,8-TCDD (Dioxon)	0.0

5. COMPARISON OF SUPPLY AND DEMAND

5.1 Introduction

A description of the demand for both potable water supply and production is presented in chapter 3 for the various potable water supply entities. It was estimated that the overall potable water demand for the 10- county area will increase from 52,533 ac-ft/yr in 1990 to 64,778 ac-ft/yr in 2020 under the high population projections. These estimates are 52,054 ac-ft/yr and 58,806 ac-ft/yr in 1990 and 2020, respectively, under the low population projections. Chapter 4 presents the estimates of the water supply available for potable use within the area. This showed a total of 70,329 ac-ft per year of safe yield available for municipal use in 1990 and 65,143 ac-ft per year available in 2020. Though across the 10-county area, the total water supply available exceeds the total potable demand, the locations of the supply sources do not match the locations of the demands. Several cities show a net deficit of water supply available, while others show a surplus. The comparison of supply and demand for each of the potable water supply entities is shown in the following sections for both potable water supply and potable water production capacities.

5.2 Comparison of Potable Water Supply and Demand

Summaries of the projected potable water demands and supplies for each of the identified potable water supply entities are listed in Table 5.1 for both the high and low population projections. The demands are summarized from Tables 3.8 and 3.9, for the high and low population projections, respectively. The supplies available are summarized from Table 4.3, respectively. The cities of Buffalo Gap, Cross Plains, Miles, and Rising Star are shown to have deficits equal to their projected demand because of their dependance on groundwater, for which no dependable withdrawal rate was available. The Cities of Baird and Woodson show deficits equal to their demands, because their sole sources of surface water supply have no dependable yield in a critical drought. The Cities of Abilene, Albany, Anson, Ballinger, Breckenridge, Coleman, and Winters show a net surplus of water supply throughout the study period for both the high and low population projections. Eastland County shows a surplus of water supply under the high population estimates until the year 2020, for which they show a deficit. However, the entity shows a net surplus through 2020 under the low population projections. Abilene also has water rights for 15,000 ac-ft per year from O.H. Ivie Reservoir that will provide them with additional surplus water supply through at least the year 2020 once the pump station and pipeline are completed. The remaining entities, Cisco, Clyde, Cross Plains, Stamford, and Sweetwater show net deficits in water for the entire study period.

Table 5.1
Regional Water Supply Study
Comparison of Potable Water Supply and Demand
(Acre-Feet/Year)

		High Population High Per Capita Use				Low Population High Per Capita Use			
		1990	2000	2010	2020	1990	2000	2010	2020
ABILENE*	Total Demand	31,310	33,514	35,902	40,528	31,137	33,172	34,774	37,648
	Total Available	41,736	41,482	41,428	41,374	41,736	41,482	41,428	41,374
	Surplus/(Deficit)	10,426	7,968	5,526	846	10,599	8,310	6,654	3,726
ALBANY*	Total Demand	737	742	731	700	723	732	721	690
	Total Available	2,033	1,995	1,957	1,919	2,033	1,995	1,957	1,919
	Surplus/(Deficit)	1,296	1,253	1,226	1,219	1,310	1,263	1,236	1,229
ANSON*	Total Demand	711	743	767	850	708	710	709	732
	Total Available	2,061	2,061	2,061	2,061	2,061	2,061	2,061	2,061
	Surplus/(Deficit)	1,350	1,318	1,294	1,211	1,353	1,351	1,352	1,329
BAIRD*	Total Demand	428	485	541	593	428	472	458	500
	Total Available	0	0	0	0	0	0	0	0
	Surplus/(Deficit)	(428)	(485)	(541)	(593)	(428)	(472)	(458)	(500)
BALLINGER	Total Demand	1,156	1,136	1,107	1,107	1,156	1,106	1,076	1,077
	Total Available	1,596	1,596	1,596	1,596	1,596	1,596	1,596	1,596
	Surplus/(Deficit)	440	460	489	489	440	490	520	519
BRECKENRIDGE*	Total Demand	1,894	2,044	2,097	2,284	1,845	1,921	1,960	2,026
	Total Available	3,527	3,267	3,007	2,747	3,527	3,267	3,007	2,747
	Surplus/(Deficit)	1,633	1,223	910	463	1,682	1,346	1,047	721

Table 5.1, Continued

		High Population High Per Capita Use				Low Population High Per Capita Use			
		1990	2000	2010	2020	1990	2000	2010	2020
BUFFALO GAP	Total Demand	59	65	72	82	59	64	69	75
	Total Available	0	0	0	0	0	0	0	0
	Surplus/(Deficit)	(59)	(65)	(72)	(82)	(59)	(64)	(69)	(75)
CISCO*	Total Demand	1,143	1,104	1,068	1,116	1,096	979	886	889
	Total Available	540	510	480	450	540	510	480	450
	Surplus/(Deficit)	(603)	(594)	(588)	(666)	(556)	(469)	(406)	(439)
CLYDE	Total Demand	631	870	962	1,048	630	849	814	883
	Total Available	498	482	466	450	498	482	466	450
	Surplus/(Deficit)	(133)	(388)	(496)	(598)	(132)	(367)	(348)	(433)
COLEMAN (incl. Lawn)	Total Demand	1,912	2,254	2,226	2,342	1,881	2,070	2,027	2,025
	Total Available	8,855	8,715	8,573	8,435	8,855	8,715	8,573	8,435
	Surplus/(Deficit)	6,943	6,461	6,347	6,093	6,974	6,645	6,546	6,410
CROSS PLAINS*	Total Demand	269	278	311	341	268	271	263	287
	Total Available	165	165	165	0	165	165	165	0
	Surplus/(Deficit)	(104)	(113)	(146)	(341)	(103)	(106)	(98)	(287)
EASTLAND CO.	Total Demand	3,066	3,006	2,891	2,993	2,931	2,647	2,363	2,334
	Total Available	4,113	3,646	3,179	2,713	4,113	3,646	3,179	2,713
	Surplus/(Deficit)	1,047	640	288	(280)	1,182	999	816	379

Table 5.1, Continued

		High Population High Per Capita Use 1990	2000	2010	2020	Low Population High Per Capita Use 1990	2000	2010	2020
MILES	Total Demand	105	108	109	115	105	105	106	107
	Total Available	0	0	0	0	0	0	0	0
	Surplus/(Deficit)	(105)	(108)	(109)	(115)	(105)	(105)	(106)	(107)
RISING STAR	Total Demand	157	154	145	141	150	135	119	110
	Total Available	0	0	0	0	0	0	0	0
	Surplus/(Deficit)	(157)	(154)	(145)	(141)	(150)	(135)	(119)	(110)
STAMFORD*	Total Demand	2,130	2,189	2,235	2,483	2,125	2,091	2,066	2,140
(Incl. Hamlin*)	Total Available	(170)	(348)	(525)	(703)	(170)	(348)	(525)	(703)
	Surplus/(Deficit)	(2,300)	(2,537)	(2,760)	(3,186)	(2,295)	(2,439)	(2,591)	(2,843)
SWEETWATER*	Total Demand	5,807	6,030	6,468	7,083	5,796	5,842	6,097	6,416
	Total Available	4,015	3,871	3,726	2,741	4,015	3,871	3,726	2,741
	Surplus/(Deficit)	(1,792)	(2,159)	(2,742)	(4,342)	(1,781)	(1,971)	(2,371)	(3,675)
WINTERS	Total Demand	959	965	927	912	958	938	900	853
	Total Available	1,360	1,360	1,360	1,360	1,360	1,360	1,360	1,360
	Surplus/(Deficit)	401	395	433	448	402	422	460	507

Table 5.1, Continued

		High Population High Per Capita Use				Low Population High Per Capita Use			
		1990	2000	2010	2020	1990	2000	2010	2020
WOODSON*	Total Demand	59	67	63	60	58	64	59	54
	Total Available	0	0	0	0	0	0	0	0
	Surplus/(Deficit)	(59)	(67)	(63)	(60)	(58)	(64)	(59)	(54)
	Grand Total Demand	52,533	55,754	58,622	64,778	52,054	54,168	55,467	58,806
	Grand Total Available	70,329	68,802	67,473	65,143	70,329	68,802	64,473	65,143
	Overall Surplus/(Deficit)	17,796	13,048	8,851	365	18,275	14,634	12,006	6,337

*participant
Water supply based on safe yields

5.3 Comparison of Potable Water Production Capacity and Demand

Summaries of the total potable water demands and treatment plant capacities for each of the identified potable water supply entities are listed in Table 5.2 for both the high and low population projections. The demands are summarized from Tables 3.10 and 3.11, for the high and low population projections, respectively. The treatment capacities available are summarized from Table 4.5. Using the high population projections, the entities of Abilene, Albany, Baird, Breckenridge, Eastland Co., Hamlin, Lawn, Sweetwater, and Woodson do not currently have the potable water production capacity to meet the demands of a high per capita municipal use year. It should be noted that the demands are based upon Texas Water Development Board projections of population and forecasts of potential per capita municipal use and historical peak-day to average-day rates as shown in the water audits. The conservatism of these numbers combined with the conservatism of the high municipal use figures, which are appropriate for drought conditions, are appropriate for long-range planning. However, they may provide for inconsistencies with observed data for 1990.

Only Ballinger, Buffalo Gap, Cisco, Coleman, Cross Plains, and Winters currently have sufficient treatment capacity to meet the projected demands through the year 2020, assuming the high population projections. However, the plants used by Buffalo Gap and Cross Plains are not capable of treating surface water and would need significant expansions in order to treat raw surface water. The remaining entities

Table 5.2

Regional Water Supply Study
Comparison of Treatment Plant Capacity and Demand

Water Supply Entity		High Population Peak Day (MGD) 1990	High Population Peak Day (MGD) 2000	High Population Peak Day (MGD) 2010	High Population Peak Day (MGD) 2020	1990 WTP Capacity (MGD)	Low Population Peak Day (MGD) 1990	Low Population Peak Day (MGD) 2000	Low Population Peak Day (MGD) 2010	Low Population Peak Day (MGD) 2020
ABILENE*	Total Demand	55.90	59.83	64.09	72.35	52.00	55.59	59.22	62.08	67.21
	Surplus/(Deficit)	(3.90)	(7.83)	(12.09)	(20.35)		(3.59)	(7.22)	(10.08)	(15.21)
ALBANY*	Total Demand	1.81	1.82	1.79	1.72	1.70	1.78	1.80	1.77	1.69
(incl.Moran)	Surplus/(Deficit)	(0.11)	(0.12)	(0.09)	(0.02)		(0.08)	(0.10)	(0.07)	0.01
ANSON*	Total Demand	1.27	1.33	1.37	1.52	1.40	1.26	1.27	1.27	1.31
	Surplus/(Deficit)	0.13	0.07	0.03	(0.12)		0.14	0.13	0.13	0.09
BAIRD*	Total Demand	0.67	0.76	0.85	0.93	0.46	0.67	0.74	0.72	0.78
	Surplus/(Deficit)	(0.21)	(0.30)	(0.39)	(0.47)		(0.21)	(0.28)	(0.26)	(0.32)
BALLINGER	Total Demand	2.06	2.42	1.97	1.98	2.80	2.06	1.97	1.93	1.85
	Surplus/(Deficit)	0.74	0.38	0.83	0.82		0.74	0.83	0.87	0.95
BRECKENRIDGE*	Total Demand	3.55	3.83	3.94	4.28	3.46	3.46	3.60	3.68	3.79
	Surplus/(Deficit)	(0.09)	(0.37)	(0.48)	(0.82)		0.00	(0.14)	(0.22)	(0.33)
BUFFALO GAP	Total Demand	0.13	0.15	0.16	0.18	0.46	0.13	0.14	0.15	0.17
	Surplus/(Deficit)	0.33	0.31	0.30	0.28		0.33	0.32	0.31	0.29

Table 5.2, Continued

Water Supply Entity		High Population Peak Day (MGD) 1990	2000	2010	2020	1990 WTP Capacity (MGD)	Low Population Peak Day (MGD) 1990	2000	2010	2020
CISCO*	Total Demand	3.06	2.96	2.86	2.99	4.50	2.93	2.63	2.37	2.38
	Surplus/(Deficit)	1.44	1.54	1.64	1.51		1.57	1.87	2.13	2.12
CLYDE	Total Demand	1.41	1.94	2.15	2.34	2.00	1.41	1.89	1.82	1.97
	Surplus/(Deficit)	0.59	0.06	(0.15)	(0.34)		0.59	0.11	0.18	0.03
COLEMAN	Total Demand	3.95	4.69	4.59	4.80	6.00	3.89	4.30	4.18	4.15
	Surplus/(Deficit)	2.05	1.30	1.41	1.20		2.11	1.70	1.82	1.85
CROSS PLAINS	Total Demand	0.42	0.43	0.49	0.53	0.65	0.42	0.42	0.41	0.45
	Surplus/(Deficit)	0.23	0.22	0.16	0.12		0.23	0.23	0.24	0.20
EASTLAND CO.	Total Demand	4.79	4.70	4.52	4.68	4.00	4.58	4.13	3.69	3.65
	Surplus/(Deficit)	(0.79)	(0.70)	(0.52)	(0.68)		(0.58)	(0.13)	0.31	0.35
HAMLIN*	Total Demand	2.26	2.30	2.36	2.66	1.62	2.26	2.20	2.18	2.29
	Surplus/(Deficit)	(0.64)	(0.68)	(0.74)	(1.04)		(0.64)	(0.58)	(0.56)	(0.67)
LAWN	Total Demand	0.31	0.34	0.38	0.44	0.22	0.31	0.32	0.35	0.38
	Surplus/(Deficit)	(0.09)	(0.12)	(0.16)	(0.22)		(0.09)	(0.14)	(0.13)	(0.16)
MILES	Total Demand	0.35	0.36	0.36	0.38	-	0.35	0.35	0.35	0.36
RISING STAR	Total Demand	0.35	0.34	0.32	0.31	-	0.33	0.30	0.27	0.25

Table 5.2, Continued

Water Supply Entity		High Population Peak Day (MGD) 1990	2000	2010	2020	1990 WTP Capacity (MGD)	Low Population Peak Day (MGD) 1990	2000	2010	2020
STAMFORD*	Total Demand	2.86	2.96	3.01	3.33	3.00	2.86	2.83	2.79	2.87
	Surplus/(Deficit)	0.14	0.04	(0.01)	(0.33)		0.14	0.17	0.21	0.13
SWEETWATER*	Total Demand	10.48	10.88	11.68	12.78	7.46	10.46	10.54	11.00	11.57
	Surplus/(Deficit)	(3.02)	(3.42)	(4.22)	(5.32)		(3.00)	(3.08)	(3.54)	(4.11)
WINTERS	Total Demand	1.92	1.95	1.86	1.84	2.00	1.92	1.89	1.81	1.72
	Surplus/(Deficit)	0.08	0.05	0.14	0.16		0.08	0.11	0.19	0.28
WOODSON*	Total Demand	0.17	0.19	0.18	0.17	0.16	0.17	0.19	0.17	0.16
	Surplus/(Deficit)	(0.01)	(0.03)	(0.02)	(0.01)		(0.01)	(0.03)	(0.01)	0.00

have sufficient production capacity to meet current need, but will need to upgrade their facilities to meet the projected demands of 2020.

Using the low population projections, the entities of Abilene, Albany, Baird, Eastland Co., Hamlin, Sweetwater, and Woodson currently do not have the treatment capacity to meet the estimated 1990 demands for high per capita use. Anson, Ballinger, Buffalo Gap, Cisco, Clyde, Coleman, Cross Plains, Stamford, and Winters have sufficient capacity to meet the demands projected throughout the 30 year study period, though Buffalo Gapand Cross Plains have plants that can treat only groundwater. Due to declining population projections under the low series, Albany, Eastland Co., and Woodson are projected to meet their 2020 demands despite having insufficient capacity for the estimated 1990 demands. The remaining entities, which are shown to currently have sufficient treatment capacity, are projected to outgrow their current production capacity prior to the year 2020.

6. POTENTIAL ADDITIONAL WATER SUPPLY SOURCES

6.1 Introduction

Numerous additional raw water supply sources were reviewed for potential use by the potable water supply entities within the 10-county area. These potential raw water sources included proposed new reservoirs, the purchase and diversion of raw water from existing reservoirs outside the study area, diversion of streamflows into an existing reservoir, and proposed groundwater sources, as well as the possibility of utilizing reclaimed water. In the following sections, brief descriptions of the potential sources identified are given. Several were ruled out due to lack of water supply available or lack of suitable water quality. The remaining potential supplies are discussed in the final section of the chapter, a summary of the potential sources.

6.2 Proposed Surface Water Reservoirs

At this time, most of the better water supply sources in or near the study area are already being utilized. In general, those sources which are still available offer only moderate amounts of dependable yield, and much of the remaining undeveloped water is of poor quality. This applies to potential sites in both the Brazos and Colorado River Basins.

Problems of water quality, arising from natural and man-made pollution on the watersheds, have long been a matter of concern in west central Texas. According to the Texas Water Development Board, in "Continuing Water Resources Planning and Development for Texas" (1977), flows of the Salt Fork, parts of the Double Mountain Fork, and the main stem of the Brazos River above Possum Kingdom tend to be too saline for most beneficial uses. Saline waters resulting from oil and gas exploration and production appear to affect the chemical quality of the Clear Fork of the Brazos River during periods of low flow.

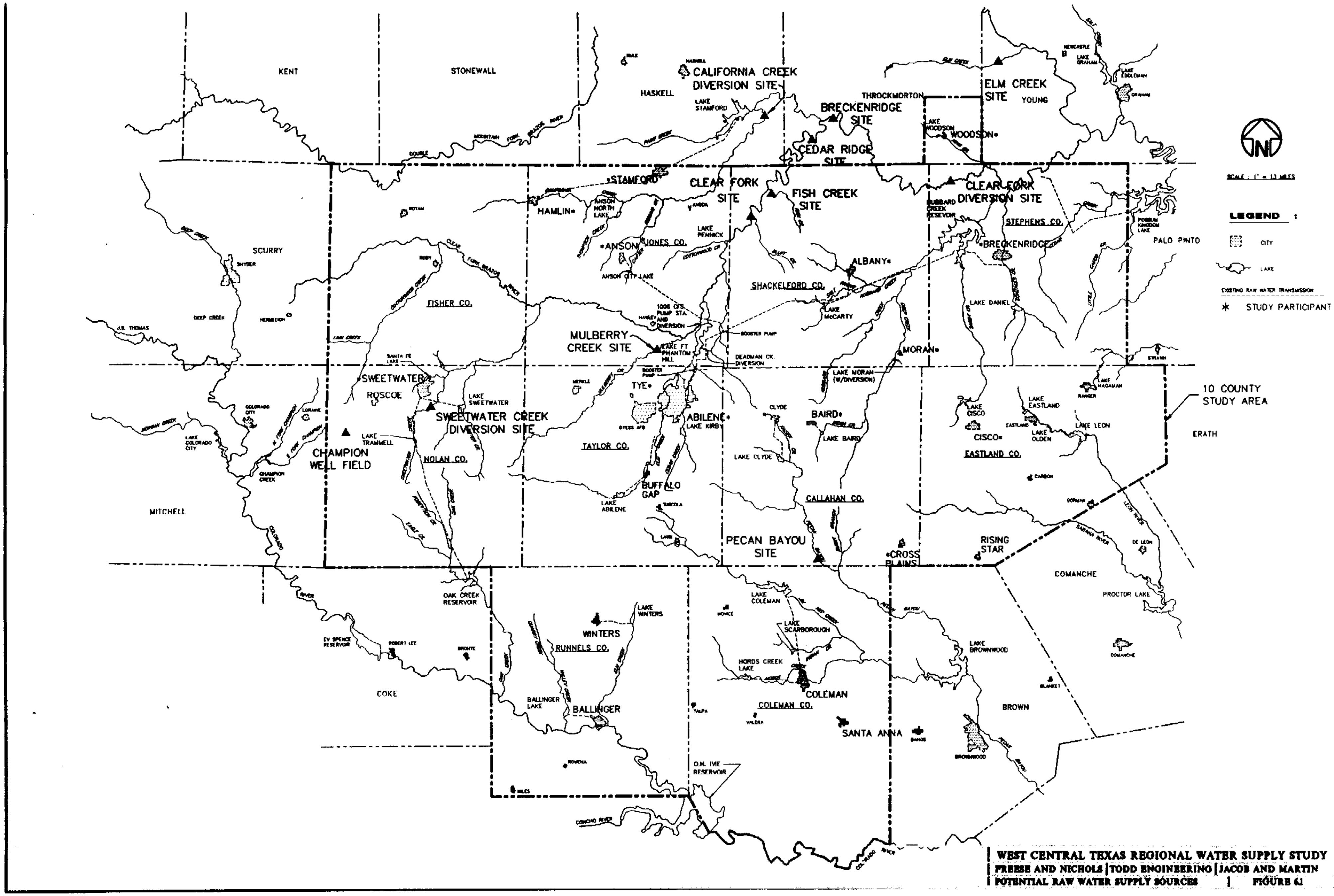
In the Colorado River Basin, the potential supply is already committed to holders of water rights within the Colorado Basin. The O.H. Ivie Reservoir, south of Abilene on the main stem of the Colorado, recently developed by the Colorado River Municipal Water District, probably represents the last significant project that will be built in the upper reaches of that basin. It is unlikely that any new water from the Colorado River upstream of O.H. Ivie Reservoir could be obtained for use in the study area. Downstream of O.H. Ivie Reservoir, the pumping distances would make any potential source uneconomical. The only potential site left for development within the Colorado River Basin would be the Pecan Bayou Reservoir on the Pecan Bayou in the southern portion of Callahan County. However, this site would be difficult to develop due to prior downstream water rights. Based on these considerations, it is apparent that any future surface water supply source, with the possible exception of Pecan Bayou, would have to be located within the Brazos River Basin.

Several potential sources of supply in the Brazos Basin have received consideration previously. The most attractive of these, along with some additional potential alternatives, were selected for initial consideration and screening. The alternatives considered and their general characteristics are described below. The general location of each site is indicated in Figure 6.1. Table 6.1 lists the estimated safe yields of each of the potential sites reviewed.

Several potential new reservoir sites were considered. The Breckenridge, Cedar Ridge, and the Clear Fork sites are on the main stem of the Clear Fork of the Brazos; the California Creek and Mulberry Creek Reservoir sites are on tributaries of the Clear Fork; the Elm Creek Reservoir site is on a tributary of the Brazos River; and Pecan Bayou Reservoir is on a tributary of the Colorado River.

Breckenridge and Cedar Ridge Sites

The Breckenridge site is located on the Clear Fork of the Brazos River, approximately six miles downstream from the confluence of Paint Creek with the Clear Fork. The Cedar Ridge site is located above this confluence, with the intent to eliminate some of the poorer quality water that is associated with low flows from Paint Creek. As indicated in Table 6.1, either site is capable of producing a significant amount of new yield and would represent a substantial increase in the area's total supply. The yield of the proposed reservoirs are listed in Table 6.1. Water quality data on the Clear Fork of the Brazos near the proposed sites indicate that poor quality water would be available in the Breckenridge Reservoir. Elimination of the flows from Paint Creek would help to some extent, but the quality of water from the Cedar Ridge Reservoir site would be marginal at best. Only the Cedar Ridge site is considered potentially viable.



WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
FREESE AND NICHOLS | TODD ENGINEERING | JACOB AND MARTIN
POTENTIAL RAW WATER SUPPLY SOURCES | FIGURE 6.1

Table 6.1

Regional Water Supply Study
Potential Raw Water Supply Sources
Estimated Available Supply

Supply Source:	Known Yields Year	Yield	F/S	Year	Yield	F/S	Crit. Per.	Estimated Supply 1990 (Af/Yr)	2000 (Af/Yr)	2010 (Af/Yr)	2020 (Af/Yr)
Proposed Reservoirs:											
Breckenridge (Clear Fork)	1990	60,600	F	2040	54,900	F	15	56,813	55,744	54,675	53,606
Cedar Ridge (Clear Fork) (w/ depletion allowance)	1990	20,600	S	2030	20,600	S		20,600	20,600	20,600	20,600
Clear Fork Reservoir (w/ depletion allowance)	1990	5,450	S	2030	5,450	S		5,450	5,450	5,450	5,450
Elm Creek Reservoir	1990	5,470	S	2040	4,000	S		5,470	5,176	4,882	4,588
Fish Creek Res/Clear Fork Div (w/ depletion allowance)	1990	8,365	S	2040	6,100	S		8,365	7,912	7,459	7,006
Pecan Bayou Reservoir	1990	4,800	F	2020	4,300	F	9	4,320	4,170	4,020	3,870
Diversions:											
Sweetwater Creek Diversion								790	790	790	790
Clear Fork Div to Hubbard Ck (w/ depletion allowance)								14,500	14,500	14,500	14,500

Table 6.1, Continued

Supply Source:	Known Yields: Year	Yield	F/S	Year	Yield	F/S	Crit. Per.	Estimated Supply: 1990 (Af/Yr)	2000 (Af/Yr)	2010 (Af/Yr)	2020 (Af/Yr)
Lake Stamford/California Creek Div.											
- 25 cfs pumps								2,500	2,500	2,500	2,500
- 50 cfs pumps								4,100	4,100	4,100	4,100
- 100 cfs pumps								5,500	5,500	5,500	5,500
- 150 cfs pumps								5,800	5,800	5,800	5,800
- channel diver.								5,700	5,700	5,700	5,700
Water Reclamation:											
Water Reclamation - Abilene								5,000	5,000	5,000	5,000
Water Reclamation - Sweetwater								1,120	1,120	1,120	1,120
Groundwater:											
Champion Well Field								1,171	1,171	1,171	1,171
Diversions From Existing Reservoirs:											
Lake Brownwood - Available (Existing Customers)								8,168	6,882	4,986	n/a
Lake Brownwood - Available (Potential Customers)								4,516	3,010	1,106	n/a
E.V. Spence Res. & J.B. Thomas - Available								16,100	13,400	10,400	5,700
O.H. Ivie - Abilene Contract								15,000	15,000	15,000	15,000
O.H. Ivie - Available								0	0	0	0

Table 6.1, Continued

Supply Source:	Known Yields							Estimated Supply			
	Year	Yield	F/S	Year	Yield	F/S	Crit. Per.	1990 (Af/Yr)	2000 (Af/Yr)	2010 (Af/Yr)	2020 (Af/Yr)
Lake Colorado City/Champion Ck Res. - Available								0	0	0	0
Lake Proctor - Available								0	0	0	0

Clear Fork Reservoir Site

The Clear Fork Reservoir site was included in a 1966 long-range water supply study for the City of Abilene. At that time, a conservation storage capacity of 94,000 acre-feet was determined to have a firm yield approximately 30,500 acre-feet per year. The computations of the runoff for those reservoir operation studies were made prior to establishing the present Abilene Clear Fork diversion facilities, and they did not include an allowance for runoff depletions. The year 2030 safe yield of this site has recently been estimated to be approximately 5,450 acre-feet per year. The proposed reservoir would cover a portion of the community of Lueders at the normal water surface elevation, and the inundation would increase significantly during flooding. The reservoir would also necessitate relocation or raising of U.S. Highway 380. The water quality would be comparable to that anticipated in Cedar Ridge Reservoir site. Because of these costs and the reduced yield, this site was not determined to be viable and was not studied further.

Mulberry Creek Reservoir Sites

Several reservoir sites have been previously considered on Mulberry Creek on the west side of Abilene. The quality of the water should be good, but a reservoir would have a significant impact on both the quantity and quality of water available at the existing Clear Fork diversion into Lake Fort Phantom Hill. In addition, the studies have shown that no suitable dam construction sites appear to exist on Mulberry Creek. Therefore, none of the sites reviewed were considered viable.

Elm Creek Reservoir Site

The Elm Creek Reservoir site is located on a tributary of the main stem of the Brazos River, approximately 23 miles north of Hubbard Creek Reservoir. Preliminary indications based on limited quality data are that the site should produce water of good quality. Previous reservoir operation studies for 72,500 acre-feet of storage capacity indicate a safe yield of 5,470 acre-feet per year. In order to supply entities within the 10 county area, water would be pumped from Elm Creek over to Hubbard Creek Reservoir.

Clear Fork Diversions to Fish Creek Reservoir Site

Diversion of the peak flows from the Clear Fork of the Brazos River into an existing or proposed storage reservoir would provide for impoundment of the better quality water while allowing the poorer quality lower flow to pass. This concept is similar to Abilene's present diversion operation, which transfers Clear Fork water into Lake Fort Phantom Hill. Several potential off-channel storage reservoirs have been considered along the Clear Fork of the Brazos between Lueders and U.S. Highway 183. The most acceptable of the potential sites was on Fish Creek, approximately 21 miles northeast of Abilene. For 149,600 acre-feet of conservation storage in the Fish Creek Reservoir site, a dependable safe yield of 8,450 acre-feet per year has been determined. The yield is based on runoff computed from daily flows at the U.S. Geological Survey stream gaging station on the Clear Fork of the Brazos River near Nugent. The runoff values were corrected for diversions to

Lake Fort Phantom Hill, and diversions into Fish Creek were only considered possible when the flow in the Clear Fork exceeded 200 cfs. This source would require construction of a diversion structure and a 1,000 cfs pump station on the Clear Fork, as well as the dam on Fish Creek. Water impounded in the Fish Creek Reservoir site should be of fair quality.

Pecan Bayou Reservoir

The proposed Pecan Bayou Reservoir site is located on Pecan Bayou in south Callahan County, 20 miles north of Coleman. It would have a total storage capacity of 102,000 acre-feet and an estimated initial safe yield of 4,320 acre-feet per year. However, the reservoir would be located upstream of Lake Brownwood, owned by the Brown County Water Control and Improvement District No. One (BCWCID). Therefore, it is anticipated that water rights would be difficult to obtain. In addition, any negotiations for those water rights may affect the available yield, if significant downstream releases are required.

6.3 Proposed Diversions from Existing Reservoirs

Several large reservoirs that exist outside the 10-county area were reviewed to determine if raw water would be available for municipal use by those entities with a current or projected shortfall. The following eight reservoirs were studied and a brief description of each is given below.

Lake Brownwood

Lake Brownwood is located on the Pecan Bayou in the Colorado River

Basin, some seven miles north of the City of Brownwood. The reservoir was built by the Brown County Water Improvement District Number One in 1932. The reservoir has a permitted capacity of 143,400 acre-feet, although the capacity was estimated to be approximately 133,000 acre-feet in 1965.

The reservoir has permitted withdrawal rates of 15,996 acre-feet per year for municipal use, 4,500 acre-feet per year for industrial use, and 1,185 acre-feet per year for irrigation use. Based on information available, it was estimated that as much as 8,200 acre-feet of water would currently be available for municipal use. This would be reduced to 5,000 acre-feet by 2010. However, potential new customers, other than those in the study area, currently being considered by BCWCID could reduce this available supply to 4,500 acre-feet currently, and to 1,100 acre-feet per year by 2010. These values are based on high population and high use rate estimates.

Champion Creek Reservoir and Lake Colorado City

Champion Creek Reservoir is part of the Upper Colorado segment of the Colorado River Basin located in Mitchell County. The reservoir was completed in 1959 and has a permitted capacity of 40,170 acre-feet. Located on Morgan Creek, Lake Colorado City contains 31,700 acre-feet. Water from Champion Creek Reservoir is piped over to Lake Colorado City to maintain its level. The combined safe yield is estimated to be 4,980 acre-feet per year. Both reservoirs are owned by TU Electric, which has a permitted right to 5,500 acre-feet that can be used for either for municipal, industrial, recreational, and mining purposes. Both J.B. Thomas and E.V. Spence Reservoirs are currently used to supply CRMWD customers. Because of geographic location, Lake J.B. Thomas would not be a potential source for any of the entities in the 10-county study area, unless its water supply were released to E.V. Spence and diverted from there.

O.H. Ivie Reservoir

Recently completed by the CRMWD in 1990, the O.H. Ivie Reservoir has a permitted capacity of 554,340 acre-feet and provides an estimated annual yield of 102,000 acre-feet. This will be reduced to about 92,000 acre-feet per year by 2020. The CRMWD has contractual obligations to provide municipal and industrial water for its member cities, as well as residents of Midland, San Angelo, and Abilene. The existing contracts allocate all of the existing yield to these cities. Therefore, no additional water is available from this source unless purchased from one of the customer cities. The reservoir is located in three counties, Coleman, Concho, and Runnels County, and has a drainage area of 11,758 square miles.

Possum Kingdom Reservoir

Possum Kingdom Reservoir is located in Palo Pinto, Stephens, and Young Counties. Completed in 1941, Possum Kingdom was originally permitted to impound 724,739 acre-feet. Owned by the Brazos River Authority (BRA), the reservoir is permitted for both recreational and consumptive purposes. Current water use limitations include an amount municipal, domestic, industrial, or steam and power plant purposes. Additional water rights include 2,700 acre-feet per year for municipal purposes and 4,050 acre-feet per year for industrial. TU Electric uses Lake Colorado City as cooling water for the Morgan Creek power plant and also provides municipal water supply for Colorado City.

Based on TU Electric's need to maintain as high a pool as possible in Lake Colorado City for the power plant and the existing municipal demand, it is unlikely that these reservoirs could be considered for additional raw water supply to any entities in the study area.

Lake E.V. Spence

Located in Coke County, E.V. Spence Reservoir has a permitted capacity of 488,760 acre-feet. Completed in 1969, the reservoir is owned by the Colorado River Municipal Water District (CRMWD), which is authorized to divert 44,000 acre-feet of water per year for municipal, industrial, mining, and recreational purposes. CRMWD provides water supply for its member cities of Big Spring, Odessa, and Snyder, as well as Midland, Stanton, San Angelo, Robert Lee, and Pyote. The member cities all have open-ended contracts with no upper limit to their water deliveries. Because of this, it is difficult to estimate the amount of water that may be available from the CRMWD lakes.

Lake J.B. Thomas

Lake J.B. Thomas is located on the upper Colorado River in Scurry County. The reservoir is owned by the CRMWD, which is authorized to divert 30,000 acre-feet per year of the 204,000 acre-feet capacity lake for municipal, industrial, recreational, and mining purposes. Both J.B. Thomas and E.V. Spence Reservoirs are currently used to supply CRMWD customers. Because of geographic location, Lake J.B. Thomas would not be a potential source for any of the entities in the 10-county study area, unless its water supply were released to E.V. Spence and diverted from there.

O.H. Ivie Reservoir

Recently completed by the CRMWD in 1990, the O.H. Ivie Reservoir has a permitted capacity of 554,340 acre-feet and provides an estimated annual yield of 102,000 acre-feet. This will be reduced to about 92,000 acre-feet per year by 2020. The CRMWD has contractual obligations to provide municipal and industrial water for its member cities, as well as residents of Midland, San Angelo, and Abilene. The existing contracts allocate all of the existing yield to these cities. Therefore, no additional water is available from this source unless purchased from one of the customer cities. The reservoir is located in three counties, Coleman, Concho, and Runnels County, and has a drainage area of 11,758 square miles.

Possum Kingdom Reservoir

Possum Kingdom Reservoir is located in Palo Pinto, Stephens, and Young Counties. Completed in 1941, Possum Kingdom was originally permitted to impound 724,739 acre-feet. Owned by the Brazos River Authority (BRA), the reservoir is permitted for both recreational and consumptive purposes. Current water use limitations include an amount for municipal use not to exceed 175,000 acre-feet per year, industrial use not to exceed 250,000 acre-feet per year, irrigation use not to exceed 250,000 acre-feet per year, and mining use not to exceed 49,800 acre-feet per year. The water quality of Possum Kingdom Reservoir is considered poor for municipal purposes. It could only be used if mixed with water in Hubbard Creek Reservoir. A 30" pipeline exists from Possum Kingdom to Breckenridge with a branch of the system extending to the area of the City of Ranger. The quantities available would be dependent on negotiations with the BRA. Though a feasible and relatively economical source of water, it was not included as a viable alternative because of poor water quality.

Proctor Lake

Proctor Lake is located in Comanche County and was completed in 1964 by the U.S. Corps of Engineers. Used as a water supply source as well as for flood control measures, the lake's permitted capacity is 59,400 acre-feet. It is projected that by the year 2020, the firm yield will be 14,600 acre-feet per year. Available estimates indicate that no surplus water would be available for municipal supply.

6.4 Proposed Diversions To Existing Reservoirs

Another potential source of additional raw water for the water supply entities in the study area is the diversion of raw water from the higher flows of a major river or creek into an existing reservoir. This procedure has the advantage that the lower flows that tend to have the poorer quality are allowed to bypass without diversion. Only the flows that have suitable quality are diverted. The City of Abilene currently uses this technique to enhance the yield of Lake Fort Phantom Hill with diversions from both Deadman Creek and the Clear Fork of the Brazos River. This approach is particularly applicable on the Brazos River where low flows tend to be of poor quality due to high salinity and high flows tend to be of significant better quality.

Three separate proposed diversion projects were reviewed as potential sources of additional raw water. For these projects, no reduction over time in the net increase in yield afforded the receiving reservoirs is assumed because of the minimal sedimentation effects that occur at diversion structures. The projects are briefly described below.

Diversions from Sweetwater Creek to Lake Sweetwater

A plan developed in earlier reports proposes that water be diverted from Sweetwater Creek at a point about three miles southeast of the City of Sweetwater and transported through 8,700 feet of 24" pipe to an unnamed tributary of Lake Sweetwater. The water would flow by gravity to the lake. The latest data suggest that this diversion would increase the safe yield from Lake Sweetwater by 790 acre feet per year.

Diversions from the Clear Fork of the Brazos River to Hubbard Creek Reservoir

The proposed diversion site for transferring water from the Clear Fork of the Brazos River into Hubbard Creek Reservoir is located in Stephens County, approximately halfway between U.S. 183 and the Shackelford County line, about 7-1/2 miles northwest of Hubbard Creek dam. Diversions were assumed to be made only when the average daily flow was above 300 cfs. Flows in excess of 300 cfs were counted as potential transfers to Hubbard Creek, up to a maximum diversion rate of 1,000 cfs. Simulated studies have indicated that, with the Clear Fork diversions, the 282,200 acre-feet of storage capacity projected to remain in Hubbard Creek Reservoir in 2030 would yield a dependable supply of 44,000 acre-feet per year with a minimum content of 43,590 acre-feet at the end of the critical period. This is an increase in projected yield of 16,000 acre-feet per year. It was estimated that runoff depletions through the year 2030 will reduce the annual diversion benefits by approximately 1,500 acre-feet based on the average diversions during the critical period. This reduction leaves a balance of 14,500 acre-feet per year of supplemental supply resulting from the diversion facility. This increase in yield was assumed constant over the study period.

The results of a previous analysis of the quality in Hubbard Creek Reservoir with historical inflow and Clear Fork diversions indicate that the quality in Hubbard Creek Reservoir would be affected only to a small degree by the diverted water. That analysis estimated that the concentration of total dissolved solids in Hubbard Creek Reservoir would be under 968 milligrams per liter 90 percent of the time with full use of the yield.

Diversions from California Creek to Lake Stamford

The proposed diversion site is located about two miles upstream from the mouth of California Creek, four miles east of the dam at Lake

Stamford. Various plans with different size pumping facilities have been reviewed. The smallest, with 25 cfs pumps, was estimated to increase the safe yield from Lake Stamford by about 2,500 acre-feet per year. The options range up to 150 cfs pumps which should add 5,800 acre-feet per year. As an alternative, a channel diversion could be located further upstream in order to divert flow by gravity to Lake Stamford. It has been estimated that this plan would add about 5,700 acre-feet per year. A low flow outlet would be included in the diversion structure to allow poorer quality low flows to pass.

6.5 Proposed Groundwater Development

Groundwater in west central Texas is available only in certain areas and is generally not considered a renewable resource. Several water supply entities in the study area use groundwater and will continue to do so until development of a new source or the purchase of treated water from some other source becomes economically viable. Because of the widespread use of the relatively limited available sources, only one potential new source of groundwater was identified. Located southwest of the City of Sweetwater, the Champion well field has been estimated to contain approximately 35,000 to 47,000 acre feet of recoverable water with no significant recharge. This translates to a recovery rate of 1,170 to 1,560 acre feet per year over the thirty year study period. At the end of the thirty year period, a separate source of additional water supply would need to be found in order to replace the Champion well field. Other than its limited supply, the Champion well field has the additional problem of marginal water quality. The previous study indicated that some of the water tested failed to meet Texas state health standards. It indicated that portions of the water supply either would not be usable, would require mixing, or would need additional treatment that is not currently available at the existing treatment plants. Until additional information is available that would indicate otherwise, development of the Champion well field is not considered a dependable raw water supply solution for the City of Sweetwater.

6.6 Reclaimed Water

Reclamation of treated sewage effluent, or water reuse, is gaining acceptance as a viable source of additional raw water for cities. The potential has been studied extensively, but, due to unfavorable public perception, rarely implemented. Previous studies have reviewed the potential of using reclaimed water for the cities of Abilene and Sweetwater.

The plan for the City of Sweetwater, currently under consideration, proposes to replace approximately 1 MGD, or 1,120 acre-feet per year, of potable water currently being used at the area's gypsum producing plants and a power cogeneration plant, with reclaimed water. If implemented, this project would reduce the city's municipal water supply deficit by the 1,120 acre feet per year obtained from the wastewater reuse.

A study prepared in 1988 for the City of Abilene recommended a water reuse program consisting of two components. The first is an increase in the water supply by reclamation of properly treated wastewater. This plan would increase the supply available from Lake Fort Phantom Hill by an estimated 3,000 acre-feet per year when fully in place. The second component is the development of a non-potable system centered around Lake Kirby. This non-potable water would be used by the area golf courses as well as additional irrigation and industrial demands near Lake Kirby. This would reduce the demand on the potable supply system by an estimated 2,000 acre-feet per year. The combined effects of the program, if fully implemented, would be equivalent to a net increase in surplus raw water supply of 5,000 acre-feet per year.

6.7 Water Conservation Plan and Drought Contingency Plan

The objective of a water conservation program is to permanently reduce the quantity of water required for each activity, insofar as is practical, through the implementation of efficient water use practices. A drought contingency program provides procedures for voluntary and mandatory actions to be put into effect to temporarily reduce the demand placed upon a water supply system during a water shortage emergency. Although conservation is not a new water supply, it is a means of making the existing surplus last longer.

Water conservation goals are usually selected and expressed in terms of the period of effect, the level of reduction desired, and the type of user demand impacted. A short term reduction is usually limited to a year or less, generally employed in an emergency situation such as a drought. A long-term reduction is the result of a conservation program continuing for more than one year.

A water conservation plan specifies and explains the actions a water supplier will take to implement a water use reduction program. A detailed explanation of a water conservation plan is included as Appendix E of Volume III. In general, the plan includes nine major elements which are an education and information program, a water conservation plumbing code, a water conservation retrofit program, a conservation oriented water rate structure, a program for meter repair and replacement, water conserving landscaping, water audits and leak detection, recycling and reuse, and means of implementing and enforcing the plan.

A drought contingency plan is typically developed in advance and implemented for short durations of one to several years or less, dependent upon such things as climatic conditions. Appendix E of Volume III includes a detailed description of the elements of a drought contingency plan. The first step in developing a plan is to determine what will trigger the plan, as well as, distinguishing between mild, moderate, or severe drought conditions. The major items which trigger drought conditions are low reservoir levels and/or reaching the systems treatment or distribution capacity. The next part of a drought contingency plan is to establish the steps in implementing the plan. The first step would be for mild drought conditions and would include voluntary conservation and an informational system. Upon determining that a moderate drought condition exists, the requirements for rationing would become mandatory. The final step for a severe drought condition would include a much more restricted use of water and a complete ban of water for some uses, such as vehicle washing.

The remaining elements of a drought contingency plan would include the development of an information and education system, a method of initiating and terminating the curtailments, and a method of modifying the plan as the need arises.

Appendix E of Volume III also includes conservation tips and a sample of a conservation/drought contingency plan ordinance.

6.8 Summary of Potential Raw Water Supply Sources

A variety of potential new raw water sources for the 10-county study area were reviewed, including:

1) new reservoirs,
2) diversions from existing reservoirs outside of the study area,
3) diversion from uncontrolled rivers or creeks into existing reservoirs,
4) groundwater, and
5) reclaimed water use.

Of the numerous proposed projects, several could be discounted without further study due to economic considerations, lack of suitable water quality, or lack of available water rights. Others would be ruled out due to marginal water quality or expected difficult and extended processes for obtaining appropriate water rights. Few appear to be strongly viable projects with good water quality and a potentially short development time. The potential projects considered to be worthwhile for further consideration are listed in Table 6.2. Also included in this table is a list of the potable water supply entities that could possibly benefit from the proposed project.

Table 6.2

Summary of Viable New Supply Sources
Estimated Supply
(Acre-Feet/Year)

	Project	Initial	After 30-Years	Potential Customers
1	Cedar Ridge Reservoir	20,600	n.a.	Abilene Sweetwater Stamford
2	Elm Creek Reservoir	5,470	4,588	WCTMWD member cities and customers
3	Fish Creek with Clear Fork Diversion	8,365	7,006	Abilene Sweetwater Stamford
4	Pecan Bayou	4,320	3,870	Baird Clyde Cisco Cross Plains Rising Star
5	Sweetwater Creek Div.	790	790	Sweetwater
6	Clear Fork Diversion to Hubbard Creek Res.	14,500	14,500	WCTMWD member cities and customers
7	California Creek Div. to Lake Stamford			Stamford
	-100 cfs pumps	5,500	5,500	
	-channel diversion	5,700	5,700	
8	Water Reclamation			
	-Sweetwater	1,120	1,120	Sweetwater
	-Abilene	5,000	5,000	Abilene
9	Champion Well Field	1,170	0	Sweetwater
10	Div. from O.H. Ivie Reservoir	15,000	15,000	Abilene & its customers

Table 6.2, Continued

Project	Initial	After 30-Years	Potential Customers
11 Lake Brownwood	8,200	3,400	Baird, Clyde, Cisco, Cross Plains, Rising Star
12 Div. from E.V. Spence Reservoir	16,100	5,700	Sweetwater

7. WATER SUPPLY ALTERNATIVES

7.1 Introduction

Chapter five presented, for each of the potable water supply entities identified within the 10-county study area, a comparison of the projected potable water demands with the current available water supplies. Table 5.1 outlined this comparison for both the high and low population projections and the water demands developed for each. Each of the potable water supply entities were listed with either a surplus or a deficit of water supply for potable use for the years 1990, 2000, 2010, and 2020 for both the high and low population projections. Table 7.1 summarizes the projected deficits tabulated in Table 5.1. Table 7.2 summarizes the projected surpluses. Both tables include the entities that show both a surplus and a deficit during the study period. Based on these figures, a list of potential water supply alternatives was developed for each of the potable water supply entities. The list also took into account a comparison of each entity's surplus or deficit, its location relative to other entities, and the potential raw water supply sources described in Chapter 6.

For those entities with a surplus over the entire study period, no alternatives for future new supplies were developed, though each of these entities was considered as a potential source for entities with a projected deficit. For each of the entities with a projected deficit, a set of alternatives was indicated consisting of either development of new water sources or purchase of water from adjacent water supply

Table 7.1
Regional Water Supply Study
Summary of Potable Water Supply and Demand
Entities with Deficits
(Acre-Feet/Year)

		High Population High Per Capita Use				Low Population High Per Capita Use			
		1990	2000	2010	2020	1990	2000	2010	2020
Baird*	Surplus/(Deficit)	(428)	(485)	(541)	(593)	(428)	(572)	(458)	(500)
Buffalo Gap	Surplus/(Deficit)	(59)	(65)	(72)	(82)	(59)	(64)	(69)	(75)
Cisco*	Surplus/(Deficit)	(603)	(594)	(588)	(666)	(556)	(469)	(406)	(439)
Clyde	Surplus/(Deficit)	(133)	(388)	(496)	(598)	(132)	(367)	(348)	(433)
Cross Plains*	Surplus/(Deficit)	(104)	(113)	(146)	(341)	(103)	(106)	(98)	(287)
Eastland Co.	Surplus/(Deficit)	1,047	640	288	(280)	1,182	999	816	379
Miles	Surplus/(Deficit)	(105)	(108)	(109)	(115)	(105)	(105)	(106)	(107)
Rising Star	Surplus/(Deficit)	(157)	(154)	(145)	(141)	(150)	(135)	(119)	(110)
Stamford* (incl. Hamlin)	Surplus/(Deficit)	(2,300)	(2,537)	(2,760)	(3,186)	(2,295)	(2,439)	(2,591)	(2,843)
Sweetwater	Surplus/(Deficit)	(1,792)	(2,159)	(2,742)	(4,342)	(1,781)	(1,971)	(2,371)	(3,675)
Woodson*	Surplus/(Deficit)	(59)	(67)	(63)	(60)	(58)	(64)	(59)	(54)
Sum of Deficits†		(5,740)	(6,670)	(7,662)	(10,404)	(5,667)	(6,312)	(6,625)	(8,523)

*participant
†Total of deficits only. Surpluses shown are not included.

Table 7.2
Regional Water Supply Study
Summary of Potable Water Supply and Demand
Entities with Surpluses
(Acre-Feet/Year)

		High Population High Per Capita Use				Low Population High Per Capita Use			
		1990	2000	2010	2020	1990	2000	2010	2020
Abilene*	Surplus/(Deficit)	10,426	7,968	5,526	846	10,599	8,310	6,654	3,726
Albany*	Surplus/(Deficit)	1,296	1,253	1,226	1,219	1,310	1,263	1,236	1,229
Anson*	Surplus/(Deficit)	1,350	1,318	1,294	1,211	1,353	1,351	1,352	1,329
Ballinger	Surplus/(Deficit)	440	460	489	489	440	490	420	519
Breckenridge*	Surplus/(Deficit)	1,633	1,223	910	463	1,682	1,346	1,047	721
Coleman (incl. Lawn)	Surplus/(Deficit)	6,943	6,461	6,347	6,093	6,974	6,645	6,546	6,410
Eastland Co.	Surplus/(Deficit)	1,047	640	288	(280)	1,182	999	816	379
Winters	Surplus/(Deficit)	401	395	433	448	402	422	460	507
Sum of Surpluses†		23,536	19,718	16,513	10,769	23,942	20,826	18,531	14,820

*participant
†Total of surpluses only. Entities with deficits not included.

entities. For each of the entities with a deficit, future supplies purchased from a neighboring supplier could be either as treated water or raw water, depending on the economics of expanding existing treatment facilities. This is further discussed in Chapter 8.

For entities that depend either entirely or partially on groundwater and for which a renewable yield was not available, alternatives for surface water sources were developed. These should be implemented when the groundwater source becomes uneconomical to use. This is discussed further in Chapter 4.

7.2 Local Water Supply Alternatives

For each of the potable water supply entities, potential alternatives were identified for additional water supply to meet the estimated potable water demand. These are described below. These alternatives were developed on a local basis only, assuming that each entity would maintain its current customers. Alternatives for the purchase of both raw or treated water from other entities were developed. In certain cases, where the entity is purchasing its raw water from a water district, such as the member cities of West Central Texas Municipal Water District, the existing contracts preclude the sale of raw water by the receiving entity. These entities can currently only sell potable water. It has been assumed, for the purposes of this report, that the member cities of WCTMWD, if needed in order to supply a new entity with raw water, would be able to renegotiate their contracts with WCTMWD in order that WCTMWD could supply the new entity with raw water without increasing the actual contracted amount supplied by WCTMWD. It was also assumed that this renegotiation would not be possible with other supplying water districts.

1) ABILENE:

Abilene is not projected to have a deficit of water supply before the year 2020, even with the high population projections and high per capita use rates for its current water supply sources and customers. For the low population projections, a surplus is projected in 2020. In addition, the City has obtained a contract with the Colorado River Municipal Water District for up to 15,000 acre feet per year of raw water from the recently completed O.H. Ivie Reservoir. By the year 2020, this will provide the City a surplus of water supply ranging from 15,846 to 18,726 acre-feet per year for the high and low population projections, respectively. In addition, Abilene has the potential to develop a water reclamation program that would reduce the demand on potable water by 5,000 acre-feet per year, effectively increasing the surplus. Therefore, for the current customers, Abilene should require no additional water supply source until after the year 2020. The pipeline and other facilities needed to use the available water from the O.H. Ivie Reservoir can be developed in time to meet Abilene's full requirements.

2) ALBANY:

The City of Albany currently has a contract with the West Central

Texas Municipal Water District (WCTMWD) for a supply of 1,881 acre-feet per year. In addition to the supplies from Lake McCarty, this provides more than twice the projected demand under either the high or low population projections. Because of this surplus, the City of Albany does not need to develop any future supplies of raw water to supply its existing customers.

3) ANSON:

The City of Anson currently has a contract with the WCTMWD to supply 2,061 acre-feet per year. Though Anson does not have an additional source with a dependable yield, this quantity does provide a supply that is more than twice the projected demand under either the high or low population projections. Because of this surplus, the City of Anson does not need to develop any future supplies of raw water to supply its existing customers.

4) BAIRD:

The City of Baird draws its water supply from Lake Baird, which has no dependable yield. Therefore, the City faces a deficit equal to its demand. The deficit, which is projected to be less than 600 acre feet per year through the study period for the high population projections, is much less than the yield available from the potential new sources described in Chapter 6. Therefore, it would not be economical for the City of Baird to pursue one of these options on its own. The City would be better off purchasing either raw or treated water from a neighboring entity that has a sufficient surplus. These would include the cities of Abilene and Coleman and possibly the Brown County Water Control and Improvement District No. One (BCWCID) from Lake Brownwood. Baird has recently entered into a contract to purchase treated water from the City of Abilene. Therefore, none of the other alternatives were developed further.

5) BALLINGER:

The City of Ballinger's estimated supply is greater than the projected demand for the study period. However, this surplus is dependent on the City's irrigation water rights being transferred to municipal use. The projections of the TWDB indicate no long-term need for development of a new source of raw water. If an emergency develops, the City could purchase water from CRMWD, as it has done in the past, or possibly from the City of Winters, which has a projected surplus.

6) BRECKENRIDGE:

The City of Breckenridge currently has a contract with the West Central Texas Municipal Water District (WCTMWD) to supply 2,487 acre-feet per year. Including the supplies from Lake Daniel, this is more than the projected demand in 2020 by 20 percent and 36 percent under the high and low population projections, respectively. Because of this surplus, the City of Breckenridge is indicated not to need to develop a new source of raw water prior to 2020 to supply its existing customers.

7) BUFFALO GAP:

The City of Buffalo Gap currently uses groundwater for its water supply. As described before, groundwater in west central Texas tends to be a nonrenewable water supply. Since the reserve in Buffalo Gap's available supply is not known, it is recommended that the City use the available groundwater as long as it is economical and of suitable quality. When needed, Buffalo Gap should purchase treated water from the City of Abilene via the Steamboat Mountain/Tuscola WSC.

8) CISCO:

The City of Cisco is projected to have a dependable yield of approximately one half of the estimated demand over the study period. The City currently has existing water rights for 110 acre-feet storage and 11.14 cfs withdrawal rate on Battle Creek which could possibly meet the projected deficits. Available information indicates that an average of about 230 acre-feet per year could be obtained with the existing system and about 500 acre-feet per year could be obtained if the structures were enlarged to the full permitted storage volume. These are averages estimated from the entire period of record and would not be reflective of that available in a prolonged drought. However, due to the excess capacity in Lake Cisco, the typical critical period concept does not apply as the lake is unlikely to ever fill. An additional consideration is the structural integrity of Cisco Dam, about which concerns have been raised in the past. Further development of the Battle Creek site increases the dependence of the City on the dam and its future use.

Other options available to the City include the purchase of raw or treated water from the City of Abilene, Coleman, or BCWCID, from Lake Brownwood. Both the City of Breckenridge and Eastland County show sufficient surplus to supply Cisco for the next ten to twenty years, but not for the entire study period and so were not considered as a long term source of water supply. If, under some of the regional alternatives, the WCTMWD implements a plan to divert water from the Clear Fork of the Brazos into Hubbard Creek, the potential for purchasing raw water from WCTMWD out of Hubbard Creek would also be available.

9) CLYDE:

The City of Clyde currently has sufficient dependable yield to supply approximately 80% of its current demand. This 20% deficit is projected to grow to about 50% by 2020. The deficit, which is projected to be less than 600 acre-feet per year through the study period for the high population projections, is much less than the yield available from the potential new sources described in Chapter 6. Therefore, it would not be economical for the City of Clyde to pursue one of these options on its own. The City would be better off purchasing either raw or treated water from a neighboring entity that has a sufficient surplus. These would include the cities of

Abilene and Coleman and possibly the Brown County Water Control and Improvement District No. One (BCWCID) from Lake Brownwood. The City has recently entered into a contract with the City of Abilene, so none of the other alternatives were developed any further.

10) COLEMAN:

The City of Coleman, because of the significant dependable yield of Lake Coleman, is projected to have an available supply roughly equal to four times the estimated demand throughout the study period. Therefore, the City has no need to develop any future raw water supply prior to the year 2020.

11) CROSS PLAINS:

The City of Cross Plains currently uses groundwater for its water supply. As described before, groundwater in west central Texas tends to be a nonrenewable water supply. The City should continue to use the available groundwater as long as it is economical, of suitable quality, and meets state health requirements. However, since the City pulls water from shallow wells, state health requirements regarding surface water treatment may become a critical issue. The City should initiate the development of a new source of water to meet its long term demands. This water should be potable as the City treatment plant would require a major upgrade to treat surface water. Potable water might be purchased from Abilene, Coleman, or possibly the BCWCID. Regional alternatives could have a significant impact on the final solution for Cross Plains because of its need for potable water and its distance from its potential suppliers.

12) EASTLAND COUNTY WSD:

Eastland County's only supply source with a dependable yield is Lake Leon. This reservoir should supply the area with its current customers until about the 2020. The projections show a deficit of 280 acre-feet, about 9% of the total demand, under the high population projections, and a surplus of 379 acre feet, about 16% of the estimated demand for the low population projections. Unless the population projections prove to be too high, Eastland County WSD should plan on bringing in a new supply of raw water by about the year 2020. Additional potential supply sources would include the City of Abilene, the City of Coleman from Lake Coleman, and the BCWCID's Lake Brownwood. If, under some of the regional alternatives, the WCTMWD implements a plan to divert water from the Clear Fork of the Brazos into Hubbard Creek, the potential for purchasing raw water from WCTMWD out of Hubbard Creek would also be suitable.

13) HAMLIN:

The City of Hamlin currently obtains its raw water from the City of Stamford. Its existing contract with Stamford calls for a maximum amount of 1,120 acre-feet per year, which should meet the projected demands for their current customers under both the high and low population projections. However, the City of Stamford is currently facing a significant deficit of water supply, and Hamlin, as a major customer of Stamford, faces a risk of a water shortfall despite its existing contract. The potential alternative solutions are discussed in section 18) for the City of Stamford.

14) LAWN:

The City of Lawn is currently supplied raw water from the City of Coleman out of Lake Coleman. As long as it is economical to treat this water, the City should continue to purchase raw water from Coleman. If major upgrades to its treatment facilities become necessary, the City could pursue purchasing potable water from the City of Abilene or the City of Coleman. If purchased from Coleman, the existing line could be used, but would have to be extended to Coleman's treatment plant.

15) MILES:

The City of Miles currently uses groundwater for its water supply. The State Department of Health has recently issued a letter to the City stating that the nitrate levels in the groundwater exceed exceptable standards. Therefore, the City should initiate the development of a new source of water to meet water quality needs and long-term demands. Potable water could be possibly be purchased from Ballinger, the City of Winters or the City of San Angelo.

16) RISING STAR:

The City of Rising Star currently uses groundwater for its water supply. Since the reserve in Rising Star's available supply is not known, the City should use the available groundwater as long as it is economical and of suitable quality. The City should, however, initiate the process of obtaining a new source of water to meet its long-term demands. This water should be potable, as the City does not have a treatment plant. Potable water could be purchased from Abilene, Coleman, or possibly the BCWCID. Regional alternatives could have a significant impact on the final solution for Rising Star because of its need for potable water and its distance from its potential suppliers.

17) ROSCOE:

The City of Roscoe currently uses groundwater for its water supply. Since the reserve in Roscoe's available supply is not known, we recommend that the City use the available groundwater as long as it is economical and of suitable quality. The City currently has a contract with the City of Sweetwater for potable water. Roscoe should utilize this water as needed for long-term demands. Its existing contract with Sweetwater calls for a maximum amount of 560 acre-feet per year, which should meet the projected demands for current customers under both the high and low population projections. However, the City of Sweetwater is currently facing a significant deficit of water supply, and Roscoe, as a major customer of Sweetwater, faces a risk of a water shortfall despite the existing contract. The potential solution alternatives are discussed in section 19) for the City of Sweetwater.

18) STAMFORD:

The City of Stamford faces a major raw water deficit, as its available dependable yield in Lake Stamford is estimated to be about 26% of the current municipal and industrial demand and is projected to be less than 10% of the estimated demand of Stamford and its existing customers in the year 2020 under both the high and low population projections. Potential new alternatives include the diversion of water from California Creek into Lake Stamford, the construction of the Fish Creek Reservoir with diversions from the Clear Fork of the Brazos, or the purchase of either raw water from the City of Abilene out of its Hubbard Creek pipeline. The projected yield of Lake Stamford is less than the estimated raw water demand of WTU and any solution that does not divert water into Lake Stamford will not alleviate this deficit of water. No other city with sufficient surplus exists within a reasonable distance of Stamford. Anson is the closest city with a surplus, but it would not be able to meet Stamford's estimated demands by itself. That source could only be used in conjunction with another alternative.

19) SWEETWATER:

The City of Sweetwater faces a significant deficit in its water supply. Its current deficit is approximately 30 percent of its estimated demand, meaning that the city's dependable supply is only about 70 percent of the estimated demand of its current customers. This deficit is projected to grow to about 50 percent under the high population projections and to about 45 percent under the low projections by the year 2020. Potential new alternative sources for the City of Sweetwater include the development of the Champion Well Field, which is of marginal quality due to high concentrations of nitrates and selenium and is not a long term solution as the groundwater is not a renewable resource; construction of the diversion from Sweetwater Creek into Lake Sweetwater; and development of a water reclamation program for portions of the industrial demand. None of these alternatives would eliminate the city's deficit of supply by itself, but, in combination, they would provide sufficient water. However, due to the temporary nature of the groundwater supply, other sources of water need to be developed. The combination of the Sweetwater Creek diversion and the water reclamation program would meet the projected deficit until about the year 1993, under the high population projections and 1997 under the low projections. Additional sources of water could possibly be purchased from CRMWD out of E.V. Spence Reservoir, the City of Coleman from Lake Coleman, or from the City of Abilene.

20) WINTERS:

The City of Winters is dependent on Lake Winters for its water supply. The reservoir's estimated dependable yield appears to be greater than the projected demands of the City's current customers for the study period. Therefore, no further action on the City's part towards developing additional future water supply within the study period appears to be warranted at this time.

21) WOODSON:

The City of Woodson draws its water supply from Lake Woodson, which has no dependable yield. Therefore, the City faces a deficit equal to its demand. The deficit, which is projected to be less than 100 acre-feet per year through the study period for the high population projections, is much less than the yield available from the potential new sources described in Chapter 6. Therefore, it would not be economical for the City of Woodson to pursue one of these options on its own. The City would be better off purchasing either raw or treated water from a neighboring entity that has a sufficient surplus. These would include the cities of Breckenridge and Albany. Supplies from Breckenridge could be either directly from the City or through Stephens Co. Rural Water Co-op. If, under some of the regional alternatives, the WCTMWD implements the plan to divert water from the Clear Fork of the Brazos into Hubbard Creek, the potential for purchasing raw water from WCTMWD out of Hubbard Creek would also be available.

7.3 Regional Water Supply Alternatives

For the entities listed in Table 7.1 as having a water supply deficit, some potential regional water supply alternatives were examined to determine if they could serve more than one entity from the same source. The entities with projected deficits were grouped together based on geographical location. The first grouping involved combinations of the entities with deficits in the southeastern portion of the 10-county area, including Baird, Cisco, Clyde, Cross Plains, Eastland County WSD, and Rising Star. Eastland County shows a small deficit only for the year 2020 and only under the high population estimates. It was, therefore, not included. The second set of alternatives involves the two entities in the western portion of the 10-county area that show a supply deficit, Stamford and Sweetwater. The third set of alternatives includes both of these combinations.

The remaining cities that indicate a deficit for at least a portion of the study period, assuming current supplies and current customers, include Ballinger, Miles, and Woodson. Ballinger shows a declining population and demand trend, and may have sufficient water supply available if the appropriate water rights can be adjusted. Miles' future water supply is unknown due to its dependence on groundwater. In addition, Miles is located south of the Colorado River and is therefore not conveniently located for consideration in a regional supply. Woodson is not conveniently located near other cities that show deficits in water supply and would be better served by purchasing water from either of the

Cities of Breckenridge or Albany.

Table 7.3 lists the groups of water supply entities considered in the regional supply alternatives as described above. The first set, including the eastern entities, is broken down into different subsets of entities, as shown on Table 7.3. The different sets of entities are described below along with potential regional raw water supply alternatives. Since the City of Abilene has recently contracted with the Cities of Clyde and Baird to supply them with treated water, only the City of Abilene would be considered a viable alternative supply source for regional alternatives including these cities.

1A) BAIRD, CISCO, AND CLYDE:

The combined projected deficit for these four entities totals 1,164 acre-feet in 1990 and 1,857 acre-feet in 2020 under the high population projections and 1,116 to 1,372, respectively, under the low projections. The planned line to reach Clyde and Baird from Abilene would need to be sized and extended to include Cisco.The use of water supplied from the City of Abilene would require that the facilities needed to utilize O.H. Ivie water be installed earlier than otherwise planned. Given the estimated rate of reduction in the projected surplus for the City of Abilene, the addition of these three cities would accelerate the need for the Ivie pipeline by about three to five years.

1B) CROSS PLAINS and RISING STAR:

Both of these cities depend entirely on groundwater supplies with

Table 7.3

Regional Water Supply Study
Summary of Regional Potable Water Supply Deficits

		Potable Water Supply Deficits							
		High Population Estimates Volume (Ac-Ft/Yr)				Low Population Estimates Volume (Ac-Ft/Yr)			
	Customers:	1990	2000	2010	2020	1990	2000	2010	2020
1) A	Clyde	133	388	496	598	132	367	348	433
	Baird	428	485	541	593	428	472	458	500
	Cisco	603	594	588	666	556	469	406	439
	Total	1,164	1,467	1,625	1,857	1,116	1,308	1,202	1,372
B	Cross Plains	269	278	311	341	268	271	263	287
	Rising Star	157	154	145	141	150	135	119	110
	Total	426	432	456	482	418	406	382	397
C	Clyde	133	388	496	598	132	367	348	433
	Baird	428	485	541	593	428	472	458	500
	Cross Plains	269	278	311	341	268	271	263	287
	Rising Star	157	154	145	141	150	135	119	110
	Total	987	1,305	1,493	1,673	978	1,245	1,188	1,330
D	Clyde	133	388	496	598	132	367	348	433
	Baird	428	485	541	593	428	472	458	500
	Cisco	603	594	588	666	556	469	406	439
	Cross Plains	269	278	311	341	268	271	263	287
	Rising Star	157	154	145	141	150	135	119	110
	Total	1,590	1,899	2,081	2,339	1,534	1,714	1,594	1,769
2) A	Sweetwater	1,792	2,159	2,742	4,342	1,781	1,971	2,371	3,675
	Stamford/Hamlin	2,300	2,537	2,760	3,186	2,295	2,439	2,591	2,843
	Total	4,092	4,696	5,502	7,528	4,076	4,410	4,962	6,518

Table 7.3, Continued

		Potable Water Supply Deficits							
		High Population Estimates				Low Population Estimates			
		Volume (Ac-Ft/Yr)				Volume (Ac-Ft/Yr)			
	Customers:	1990	2000	2010	2020	1990	2000	2010	2020
3) A	Clyde	133	388	496	598	132	367	348	433
	Baird	428	485	541	593	428	472	458	500
	Cisco	603	594	588	666	556	469	406	439
	Cross Plains	269	278	311	341	268	271	263	287
	Rising Star	157	154	145	141	150	135	119	110
	Sweetwater	1,792	2,159	2,742	4,342	2,295	2,439	2,591	3,675
	Stamford/Hamlin	2,300	2,537	2,760	3,186	2,295	2,439	2,591	2,843
	Total	5,682	6,595	7,583	9,867	5,601	6,124	6,556	8,287

unknown reserves. Both would need to purchase treated water as neither has any treatment facilities. Each has the same local alternatives, and since their combined deficits are less than the projected surpluses or available supplies, the regional alternatives for these entities combined would be the same as well. These alternatives were to purchase treated water from the City of Abilene, the City of Coleman out of Lake Coleman, or possibly the BCWCID from Lake Brownwood. Use of water supply from the City of Abilene would mean that the O.H. Ivie pipeline would need to be installed earlier than otherwise planned. Given the estimated rate of reduction in the projected surplus for the City of Abilene, the addition of these two cities would accelerate the need for the Ivie pipeline by about one year. Use of raw water from any of these sources would require local treatment.

1(C) BAIRD, CLYDE, CROSS PLAINS, AND RISING STAR:

This alternative would extend the planned treated water line from Abilene to the Cities of Baird and Clyde on out to Cross Plains and Rising Star. The combined projected deficits range from 987 to 1,673 in 1990 and 2020 under the high population projections, and from 978 to 1,330 under the low population projections. Use of water supply from the City of Abilene for this group would push up the planned installation of the O. H. Ivie pipeline by three to four years.

1D) BAIRD, CLYDE, CISCO, CROSS PLAINS, AND RISING STAR:

This set of cities is a combination of 1A and 1B and has similar alternatives for raw water supply. The total deficits range from 1,590 acre-feet per year in 1990 to 2,329 acre-feet per year in 2020 for the high population projection and 1,534 acre-feet per year in 1990 to 1,769 acre-feet per year in 2020 under the low population projections. Since Abilene has contracted to supply treated water to Baird and Clyde, the lines would have to be sized and extended appropriately. Use of water from the City of Abilene for the entire group would require that the O.H. Ivie pipeline be installed five to six years earlier than otherwise planned.

2) SWEETWATER and STAMFORD:

Both the cities of Stamford and Sweetwater currently face significant deficits in their raw water supply sources. Therefore, the time of development of a new project is an important factor. The two cities are indicated to have a combined 1990 deficit of 4,092 and 4,076 acre-feet per year under the high and low population estimates, respectively. By 2020, the combined deficit, assuming current supplies and current customers, is estimated to grow to 7,528 and 6,518 acre-feet per year for the high and low population projections, respectively. Only the City of Abilene would be in a position, both by geographic location and by available surplus, to provide this quantity of water. Though local alternatives are available, the only other potential regional alternative identified would be construction of the Fish Creek Reservoir with diversions from the Clear Fork of the Brazos. Under either alternative, raw water would need to be pumped to each city for local treatment.

3) ALL CITIES WITH DEFICITS:

The sum of all the deficits showed by the entities considered for regional supply, Baird, Cisco, Clyde, Cross Plains, Rising Star, Sweetwater, and Stamford, totals 5,682 acre-feet per year in 1990 and 9,867 acre-feet per year in 2020 for the high population projections. For the low population projections, these total deficits sum to 5,601 acre-feet per year in 1990 and 8,287 acre-feet per year in 2020. Because of the geographical location of the entities involved in this regional supply alternative, only the City of Abilene has the available surplus and central location to provide either the raw or treated water to these entities on a regional basis. None of the potentially new projects listed in Table 6.2 would be suitable during the study period because of either poor water quality or excessive construction and/or operating cost. However, because of the location of the entities, this alternative, City of Abilene, would effectively be implemented as a combination of the eastern and western regional alternatives. The combination is presented for comparison.

7.4 Summary of Water Supply Alternatives

The local alternatives for each of the entities listed in Table 7.1 as having a water supply deficit at some time within the study period are summarized in Table 7.4. These alternatives are described in more detail in section 7.2. The regional alternatives are summarized in Table 7.5. These alternatives are described in more detail in section 7.3. The impact of these alternatives on the treatment alternatives is discussed in Chapter 8. The recommendations, along with those of Chapter 8, are summarized in Chapter 9.

Table 7.4

Regional Water Supply Study
Summary of Local Water Supply Alternatives

	Surplus/ Deficit**	Potential New Sources:	Purchase Water From:
ABILENE*	Both	Div. - O.H. Ivie Res. Water Reclamation	-
ALBANY*	Surplus	-	-
ANSON*	Surplus	-	-
BAIRD*	Deficit	-	Abilene Coleman BCWCID WCTMWD
BALLINGER	Surplus	-	-
BRECKENRIDGE*	Surplus	-	-
BUFFALO GAP	Deficit	-	Abilene (Steamboat/ Tuscola WSD)
CISCO*	Deficit	-	Abilene Coleman BCWCID WCTMWD
CLYDE	Deficit	-	Abilene Coleman BCWCID WCTMWD
COLEMAN	Surplus	-	-
CROSS PLAINS*	Deficit	-	Abilene Coleman BCWCID WCTMWD

Table 7.5

Regional Water Supply Study
Summary of Regional Water Supply Alternatives

	Customers:	Potential New Sources:	Purchase Water From:
A	Clyde Baird* Cisco*	-	Abilene
B	Cross Plains* Rising Star	-	Abilene Coleman BCWCID
C	Clyde Baird* Cross Plains* Rising Star	-	Abilene
D	Clyde Baird* Cisco* Cross Plains* Rising Star	-	Abilene
A	Sweetwater* Stamford*	Fish Ck Res/Cl Fork Div	Abilene
A	Clyde Baird* Cisco Cross Plains* Rising Star Sweetwater* Stamford*	-	Abilene

* Participant

BCWCID - Brown County Water Control & Improvement District No. One (From Lake Brownwood)
WCTMWD - West Central Texas Municipal Water District (With diversions from the Clear Fork into Hubbard Creek)
CRMWD - Colorado River Municipal Water District

8. POTABLE WATER PRODUCTION ALTERNATIVES

8.1 Introduction

Chapter five presented, for each of the potable water supply entities identified within the 10-county study area, a comparison of the projected municipal potable water supply demands and the current available treatment facility capacities. Table 5.2 outlined this comparison for both the high and low population projections and the estimated peak day water demands developed for each. Each of the potable water supply entities was listed with either a surplus or a deficit of treatment capacity for the years 1990, 2000, 2010, and 2020 for both the high and low population projections. Based on these figures for demand and available capacity, a comparison of each entity's surplus or deficit and its location relative to other entities, and the feasibility of updating the plant capacities, a list of potable water production capacity alternatives was developed for each of the entities. Table 8.1 summarizes the projected deficits tabulated in Table 5.2. This includes the entities that are projected to go from a surplus to a deficit during the study period. For this table, Roscoe was included with the City of Sweetwater, as Sweetwater will replace the potable water currently obtained by Roscoe from groundwater as that source is depleted. Table 8.2 summarizes the projected surpluses.

For those entities with a surplus over the entire study period, no local alternatives were developed, though each of these entities was considered as a potential source of treated water for entities with

Table 8.1

Regional Water Supply Study
Summary of Treatment Plant Capacity
Entities with Deficit Capacity

Water Supply Entity		High Population Peak Day Surplus(Deficit)(MGD) 1990	2000	2010	2020	1990 WTP Capacity (MGD)	Low Population Peak Day Surplus(Deficit)(MGD) 1990	2000	2010	2020
Abilene*	Surplus/(Deficit)	(3.90)	(7.83)	(12.09)	(20.35)	52.00	(3.59)	(7.22)	(10.08)	(15.21)
Albany* (incl. Moran)	Surplus/(Deficit)	(0.11)	(0.12)	(0.09)	(0.02)	1.70	(0.08)	(0.10)	(0.07)	0.01
Anson*	Surplus/(Deficit)	0.13	0.07	0.03	(0.12)	1.40	0.14	0.13	0.13	0.09
Baird*	Surplus/(Deficit)	(0.21)	(0.30)	(0.39)	(0.47)	0.46	(0.21)	(0.28)	(0.26)	(0.32)
Breckenridge*	Surplus/(Deficit)	(0.09)	(0.37)	(0.48)	(0.82)	3.46	0.00	(0.14)	(0.22)	(0.33)
Clyde	Surplus/(Deficit)	0.59	0.06	(0.15)	(0.34)	2.00	0.59	0.11	0.18	0.03
Eastland Co.	Surplus/(Deficit)	(0.79)	(0.70)	(0.52)	(0.68)	4.00	(0.58)	(0.13)	0.31	0.35
Hamlin*	Surplus/(Deficit)	(0.64)	(0.68)	(0.74)	(1.04)	1.62	(0.64)	(0.58)	(0.56)	(0.67)
Miles	Surplus/(Deficit)	(0.35)	(0.36)	(0.36)	(0.38)	-	(0.35)	(0.35)	(0.35)	(0.36)
Rising Star	Surplus/(Deficit)	(0.35)	(0.34)	(0.32)	(0.31)	-	(0.33)	(0.30)	(0.27)	(0.25)
Stamford*	Surplus/(Deficit)	0.14	0.04	(0.01)	(0.33)	3.00	0.14	0.17	0.21	0.13
Sweetwater* (incl. Roscoe)	Surplus/(Deficit)	(3.02)	(3.42)	(4.22)	(5.32)	7.46	(3.00)	(3.08)	(3.54)	(4.11)
Woodson*	Surplus/(Deficit)	(0.01)	(0.03)	(0.02)	(0.01)	0.16	(0.01)	(0.03)	(0.01)	0.00

*Participant

Note: Buffalo Gap and Cross Plains show sufficient capacity, but would require extensive modifications to treat surface water.

Table 8.2

Regional Water Supply Study
Summary of Treatment Plant Capacity
Entities with Surplus Capacity

Water Supply Entity		High Population Peak Day Surplus(Deficit)(MGD) 1990	2000	2010	2020	1990 WTP Capacity (MGD)	Low Population Peak Day Surplus(Deficit)(MGD) 1990	2000	2010	2020
Ballinger	Surplus/(Deficit)	0.74	0.38	0.83	0.82	2.80	0.74	0.83	0.87	0.95
Buffalo Gap	Surplus/(Deficit)	0.33	0.31	0.30	0.28	0.46	0.33	0.32	0.31	0.29
Cisco*	Surplus/(Deficit)	1.44	1.54	1.64	1.51	4.50	1.57	1.87	2.13	2.12
Coleman	Surplus/(Deficit)	2.05	1.30	1.41	1.20	6.00	2.10	1.70	1.82	1.85
Cross Plains*	Surplus/(Deficit)	0.23	0.22	0.16	0.12	0.65	0.23	0.23	0.24	0.20
Winters	Surplus/(Deficit)	0.08	0.05	0.14	0.16	2.00	0.08	0.11	0.19	0.28

*Participant

Note: Buffalo Gap and Cross Plains show sufficient capacity, but would require extensive modifications alone to treat surface water.

projected deficits. For each of the entities with a projected deficit, a set of alternatives was developed consisting of either an upgrade of the existing facilities or purchase of potable water from adjacent water supply entities. For each of the entities with a deficit, the possible options were based on the applicable water supply alternatives discussed in Chapter 7.

8.2 Local Treatment Facility Alternatives

For each of the potable water supply entities, alternatives were considered for additional water treatment capacity, if needed, as described below. These alternatives were developed on a local basis only, assuming that each entity would maintain its current customers and treatment facilities.

1) ABILENE:

In Table 8.1, Abilene is shown to have a current deficit of treatment plant capacity using either the high or low population projections. This assumes both TWDB's population projections and high per capita use rates, which may be conservative for current demands. The deficits listed in Table 8.1 show the expansion needed to keep treatment capacity up to the level of the projected demands of the City's existing customers. Any additional customers will increase the needed level of expansion. These changes will be discussed in the next section on regional alternatives.

2) ALBANY:

Using the deficits listed in Table 8.1, the City of Albany currently has a deficit equivalent to between 4 percent and 6 percent of the currently available treatment facility capacity, based on the low and high population projections. These estimates include the demands of the City of Moran and Shackelford County WSC. Because of a projected decline in the population and the resulting peak day demand, the City shows treatment facility capacity to be essentially equal to demand in 2020. It is beyond the scope of this study to evaluate the current conditions of the treatment facilities, but based on discussions with the Texas Department of Health (TDH), the treatment facilities at both Albany and Moran have some difficulty meeting current treatment standards. Because the City does not have a raw water supply deficit, there is no need for any capital expenditures on additional supply, either raw or potable. Therefore, it is recommended that the City upgrade its treatment facilities to meet state criteria and upgrade the plant capacity as needed at the same time. It is also recommended that this expansion include the projected demands of Moran, as listed in table 8.1 and that provisions be made to provide Moran with its full potable water needs.

3) ANSON:

The City of Anson shows a slight surplus of treatment capacity through the study period for the low population projections and a small deficit in 2020 for the high projections. However, the surplus is equal to or less than ten percent of the projected demand throughout the study period. Based on discussions with the Texas Department of Health, the treatment facilities at Anson have some difficulty meeting current treatment standards. Because the City does not have a raw water supply deficit, there is no need for any capital expenditures on additional supply, either raw or potable. Therefore, it is recommended that the City upgrade their treatment facilities to meet state criteria and projected demands as needed.

4) BAIRD:

The City of Baird shows a deficit in treatment capacity ranging from one third to one half of the estimated peak day demands. However, the City faces a water supply deficit equal to the demand, as described in Chapter 7. The City's water supply alternatives include purchasing virtually their entire water supply. The City has recently contracted with the City of Abilene for treated water, which will reduce or eliminate the need for updating their treatment facilities.

5) BALLINGER:

The City of Ballinger is dependent on Lake Ballinger for its water supply. Based on available information, the City has a surplus of both water supply and treatment capacity. Therefore, unless any upgrade is needed to meet treatment standards, no further action on the City's part towards developing additional future raw or potable water supply appears to be warranted at this time.

6) BRECKENRIDGE:

The City of Breckenridge shows a slight deficit in treatment plant capacity under the high population projections and a small surplus under the low projections. However, by 2020, the current capacity is estimated to have a shortfall of 0.78 mgd under the high projections and 0.29 MGD under the low projections, assuming current customers. Because the City shows a projected raw water surplus under both the high and low population projections, it is recommended that the City upgrade the capacity of its treatment facilities as needed to match the projected peak day demands shown in Table 8.1.

7) BUFFALO GAP:

The City of Buffalo Gap currently uses groundwater for its water supply. The water supply recommendation described in Chapter 7 was to purchase water from the City of Abilene under its existing water contract. Buffalo Gap's existing treatment facility shows a surplus over the entire study period, but is expected to require a significant upgrade to be able to treat surface water. Therefore, Buffalo Gap should purchase potable water from the City of Abilene as needed through Steamboat/Tuscola WSC.

8) CISCO:

The City of Cisco is shown to have a treatment capacity surplus of 47 percent or more of projected peak day demand throughout the study period. Therefore, no upgrade of plant capacity is needed. However, the City currently faces a significant deficit of raw water supply.

The raw water alternatives included purchasing water from a series of potential suppliers. Because of the City's excess treatment capacity, it is recommended that Cisco purchase or divert raw water and continue to provide its own treatment, assuming that no major updates are required to meet treatment standards. However, if a regional supply system is implemented that will only provide treated water, the City should compare the costs of purchasing treated water and using the existing facilities to treat only the water from Lake Cisco versus the cost of purchasing additional raw water from a separate source.

9) CLYDE:

The City of Clyde is projected to have sufficient treatment capacity until about the year 2004 under the high population projections and through 2020 under the low projections. However the City faces a current raw water supply deficit equal to 20% of the estimated demand, and the deficit is projected to grow to about 50% by 2020. The City has recently entered into a contract with the City of Abilene for treated water supply which should relieve both the current water supply deficit and the predicted treatment deficit.

10) COLEMAN:

The City of Coleman shows significant surpluses in both water supply and treatment capacity. Therefore, the City has no need to develop any future water supply facilities at this time, assuming that no major upgrade is needed at the treatment facilities to meet appropriate standards. However, the City of Lawn, which is a raw water customer of Coleman, appears to have some difficulty in meeting state criteria, based on conversations with the TDH. If possible, Lawn should continue to purchase raw water from Coleman and upgrade its existing treatment facilities as needed. However, if major upgrades in the treatment facilities at Lawn become necessary, Lawn might purchase potable water from the City of Coleman or the City of Abilene. This would reduce the available surplus in plant capacity.

11) CROSS PLAINS:

The City of Cross Plains currently uses groundwater for its water supply. The raw water recommendations described in Chapter 7 was to purchase water from one of several suppliers. Cross Plains' existing treatment facility shows a surplus over the entire study period, but it is expected that major improvements would be required to treat surface water. Therefore, it is recommended that the City provide for the purchase of treated water as its groundwater supply becomes uneconomical or of poor quality. It is likely that, since Cross Plains pulls their water from shallow wells, it will be required to treat that water as surface water. If this occurs, the City should immediately pursue the purchase of potable water. Potential suppliers include the Cities of Abilene and Coleman, and BCWCID.

12) EASTLAND COUNTY WSD:

Eastland County WSD currently shows a significant deficit in treatment capacity of between 13% and 16% of the estimated demand for the low and high population projections, respectively. However, due to projected declining population and water demand, this deficit is projected to be reduced to 15% by 2020 under the high projections, and a surplus of 10% is shown for 2020 under the low population projections. The WSD shows a surplus of raw water until about the year 2015. Therefore, it is recommended that the treatment capacity be upgraded to meet the projected demands. If a raw water supply deficit develops, the WSD should arrange at that time to purchase the additional needed raw water supplies as described in Chapter 7.

13) HAMLIN:

The City of Hamlin currently obtains its raw water from the City of Stamford. Its treatment facilities are currently undersized by about 28% of the estimated demand. Under the high population projections, this deficit is expected to grow to about 39% by 2020. Under the low projections, it is estimated to remain almost unchanged. The City of Hamlin has available the alternatives to upgrade its facilities to match the projected demand or to purchase potable water from the City of Stamford. However, although Stamford shows a surplus in treatment capacity, it is not sufficient to meet Hamlin's needs. In addition, a separate potable water line would have to be constructed. Therefore, it is recommended that Hamlin upgrade its treatment facilities by about 50%, to a capacity of approximately

2.4 MGD, and continue to purchase raw water from the City of Stamford. This would provide sufficient capacity through the year 2010 under the high population projections and through the entire study period under the low projections.

14) MILES:

The City of Miles currently uses groundwater for its water supply and does not have any treatment facilities. Since the nitrate levels exceed acceptable levels, the City will need to either purchase potable water from some entity or build a treatment plant to treat purchased raw water. Potable water possibly could be purchased from Ballinger, or the City of Winters, or the City of San Angelo.

15) RISING STAR:

The City of Rising Star currently uses groundwater for its water supply and does not have any treatment facilities. As the reserves in Rising Star's available supply run low, the City will either need to purchase potable water from some entity or build a treatment plant to treat purchased raw water. Potential suppliers include the Cities of Abilene and Coleman and the BCWCID. Regional alternatives would have a significant impact on the final solution for Rising Star because of its need for potable water and its distance from potential suppliers. Because of its proximity to Cross Plains, which has a similar need for potable water, it is recommended that both cities pursue the purchase of a regional potable water supply.

This is discussed more fully in the next section.

16) ROSCOE:

The City of Roscoe currently uses groundwater for its water supply. The City currently has a contract with the City of Sweetwater for potable water. Roscoe should utilize this water as needed for its long-term demands and join with the City of Sweetwater in resolving their water supply deficits.

17) STAMFORD:

The City of Stamford faces a major raw water deficit, yet is shown to have a surplus of treatment capacity of about 5 percent of its peak day demand. Under the high population projections, a deficit in capacity is projected by the year 2008, but no deficit is forecast under the low projections. Therefore, it is recommended that no upgrade of the facilities be performed at this time unless needed to meet current treatment standards. Additional water supply developments should be concentrated on obtaining adequate amounts of raw water.

18) SWEETWATER:

The City of Sweetwater faces a significant deficit in its potable water supply production capacity. The deficit is currently estimated to be about 29 percent of the estimated demand. This deficit, maintaining current customers, is projected to increase to 42 percent by 2020 under the high population projections and to 36 percent under the low projections. By comparison, the City's current water supply deficit is approximately 30 percent of its estimated demand, and is expected to grow to almost 50 percent by 2020. Based on this comparison, the solutions to Sweetwater's water supply needs could be either in the form of raw water or potable water. Since Stamford does not need potable water, a regional system for both cities would need to be based on raw water from the City of Abilene or a new construction project. For Sweetwater alone, the only viable potable water supply alternative identified would be to purchase potable water from the City of Abilene. Additional local raw water supply alternatives were described in Chapter 7.

19) WINTERS:

The City of Winters is dependent on Lake Winters for its water supply. Based on available information, the City has a surplus of both water supply and treatment capacity. Therefore, unless any upgrade is needed to meet treatment standards, no further action on the City's part towards developing additional future raw or potable water supply appears to be warranted at this time.

20) WOODSON:

One of the raw water alternatives listed in Chapter 7 for the City of Woodson is to buy water from Breckenridge or Albany. Woodson has initiated a program to purchase treated water from Breckenridge through the Stephens Co. WSC. Because Woodson has a current deficit in treatment capacity, it is recommended that Woodson obtain potable water from Breckenridge via Stephens County WSC, with provisions to meet the full projected demand due to the lack of access to a raw water source with sufficient dependable safe yield.

8.3 Regional Treatment Facility Alternatives

Chapter 7 developed potential water supply alternatives for the entities listed in Table 7.1 as having water supply deficits. The entities listed in the regional water supply alternatives, shown in Tables 7.3 and 7.5, are listed in Table 8.3, with their recommended form of water purchase and a relative time frame for the need. Sweetwater would not be included in a regional treatment plant alternative since it is the only entity west of Abilene. Stamford would not be included because of its need for raw water. Buffalo Gap is located such that it would be better supplied individually from Abilene via Steamboat/Tuscola WSC rather than from a centrally located plant. Cisco and Eastland Co. would not be included because of their need for raw water supply. Baird and Clyde have already established a contract for purchasing treated water from Abilene. As the groundwater supplies of Cross Plains and Rising Star become uneconomical or do not meet appropriate water quality criteria, these two cities would need to purchase potable water. Based on this information, no regional potable water production alternative for the identified entities was developed.

Table 8.3

Regional Water Supply Entities
Proposed Purchased Water Type and Time

Entity	Water Type	Time
Baird	potable water	immediate
Clyde	raw or potable water	immediate
Cisco	raw water	immediate
Eastland Co.	raw water	2015-2025
Cross Plains	potable water	near end of GW Supply
Rising Star	potable water	near end of GW Supply
Stamford	raw water	immediate
Sweetwater	raw or potable	immediate

Note: GW = Groundwater

9. SUMMARY OF VIABLE ALTERNATIVES

A wide range of alternatives to meet the water supply needs of the study area, both water supply and water treatment capacity, has been reviewed and discussed in Chapters 7 and 8. As much as possible, the water supply alternatives, both on a local and a regional basis, were kept general and all inclusive, since those have to be met prior to being able to meet the potable water production needs. The treatment plant alternatives were developed using the potential water supply alternatives as a controlling factor.

After completion of the review of the potential local and regional water supply and potable water production alternatives, a compilation of viable alternatives was developed that took into account both water supply and treatment facility alternatives. This compilation is summarized in Table 9.1, which shows for each entity whether it has a surplus or a deficit for water supply or treatment capacity, the viable water supply alternatives, and the viable potable water supply alternatives. It is assumed that each entity will continue to supply its current customers. For those for whom a potential to include additional raw water or potable water customers was identified, these customers are listed. They need to be included in sizing the appropriate structures. For some entities, more than one viable alternative is listed. The choice will depend on considerations beyond an economic analysis of the alternatives, including, but not limited to water quality.

Table 9.1

Regional Water Supply Study
Summary of Viable Water Supply Alternatives

	Water Supply		Potable Water Production	
	Surplus/ Deficit**	Alternatives	Surplus/ Deficit**	Alternatives
ABILENE*	Surplus	Div. - O.H. Ivie Res., Potential New Customers: - Baird - Buffalo Gap - Cisco - Clyde - Eastland Co. WSD - Rising Star - Cross Plains - Stamford - Sweetwater	Deficit	Upgrade as needed, Potential New Customers: - Baird - Buffalo Gap - Cisco - Clyde - Eastland Co. WSD - Rising Star - Cross Plains - Stamford - Sweetwater
ALBANY*	Surplus	-	Deficit	Upgrade as needed.
ANSON*	Surplus	-	Surplus	Upgrade as needed.
BAIRD*	Deficit	-	Deficit	Purchase Potable water from Abilene

Table 9.1, Continued

	Water Supply		Potable Water Production	
	Surplus/ Deficit**	Alternatives	Surplus/ Deficit**	Alternatives
BALLINGER	Surplus	-	Surplus	Upgrade as needed.
BRECKENRIDGE*	Surplus	-	Both	Upgrade as needed, Potential New Customers: - Woodson
BUFFALO GAP	Deficit	-	Deficit	Purchase Potable Water from Steamboat/Tuscola WSC (Abilene)
CISCO*	Deficit	Purchase Raw Water from: a) Abilene, Anson, or Albany (Hubbard Ck. Line) b) Coleman (Lake Coleman) c) BCWCID (Lake Brownwood) d) Div. - Battle Creek	Surplus	Upgrade as needed.
CLYDE	Deficit	-	Both	a) Upgrade WTP as needed. b) Purchase Potable Water from Abilene

Table 9.1, Continued

	Water Supply		Potable Water Production	
	Surplus/ Deficit**	Alternatives	Surplus/ Deficit**	Alternatives
COLEMAN	Surplus	- Potential New Customers: - Cisco - Cross Plains - Rising Star - Sweetwater	Surplus	Upgrade as needed.
CROSS PLAINS*	Deficit	-	Deficit	Purchase Potable Water from: a) Coleman b) Abilene c) BCWCID
EASTLAND CO.	Both	-	Both	Upgrade as needed
LAWN	Surplus	-	Deficit	Upgrade as needed.
MILES	Deficit	-	Deficit	Purchase Potable Water from: a) Ballinger b) Winters c) San Angelo

Table 9.1, Continued

	Water Supply		Potable Water Production	
	Surplus/ Deficit**	Alternatives	Surplus/ Deficit**	Alternatives
RISING STAR	Deficit	-	Deficit	Purchase Potable Water from: a) Coleman b) Abilene c) BCWCID
ROSCOE	Deficit	-	Deficit	Purchase Potable Water from Sweetwater
STAMFORD*	Deficit	a) Div. - California Ck. b) Purchase Raw Water from Abilene (Hubbard Creek)	Both	Upgrade as needed.
SWEETWATER*	Deficit	a) Div. - Sweetwater Ck. Purchase Raw Water from: a) Abilene b) Lake Coleman (Lake Coleman) c) CRMWD (E.V. Spence Res.)	Deficit	Upgrade as needed.
WINTERS	Surplus	-	Surplus	Upgrade as needed.

Table 9.1, Continued

	Water Supply		Potable Water Production	
	Surplus/ Deficit**	Alternatives	Surplus/ Deficit**	Alternatives
WOODSON	Deficit*	Purachase Raw Water from Abilene, Albany, Anson, Breckenridge (Hubbard Creek Res.)	Deficit	a) Upgrade as needed. b) Purchase Potable Water from Stephens Co. WSC (Breckenridge)

* Participant
** Surplus - Entity shows a surplus through 2020
Deficit - Entity shows a deficit through 2020
Both - Entity shows both a surplus and a deficit within study period

The demands for those entities that are recommended to update their own facilities as needed for their current customers are shown in detail in Tables 3.10 and 3.11, using the high and low population projections. They are also summarized in Table 5.2.

The City of Abilene, based on the alternatives outlined in Table 9.1, could have a significant increase in its water supply demands from those listed in Tables 3.8 and 3.9 for the high and low population series, respectively. The full potential is shown in Table 9.2 for the high population series and in Table 9.3 for the low population projections. The water supply demands of the other entities are summarized in Table 5.1.

For the City of Abilene, including the additional water customers listed in Table 9.1, will bring closer the date at which the pipeline from the O.H. Ivie Reservoir will need to be operational. With its current customers, it was projected that the line would need to be operational by about the year 2020 under the high population projections and by approximately 2030 under the low projections. With the additional recommended raw water customers, this time frame is moved to the years 2007 to 2012. If the City were to implement the full water reclamation program described in Chapter 6, which could reduce the water supply demand by as much as 5,000 acre-feet, the time frame could be pushed back to the years 2015 to 2020 for the high and low population projections, respectively.

Table 9.2
Regional Water Supply Study
Potential Water Supply Demands - City of Abilene
High Population - High Per Capita Use

(Acre-Feet per Year)

Entity	Supplies Water To:	1990 Demand	2000 Demand	2010 Demand	2020 Demand
ABILENE*	Abilene	25,944	26,841	28,224	31,566
	Merkel	601	619	653	733
	Tye	332	343	362	406
	Feed Lots	135	130	130	130
	Pride Refining	290	290	290	290
	Baird Deficit	428	485	541	593
	Buffalo Gap Deficit	59	65	72	82
	Cisco Deficit	603	594	588	666
	Clyde Deficit	133	388	496	598
	Cross Plains Deficit	104	113	146	341
	Rising Star Deficit	157	154	145	141
	Stamford Deficit	2,300	2,537	2,760	3,186
	Sweetwater Deficit	1,002	1,369	1,952	4,342
	Potosi WSC	258	316	331	346
	View-Caps WSC	181	234	260	287
	Sun WSC	205	235	244	255
	Steamboat/Tuscola WSC	217	256	271	286
	Blair WSC	47	60	66	72
	Hamby WSC	135	165	174	182
	Hawley WSC (Part)	231	276	289	302
	Industrial	2,734	3,749	4,608	5,673
	Total Demand	36,096	39,219	42,602	50,677
	Total Available	41,736	41,482	41,428	41,374
	Savings from Water Reclamation	0	0	5,000	5,000
	Diversion-O.H. Ivie Res.	0	0	0	15,000
	Surplus/(Deficit)	5,640	2.263	3,826	10,697

Table 9.3
Regional Water Supply Study
Potential Water Supply Demands - City of Abilene
Low Population - High Per Capita Use

(Acre-Feet per Year)

Entity	Supplies Water To:	1990 Demand	2000 Demand	2010 Demand	2020 Demand
*ABILENE	Abilene	25,787	26,532	27,207	28,958
	Merkel	597	612	629	672
	Tye	330	340	349	373
	Feed Lots	134	129	125	119
	Pride Refining	288	287	280	266
	Baird Deficit	428	472	458	500
	Buffalo Gap Deficit	59	64	69	75
	Cisco Deficit	556	469	406	439
	Clyde Deficit	132	367	348	433
	Cross Plains Deficit	103	106	98	287
	Rising Star Deficit	150	135	119	110
	Stamford Deficit	2,295	2,439	2,591	2,843
	Sweetwater Deficit	991	1,181	1,581	3,675
	Potosi WSC	256	312	319	317
	View-Caps WSC	180	231	251	263
	Sun WSC	204	232	235	234
	Steamboat/Tuscola WSC	216	253	261	262
	Blair WSC	47	59	64	66
	Hamby WSC	134	163	168	167
	Hawley WSC (Split)	230	273	279	277
	Industrial	2,734	3,749	4,608	5,673
	Total Demand	35,851	38,405	40,444	46,010
	Total Available	41,736	41,482	41,428	41,374
	Savings from Water Reclamation	0	0	0	5,000
	Div. - O.H. Ivie Res.	0	0	0	0
	Surplus/(Deficit)	5,885	3,077	984	364

10. ESTIMATED COSTS OF VIABLE ALTERNATIVES

10.1 Introduction

Numerous alternatives for water supply and potable water production facilities for the potable water supply entities identified in the 10-county region were identified in Chapters 7 and 8, and summarized in Chapter 9. Several of these were selected for further review and preparation of estimated capital and annual costs for developing the alternative. The alternatives for which cost estimates were prepared are listed in Table 10.1 and shown in Figure 10.1. These alternatives listed are for water supply only. Some of the alternatives proposed to supply raw water to an entity, while others proposed to supply treated water. Table 10.2 lists the same alternatives as a reference for Figure 10.1. In this table, for each of the alternatives, segment letters of the portions of the pipelines shown in Figure 10.1 that are used for that alternative are listed. For example, Alternative No. 4 which is the alternative to supply treated water from Abilene to the Cities of Baird and Clyde is listed as included in pipeline segments D and E. In Figure 10.1, pipeline segments D and E can be seen to connect the City of Baird and on to the City of Clyde.

Table 10.1

Regional Water Supply Study
Viable Alternatives

Alternative No.	Raw Treated	Source	Customers
1	Raw	Ivie Reservoir	Abilene-Grimes WTP
2	Raw	California Creek	Stamford-Lake Stamford
3	Raw	Abilene (Hubbard Creek Line)	Stamford
4	Treated	Abilene	Clyde, Baird
5	Treated	Abilene	Clyde/Baird/Cross Plains/Rising Star
6	Raw	Abilene (Hubbard Creek Line)	Cisco
7	Treated	Brownwood WTP	Cross Plains/ Rising Star
8	Treated	Coleman WTP	Cross Plains/ Rising Star
9	Raw	Hubbard Creek Res.	Woodson
10	Raw	Sweetwater Creek Div.	Sweetwater-Lake Sweetwater
11	Raw	Abilene	Sweetwater-Lake Sweetwater
12	Raw	Coleman (Lake Coleman)	Sweetwater-Oak Creek Res.
13	Raw	CRMWD (E.V. Spence Res.)	Sweetwater-Oak Creek Res.

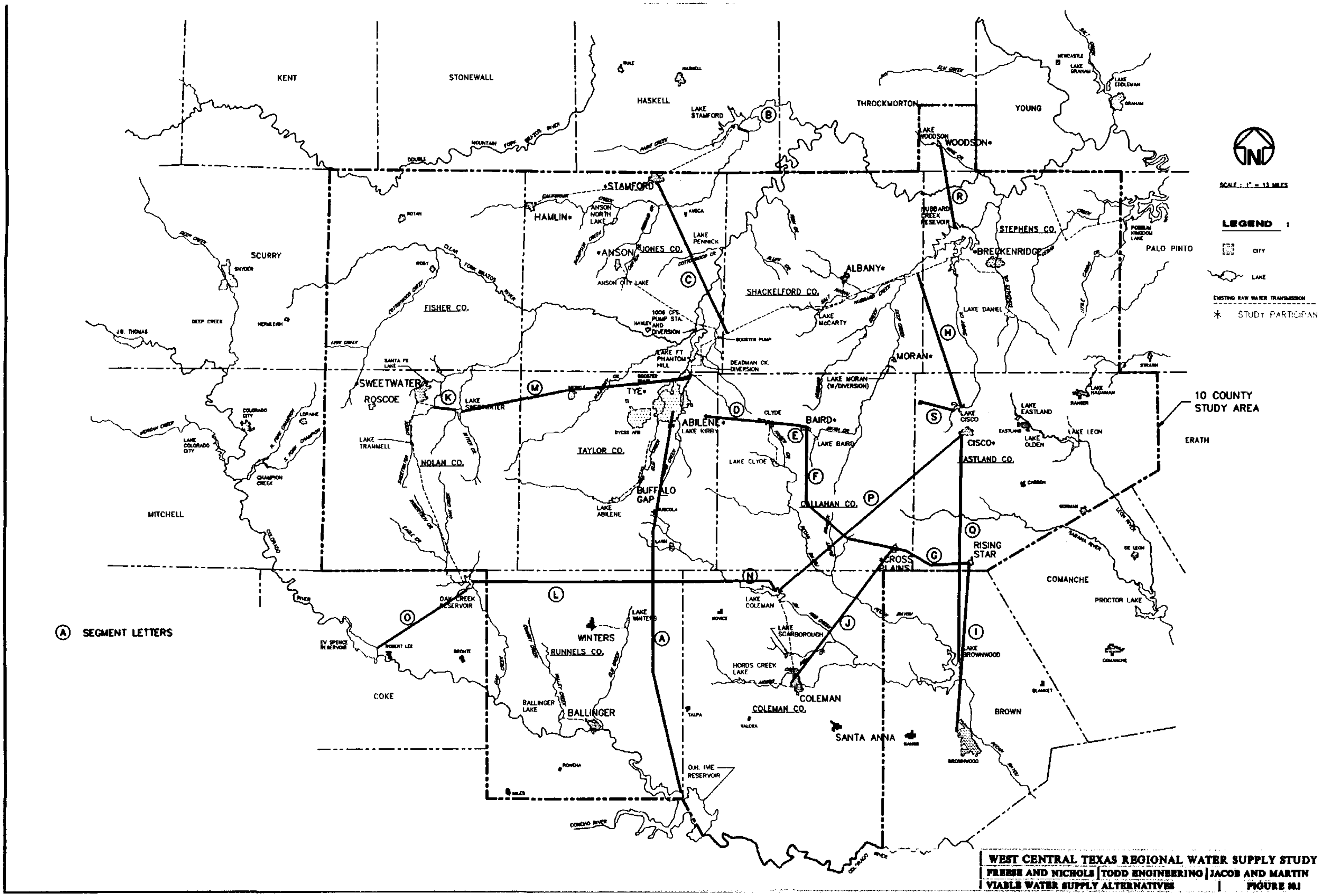
Table 10.1, Continued

Alternative No.	Raw Treated	Source	Customers
14	Raw	Coleman (Lake Coleman)	Cisco
15	Raw	BCWID (Lake Brownwood)	Cisco
16	Raw	Battle Creek Div.	Cisco

Table 10.2

Regional Water Supply Study
Viable Alternative Segments for Figure 10.1

System Number	Raw/Treated	Source	Customers	System Segment Numbers
1	Raw	Ivie Reservoir	Abilene-Grimes	A
2	Raw	California Creek	Stamford-Lake Stamford	B
3	Raw	Hubbard Creek Line	Stamford	C
4	Treated	Abilene	Baird & Clyde	D,E
5	Treated	Abilene	Clyde/Baird/Cross Plains/ Rising Star	D,E,F,G
6	Raw	Hubbard Cr. Line	Cisco	H
7	Treated	Brownwood WTP	Cross Plains/Rising Star	I,G
8	Treated	Coleman WTP	Cross Plains/Rising Star	J,G
9	Raw	Hubbard Cr. Res.	Woodson	R
10	Raw	Sweetwater Creek Div.	Sweetwater-Lake Sweetwater	K
11	Raw	Abilene	Sweetwater-Lake Sweetwater	M
12	Raw	Lake Coleman	Sweetwater-Oak Cr. Res.	N,L
13	Raw	Lake Spence	Sweetwater-Oak Cr. Res.	O
14	Raw	Lake Coleman	Cisco	P
15	Raw	Lake Brownwood	Cisco	Q
16	Raw	Battle Creek Div.	Cisco	R



WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
FREESE AND NICHOLS | TODD ENGINEERING | JACOB AND MARTIN
VIABLE WATER SUPPLY ALTERNATIVES | FIGURE 10.1

10.2 Estimated Capital Cost of Water Supply Alternatives

For each of the viable water supply alternatives listed in Table 10.1, an opinion of probable construction cost was prepared. These costs were tabulated in Tables 10.3 through 10.18. Included in these cost estimates are an assumption of 10 percent for engineering, geotechnical and administrative costs and 15 percent contingencies. The engineering is included in the capital cost items. Also tabulated in Tables 10.3 through 10.18 are estimates of the annual costs of each alternative. These costs include a debt service of 25 years at eight percent, pumping cost of 7.5¢/kwh, and annual administrative costs of 10 percent of operating cost. The pumping costs assume full use of the water supply. Table 10.19 summarizes the estimated costs of the 16 alternatives and their design flow rates. The alternatives were designed based on the average demand or the peak day demand, as appropriate. If the lines delivered raw water to a storage reservoir, average-day values were used. If raw water was delivered to a treatment plant or treated water was delivered, peak-day values were used to size the line.

Additional notes regarding these alternatives include the following:

a) The proposed pipeline from O. H. Ivie Reservoir to Abilene has a selected route up to Buffalo Gap, for which survey has been completed and field notes delivered. The cost shown adds the estimated cost of extending the line to the Grimes WTP, for which no line location has been selected.

Table 10.3

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 1

Abilene - Raw Water from O.H. Ivie Reservoir to Grimes WTP

A. Capital Costs

P.S. No. 1	Pump Station (20 mgd) & Inlet Stru.	$ 2,837,000
P.S. No. 2	Pump Station (20 mgd)	1,833,000
To Just North of Tuscola	36" - 242,000 ft., variable class Pipeline from Ivie Res. to Grimes WTP	15,740,000
To Grimes	36 - 83,000 ft. Class 100	4,905,000
	Subtotal	$25,365,000
	Contingencies @ 15%	3,805,000
	Total w/o Construction Interest	29,170,000
	Construction Interest	2,431,000
	TOTAL	$31,601,000

B. Annual Costs

Component	Annual Cost
Debt Service	$2,960,312
O&M	48,000
Pumping Costs	1,074,000
Subtotal	$4,082,312
Administration (@10%)	408,231
TOTAL	$4,490,543

Table 10.4

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 2

Stamford and Hamlin - Water Scalped from California Creek

A. Capital Costs

To Lake Stamford	Pump Station, 150 cfs, and Diversion Structure (Todd)	$11,282,000
	Pump Station - Renovate	200,000
To Stamford	Use present pipeline	0
	Expand Stamford WTP 0.29 mgd	589,000
	Pump Station - Renovate	120,000
	100,000 gal. storage tank	100,000
To Hamlin	Use present pipeline	0
	100,000 gal. storage tank	100,000
	Expand Hamlin WTP 1.04 mgd	1,674,000
	Subtotal	$14,065,000
	Contingencies @ 15%	2,110,000
	Total w/o Construction Interest	16,175,000
	Construction Interest	1,348,000
	TOTAL	$17,523,000

B. Annual Costs

Component	Annual Cost
Debt Service	$1,641,516
O&M	6,000
Pumping Costs	148,000
Subtotal	$1,795,516
Administration (@10%)	179,552
TOTAL	$1,975,068

Note: Water purchase costs not included.

Table 10.5

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 3

Stamford - Raw Water from Abilene (Hubbard Creek Line)

A. Capital Costs

To Stamford	Pump Station - none needed	$ 0
	24" - 142,000 ft. at $46/ft (5.99 mgd)	6,532,000
	Expand Stamford WTP 0.29 mgd	589,000
	100,000 gal. storage tank	100,000
	Pump Station - Renovate	120,000
To Hamlin	Use present pipeline	0
	100,000 gal. storage tank	100,000
	Expand Hamlin WTP 1.04 mgd	1,674,000
Subtotal		$ 9,115,000
Contingencies @ 15%		1,367,000
Total w/o Construction Interest		10,482,000
Construction Interest		873,000
TOTAL		$11,355,000

B. Annual Costs

Component	Annual Cost
Debt Service	$1,063,711
O&M	7,400
Pumping Costs	0
Subtotal	$1,071,111
Administration (@10%)	107,111
TOTAL	$1,178,223

Note: Water purchase costs not included.

Table 10.6

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 4

Clyde and Baird - Treated Water from Abilene (F.M. 18 & Elmdale)

A. Capital Costs

	Pump Station 2.26 mgd at 208 ft	$ 176,000
To Clyde	16" - 47,000 ft at $28/ft (2.26 mgd)	1,316,000
	100,000 gal. storage tank	100,000
To Baird	10" - 32,000 ft @ $20/ft (0.93 mgd)	640,000
	100,000 gal. storage tank	100,000
	Subtotal	$ 2,332,000
	Contingencies @ 15%	350,000
	Total w/o Construction Interest	2,682,000
	Construction Interest	223,000
	TOTAL	$ 2,905,000

B. Annual Costs

Component	Annual Cost
Debt Service	$ 272,134
O&M	4,400
Pumping Costs	26,000
Subtotal	$ 302,534
Administration (@10%)	30,253
TOTAL	$ 332,787

Note: Water purchase costs not included.

Table 10.7

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 5

Clyde, Baird, Cross Plains & Rising Star - Treated Water from Abilene (F.M. 18 & Elmdale)

A. Capital Costs

	Pump Station 3.10 mgd at 275 ft	$ 297,000
To Clyde	18" - 47,000 ft at $35/ft (3.10 mgd)	1,645,000
	100,000 gal. storage tank	100,000
To Baird	16" - 32,000 ft @ $28/ft (1.77 mgd)	896,000
	100,000 gal. storage tank	100,000
To Cross Plains	12" - 150,000 ft @ $23/ft (0.84 mgd)	3,450,000
To Rising Star	8" - 65,000 @ $17/ft (0.31 mgd)	1,105,000
	100,000 gal. storage tank	100,000
	Subtotal	$ 7,693,000
	Contingencies @ 15%	1,154,000
	Total w/o Construction Interest	8,847,000
	Construction Interest	737,000
	TOTAL	$ 9,584,000

B. Annual Costs

Component	Annual Cost
Debt Service	$ 897,808
O&M	14,000
Pumping Costs	46,000
Subtotal	$ 957,808
Administration (@10%)	95,781
TOTAL	$1,053,589

Note: Water purchase costs not included.

Table 10.8

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 6

Cisco - Raw Water from Hubbard Creek Line

A. Capital Costs

	Pump Station 0.859 mgd at 210 ft	$ 105,000
To Lake Cisco	12" - 114,000 ft at $23/ft (0.859 mgd)	2,622,000
	Subtotal	$ 2,727,000
	Contingencies @ 15%	409,000
	Total w/o Construction Interest	3,136,000
	Construction Interest	261,000
	TOTAL	$ 3,397,000

B. Annual Costs

Component	Annual Cost
Debt Service	$ 318,300
O&M	5,500
Pumping Costs	15,000
Subtotal	$ 338,800
Administration (@10%)	33,900
TOTAL	$ 372,700

Note: Water purchase costs not included.

Table 10.9

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 7

Rising Star and Cross Plains - Treated Water from BCWCID

A. Capital Costs

	Pump Station 0.84 mgd at 466 ft	$ 292,000
	100,000 gal storage tank	100,000
To Rising Star	12" - 144,000 ft at $23/ft (0.84 mgd)	3,312,000
	100,000 gal storage tank	100,000
	Pump Station 0.53 mgd at 135 ft	22,000
To Cross Plains	8" - 65,000 ft @ $17/ft (0.53 mgd)	1,105,000
	Subtotal	$ 4,931,000
	Contingencies @ 15%	740,000
	Total w/o Construction Interest	5,671,000
	Construction Interest	473,000
	TOTAL	$ 6,144,000

B. Annual Costs

Component	Annual Cost
Debt Service	$ 575,556
O&M	9,400
Pumping Costs	26,000
Subtotal	$ 610,956
Administration (@10%)	61,096
TOTAL	$ 672,052

Note: Water purchase costs not included.

Table 10.10

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 8

Rising Star and Cross Plains - Treated Water from City of Coleman

A. Capital Costs

	Pump Station 0.84 mgd at 466 ft	$ 88,000
	100,000 gal storage tank	100,000
To Cross Plains	12" - 137,000 ft at $23/ft (0.84 mgd)	3,151,000
	100,000 gal. storage tank	100,000
To Cross Plains	8" - 65,000 ft @ $17/ft (0.53 mgd)	1,105,000
	100,000 gal. storage tank	100,000
Subtotal		$ 4,644,000
Contingencies @ 15%		697,000
Total w/o Construction Interest		5,341,000
Construction Interest		445,000
TOTAL		$ 5,786,000

B. Annual Costs

Component	Annual Cost
Debt Service	$ 542,020
O&M	8,000
Pumping Costs	7,500
Subtotal	$ 558,320
Administration (@10%)	55,832
TOTAL	$ 614,152

Note: Water purchase costs not included.

Table 10.11

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 9

Woodson - Raw Water From Hubbard Creek Reservoir

A. Capital Costs

	Pump Station 0.19 mgd at 482 ft	$ 57,000
To Woodson	8" - 64,000 ft at $17/ft (0.19 mgd)	1,088,000
	100,000 gal storage tank	100,000
	Expand WTP 0.03	84,000
Subtotal		$ 1,329,000
Contingencies @ 15%		199,000
Total w/o Construction Interest		1,528,000
Construction Interest		127,000
TOTAL		$ 1,655,000

B. Annual Costs

Component	Annual Cost
Debt Service	$ 155,037
O&M	2,400
Pumping Costs	1,000
Subtotal	$ 158,437
Administration (@10%)	15,844
TOTAL	$ 174,280

Note: Water purchase costs not included.

Table 10.12

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 10

Sweetwater Creek to Lake Sweetwater

A. Capital Costs

Cost of Pump Station (7.00 mgd @ 253') and Pipeline (24")	$ 2,300,000
Subtotal	$ 2,300,000
Contingencies @ 15%	345,000
Total w/o Construction Interest	2,645,000
Construction Interest	220,000
TOTAL	$ 2,865,000

B. Annual Costs

Component	Annual Cost
Debt Service	$ 268,387
O&M	6,000
Pumping Costs	23,000
Subtotal	$ 297,387
Administration (@10%)	29,739
TOTAL	$ 327,126

Note: Water purchase costs not included.

Table 10.13

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 11

Sweetwater - Raw Water Line from Abilene NE WTP to Lake Sweetwater

A. Capital Costs

	Pump Station #1, 3.88 mgd at 400 ft	$ 523,000
	Pump Station #2, 3.88 mgd at 400 ft	523,000
To L. Sweetwater	20" - 200,000 ft @ $39/ft (3.88 mgd)	7,800,000
	Expand Sweetwater WTP (5.32)	6,762,000
	Subtotal	$15,608,000
	Contingencies @ 15%	2,341,000
	Total w/o Construction Interest	17,949,000
	Construction Interest	1,496,000
	TOTAL	$19,445,000

B. Annual Costs

Component	Annual Cost
Debt Service	$1,821,565
O&M	15,500
Pumping Costs	360,000
Subtotal	$2,197,065
Administration (@10%)	219,706
TOTAL	$2,416,771

Note: Water purchase costs not included.

Table 10.14

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 12

Sweetwater - Raw Water Line from Lake Coleman to Oak Creek Reservoir

A. Capital Costs

	Inlet Structure	$ 750,000
P.S. 1	Pump Station, 3.88 mgd at 400 ft	523,000
P.S. 2	Pump Station, 3.88 mgd at 400 ft	523,000
To Oak Cr. Res.	20" - 309,000 ft @ $39/ft (3.88 mgd)	12,051,000
	Expand Pump Station at Oak Creek	200,000
	Expand Sweetwater WTP (5.32)	6,762,000
Subtotal		$20,809,000
Contingencies @ 15%		3,121,000
Total w/o Construction Interest		23,930,000
Construction Interest		1,994,000
TOTAL		$25,924,000

B. Annual Costs

Component	Annual Cost
Debt Service	$2,428,503
O&M	20,300
Pumping Costs	515,000
Subtotal	$2,963,803
Administration (@10%)	296,380
TOTAL	$3,260,184

Note: Water purchase costs not included.

Table 10.15

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 13

Sweetwater - Raw Water Line from Lake Spence to Oak Creek Reservoir

A. Capital Costs

	Inlet Structure	$ 750,000
P.S. 1	Pump Station, 3.88 mgd at 300 ft	418,000
P.S. 2	Pump Station, 3.88 mgd at 225 ft	341,000
To Divide	20" - 78,000 ft @ $39/ft (3.88 mgd)	3,042,000
To Oak Cr. Lake	16" - 30,000 ft @ $28/ft (3.88 mgd)	840,000
	Expand Pumping Station at Oak Creek	200,000
	Expand Sweetwater WTP (5.32)	6,762,000
Subtotal		$12,353,000
Contingencies @ 15%		1,853,000
Total w/o Construction Interest		14,206,000
Construction Interest		1,184,000
TOTAL		$15,390,000

B. Annual Costs

Component	Annual Cost
Debt Service	$1,441,701
O&M	8,800
Pumping Costs	324,500
Subtotal	$1,775,001
Administration (@10%)	177,500
TOTAL	$1,952,501

Note: Water purchase costs not included.

Table 10.16

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 14

Cisco - Raw Water from Lake Coleman

A. Capital Costs

	Inlet Structure	$ 375,000
P.S. 1	Pump Station, 0.595 mgd at 448 ft	115,500
To Cisco	10" - 246,000 ft @ $20/ft (3.88 mgd)	4,920,000
	Subtotal	$ 5,410,500
	Contingencies @ 15%	812,000
	Total w/o Construction Interest	6,222,500
	Construction Interest	519,000
	TOTAL	$ 6,741,500

B. Annual Costs

Component	Annual Cost
Debt Service	$ 631,529
O&M	11,500
Pumping Costs	31,800
Subtotal	$ 674,829
Administration (@10%)	67,483
TOTAL	$ 742,312

Note: Water purchase costs not included.

Table 10.17

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 15

Cisco - Raw Water from Lake Brownwood

A. Capital Costs

	Inlet Structure	$ 375,000
P.S. 1	Pump Station, 0.595 mgd at 448 ft	108,000
To Cisco	10" - 233,000 ft @ $20/ft (3.88 mgd)	4,660,000
	Subtotal	$ 5,143,000
	Contingencies @ 15%	771,000
	Total w/o Construction Interest	5,914,000
	Construction Interest	493,000
	TOTAL	$ 6,407,000

B. Annual Costs

Component	Annual Cost
Debt Service	$ 600,194
O&M	11,000
Pumping Costs	30,000
Subtotal	$ 641,194
Administration (@10%)	64,119
TOTAL	$ 705,313

Note: Water purchase costs not included.

Table 10.18

Regional Water Supply Study
Estimates of Probable Costs (1991 Dollars)
System No. 16

Cisco - Raw Water from Battle Creek (present diversion point)
110 acre-foot lake

A. Capital Costs

At Battle Creek	New Diversion Structure & Land	$2,500,000
P.S.	Pump Station Est. Renovation, 7.1 mgd	450,000
To Cisco	Use present line	0
	Subtotal	$2,950,000
	Contingencies @ 15%	443,000
	Total W/O Construction Interest	3,393,000
	Construction Interest	283,000
	TOTAL	$3,676,000

B. Annual Costs

Component	Annual Cost
Debt Service	$ 344,360
O&M	7,500
Pumping Costs	18,000
Subtotal	$ 369,860
Administration (@10%)	36,986
TOTAL	$ 406,846

Note: Water purchase costs not included.

Table 10.19

Regional Water Supply Study
Summary of Estimated Costs of Viable Alternatives
(1991 Dollars)

System Number	Source	Customers	Annual Supply Ac-Ft/Yr	Pump Station and Pipeline Capacity MGD	Capital Costs	Annual Costs
1	Ivie Reservoir	Abilene-Grimes	15,000	20.000	$31,601,000	$4,490,543
2	Calif. Cr.	Stamford-Lake Stamford	5,800	97.000	17,523,000[3]	1,975,068
3	Hubbard Creek Line	Stamford	3,186	5.990	11,355,000[3]	1,178,223
4	Abilene[1]	Baird & Clyde	1,191	2.260[2]	2,905,000	332,787
5	Abilene[1]	Clyde/Baird/Cross Plains/ Rising Star	1,673	3.100[2]	9,584,000	1,053,589
6	Hubbard Cr. Line	Cisco	665	0.595	3,397,000	372,700
7	Brownwood WTP[1]	Cross Plains/Rising Star	482	0.840[2]	6,144,000	672,052
8	Coleman WTP[1]	Cross Plains/Rising Star	482	0.840[2]	5,786,000	614,152
9	Hubbard Cr. Res.	Woodson	67	0.190[2]	1,655,000[3]	174,280
10	Sweetwater Creek Dv.	Sweetwater-Lake Sweetwater	790	7.000	2,865,000	327,126
11	Abilene	Sweetwater-Lake Sweetwater	4,342	3.880	19,445,000[3]	2,416,771
12	Lake Coleman	Sweetwater-Oak Cr. Res.	4,342	3.880	25,924,000[3]	3,260,184
13	Lake Spence	Sweetwater-Oak Cr. Res.	4,342	3.880	15,390,000[3]	1,952,501
14	Lake Coleman	Cisco	665	0.595	6,741,500	742,312
15	Lake Brownwood	Cisco	665	0.595	6,407,000	705,313
16	Battle Creek Dv.	Cisco	500	7.199	3,676,000	406,846

Note: Costs for purchase of water and local treatment and distribution not included.
[1]Potable water supply alternative, remaining alternatives for raw water supply.
[2]Sized for peak-day demand.
[3]Capital costs include WTP expansion.

b) The Brown County Water Improvement District is considering supplying treated water to customers north of Lake Brownwood. If this is done, the estimated costs of BCWID supplying treated water to Cross Plains and Rising Star would be reduced, as a shorter pipeline would be needed to tap into the system.

10.3 Estimated Cost of Treatment Alternatives

As identified in Chapters 8 and 9, many of the potable water supply entities do not have sufficient water treatment capacity to meet projected high use demand either for current or projected customers. Opinions of probable construction cost for expanding the existing treatment facilities to meet projected high population, high use demands were prepared. These costs are summarized in Table 10.21 for current and potential customers. These expansions meet the maximum deficits listed in Table 5.2. The maximum value generally reflects the estimated 2020 deficit, but for entities with a declining demand, the largest deficit was used. Therefore, these costs estimate the maximum potential expansion needed for current customers.

Of the entities within the study area, only Coleman, Abilene and the Brown County Water District were considered as a viable source for treated water for new customers. Their maximum expansion potential and the estimated costs are also listed in Table 10.21. The capital cost estimates do not include the potential cost of local water treatment plant upgrading that may be needed to meet TDH criteria. The costs reflected are strictly for water capacity.

Table 10.20

Regional Water Supply Study
Potential Water Treatment Plant Expansions and Estimated Costs

A) Current Customers

Plant	Existing Capacity (MGD)	Projected Maximum Demand (MGD)	Year of Maximum Demand	Expand (Deficit) (MGD)	Expand (Deficit) Estimated Cost Millions
Abilene	52.00	72.35	2020	20.35	$19.414
Albany	1.70	1.82	2000	0.12	0.294
Anson	1.49	1.52	2020	0.12	0.294
Baird	0.46	0.93	2020	0.47	0.888
Breckenridge	3.46	4.28	2020	0.82	1.377
Cisco	4.50	2.99	2020	0.00	0.000
Clyde	2.00	2.34	2020	0.34	0.666
Coleman	6.00	4.80	2020	0.00	0.000
Eastland Co.	4.00	4.79	1990	0.79	1.542
Hamlin	1.62	2.66	2020	1.04	1.674
Stamford	3.00	3.33	2020	0.33	0.670
Sweetwater	7.46	12.78	2020	5.32	6.762
Winters	2.00	1.95	2000	0.00	0.000
Woodson	0.16	0.19	2000	0.03	0.084

B) Potential Customers

	Existing Capacity (MGD)	Projected 2020 Demand		
Abilene	52.00	72.35	24.64	$19.958
Baird		0.93		
Clyde		2.34		
Buffalo Gap		0.18		
Cross Plains		0.53		
Rising Star		0.31		
Total		76.64		
Coleman	6.00	4.80	0.08	$0.201
Cross Plains		0.53		
Rising Star		0.31		
Lawn		0.44		
Total		6.08		

Note: All new customers assume full peak-day demand met with treated water supply.

11. IMPLEMENTATION PLAN

11.1 Introduction

Each of the potable water supply entities discussed within the ten county study area face a different water supply and water treatment situation. As have been identified in the preceding chapters, several entities face current water supply deficits. These deficits tend to become larger over time as the demand increases while the available supply decreases. The estimated deficits of the different entities are summarized in Chapter 5 along with the surpluses. Potential alternatives to the water supply and water treatment deficits are described in chapters 6 through 8 and are summarized in chapter 9. Estimated costs for the viable options are discussed in chapter 10. Table 11.1 lists each of the entities, whether it has a deficit in either water supply or water treatment, and the year in which their deficit appears.

11.2 Implementation of Water Supply Alternatives

Eastland County is the only entity identified that shows a current water supply surplus that becomes a deficit by the end of the study period. However, this is only under the high population projections. Using the low population projections, Eastland Co. would still have surplus in the year 2020. Therefore, Eastland County would need to plan on having access to additional supply by about the year 2020, unless the actual population figures more closely match the low estimates.

Abilene shows a surplus under both the population projections, assuming current customers and supplies. However, the City is listed as

Table 11.1

Regional Water Supply Study
Summary of Deficits

	Water Supply			Potable Water Production		
	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.
Abilene*	Surplus			Deficit		
-Current Customers		2019	2029		current	current
-Potential Customers		2007	2012		current	current
Albany*	Surplus	-	-	Deficit	current	current
Anson*	Surplus	-	-	Both	2012	-
Baird*	Deficit	current	current	Deficit	current	current
Ballinger	Deficit	current	current	N/A	-	-
Breckenridge*	Surplus	-	-	Both	current	current
Buffalo Gap	Deficit	†	†	Deficit	-	-
Cisco*	Deficit	current	current	Surplus	-	-
Clyde	Deficit	current	current	Both	2003	2022
Coleman	Surplus	-	-	Surplus	-	-

Table 11.1, Continued

	Water Supply			Potable Water Production		
	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.
Cross Plains*	Deficit	†	†	Deficit	-	-
Eastland Co.	Both	2015	-	Both	current	current
Lawn	Surplus	-	-	Deficit	current	current
Miles	Deficit	†	†	Deficit	-	-
Rising Star	Deficit	†	†	Deficit	-	-
Roscoe	Deficit	current	current	Deficit	-	-
Stamford*	Deficit	current	current	Both	2008	-
Sweetwater*	Deficit	current	current	Deficit	current	current
Winters	Surplus	-	-	Surplus	-	-

Table 11.1, Continued

	Water Supply			Potable Water Production		
	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.	Surplus/ Deficit**	Year Deficit Starts High Pop.	Year Deficit Starts Low Pop.
Woodson	Deficit*	current	current	Deficit	current	current

*Participant
**Surplus - Entity shows a surplus through 2020
Deficit - Entity shows a deficit through 2020
Both - Entity shows both a surplus and a deficit within study period
†Currently on groundwater. Deficit will occur when groundwater does not meet needs.

a viable supplier for numerous entities. If the City of Abilene were to supply these entities, they would develop a deficit in water supply prior to the year 2020. This would require that the City bring on line the water supply pipeline from O.H. Ivie Reservoir earlier than currently planned. This is discussed further in Chapter 9. If Abilene were to continue supplying only their current customers plus the cities of Clyde and Baird, with whom they have entered into a contract, it is projected that water from the Ivie pipeline would be needed between the years 2019 and 2029, using the high and low population projections as bounds. Development of the full water reclamation project as described in chapter 6, would delay this by about 10 years. If all of the entities for which Abilene is listed as a viable supplier, the Ivie line would need to be in place by 2007 to 2012, again using the high and low projections as bounds. Development of the water reclamation program could also delay this by eight years.

All other entities that show a current deficit in water supply show this deficit under both the high and low population projections and over the entire study period. Therefore, some means of solving the water supply deficit should be enacted as soon as is practical. For each of the deficit entities, one or more viable alternatives were identified and estimated costs developed. The most attractive of the alternatives should be pursued for development. Each of the viable alternatives listed for each deficit entity could be developed at the present time.

Sweetwater has viable alternatives available other than purchasing water from Abilene to reduce or eliminate its supply deficit. These include purchasing water from the CRMWD out of E.V.Spence Reservoir, purchasing water from Coleman out of Lake Coleman, developing the Sweetwater Creek diversion, and developing a water reclamation program. Some of these alternatives, discussed further in chapters 6 through 9, could be developed presently, prior to the purchase of water from Abilene.

The estimated time frames required for implementing the projects shown in Table 10.19 are shown in Figures 11.1 through 11.16.

11.3 Implementation of Water Treatment Alternatives

As can be seen in Table 11.1, several of the water supply entities face current shortages in water treatment capacity, while others develop a shortage over the study period. For all of the determinations, high average per capita municipal use was assumed in order to best reflect the demands that would exist during a drought or dry season.

Some entities have one or more viable alternatives available that would provide for the purchase of treated water which would solve both the water supply deficit and the treatment capacity deficit. These include the Cities of Baird, Buffalo Gap, Clyde, Cross Plains, Miles, Rising Star, and Roscoe. For the remaining entities with capacity deficits, an expansion of the treatment facilities should be developed as needed at or before the time at which the deficit is listed. A listing of the needed expansion and the estimated costs are described in Chapter 10.

Figure 11.1

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 1

Needed: 2007-2029
Location: Ivie to Abilene
Capacity: 15,000 af/yr
Cost: $31,601,000

```
                                    #**********2003*********#**********2004*********#**********2005*********#**********2006*********#*******
                                      J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A
                                      ----------------------- ----------------------- ----------------------- ----------------------- -------

A. Final Engineering
   1. Issue and sell bonds                        ======
   2. Survey                                            ============
   3. Detailed design
      a. Pipe line                                      =======================
      b. Pump stations                                    =========================
   4. Owner review                                                          ====
   5. Prepare specifications                                                  =======

B. Construction Phase
   1. Advertise for Construction                                                      ====
   2. Receive bids and award contracts                                                    ===
   3. Construction                                                                            ==============================================
```

Figure 11.2

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 2

Needed: Now
Location: California Creek to Stamford/Hamlin
Capacity: 5,800 af/yr
Cost: $17,523,000

```
                                    #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                     J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                    ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Decision to proceed         x
   2. Deed composite mapping                          ===
   3. Easements                                         ========

B. Initial Engineering
   1. Decision to proceed         x
   2. Aerial photos                 ==
   3. Preliminary design            ======
   4. Cost estimate                     ===
   5. Permitting                    ==============

C. Financial
   1. Financial evaluation                  ====
   2. Evaluation by S&P and Moody's           ==

D. Final Engineering
   1. Issue and sell bonds                      ======
   2. Survey                                          ===
   3. Detailed design
      a. Diversion structure & pipeline               ============
      b. Pump station                                 ==========
   4. Owner review                                              ====
   5. Prepare specifications                                  ======

E. Construction Phase
   1. Advertise for Construction                                    ====
   2. Receive bids and award contracts                                  ===
   3. Construction                                                          ====================================
```

Figure 11.3

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 3

Needed: Now
Location: Hubbard Creek Line to Stamford/Hamlin
Capacity: 3,186 af/yr
Cost: $11,355,000

```
                                        #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                         J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                        ------------------------ ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)           ===============
   2. Decision to proceed                      x
   3. Deed composite mapping                                      ===
   4. Easements                                                     ========

B. Initial Engineering
   1. Decision to proceed                      x
   2. Aerial photos                             ==
   3. Preliminary design                        ========
   4. Cost estimate                                   ===

C. Financial
   1. Financial evaluation                              ====
   2. Evaluation by S&P and Moody's                       ==

D. Final Engineering
   1. Issue and sell bonds                                  ======
   2. Survey                                                      ===========
   3. Detailed design
      a. Pipe line                                                ================
      b. Pump stations (none needed)
   4. Owner review                                                          ====
   5. Prepare specifications                                                =======

E. Construction Phase
  1. Advertise for Construction                                                     ====
  2. Receive bids and award contracts                                                    ===
  3. Construction                                                                              ================================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 11.4

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 4

Needed: Now
Location: Treated Water From Abilene to Clyde/Baird
Capacity: 1,191 af/yr
Cost: $2,905,000

```
                                        #**********1991*********#**********1992*********#**********1993*********#**********1994*********
                                         J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                        ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Decision to proceed                      x
   2. Deed composite mapping                                                              ===
   3. Easements                                                                             =======

B. Initial Engineering
   1. Decision to proceed                      x
   2. Aerial photos (none needed)
   3. Preliminary design                    ====                  ========
   4. Cost estimate                                                     ===

C. Financial
   1. Financial evaluation                                                    ====
   2. Evaluation by S&P and Moody's                                             ==

D. Final Engineering
   1. Issue and sell bonds                                                        ======
   2. Survey                                                                        ====
   3. Detailed design
      a. Pipe line                                                                  ============
      b. Pump station                                                                 =========
   4. Owner review                                                                          =====
   5. Prepare specifications                                                                ======

E. Construction Phase
   1. Advertise for Construction                                                                  ====
   2. Receive bids and award contracts                                                                ===
   3. Construction                                                                                        ========================
```

Note: Based on Billy Jacob's current schedule.
Contracts between Abilene/Clyde/Baird are signed.

Figure 11.5

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 5

Needed: Now
Location: Treated Water From Abilene to Clyde/Baird/Rising Star/Cross Plains
Capacity: 1,673 af/yr (482 af/yr for Cross Plains/Rising Star)
Cost: $9,584,000 ($6,679,000 in addition to System 4)

```
                                      #**********1992*********#**********1993*********#**********1994*********#*********1995***********
                                       J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                      ------------------------ ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)         =========
   2. Cross Plains/Rising Star
      Decision to proceed                x
   3. Deed composite mapping                                ===
   4. Easements                                               ========

B. Initial Engineering
   1. Decision to proceed                x
   2. Aerial photos                       ==
   3. Preliminary design                  ========
   4. Cost estimate                             ===

C. Financial
   1. Financial evaluation                        ====
   2. Evaluation by S&P and Moody's                 ==

D. Final Engineering
   1. Issue and sell bonds                            ======
   2. Survey                                                ======
   3. Detailed design
      a. Pipe line                                          ==============
      b. Pump station                                          ============
   4. Owner review                                                      ====
   5. Prepare specifications                                          ======

E. Construction Phase
   1. Advertise for Construction                                            ====
   2. Receive bids and award contracts                                          ===
   3. Construction                                                                  ================================
```

Note: Clyde/Baird scheduled for completion in 1994. Negotiations of Cross Plains and Rising Star with Abilene need to be complete before selection of pipe size in 1992.

Figure 11.6

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 6

Needed: Now
Location: Hubbard Creek Line to Cisco
Capacity: 665 af/yr
Cost: $3,397,000

```
                                        #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                         J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                        ------------------------ ------------------------ ------------------------ ------------------------
A. Legal
   1. Negotiations (see note)           ===============
   2. Decision to proceed                      x
   3. Deed composite mapping                                      ===
   4. Easements                                                     ========

B. Initial Engineering
   1. Decision to proceed                      x
   2. Aerial photos                             ==
   3. Preliminary design                        ========
   4. Cost estimate                                   ===

C. Financial
   1. Financial evaluation                              ====
   2. Evaluation by S&P and Moody's                       ==

D. Final Engineering
   1. Issue and sell bonds                                  ======
   2. Survey                                                      ====
   3. Detailed design
      a. Pipe line                                                ============
      b. Pump station                                               ========
   4. Owner review                                                          ====
   5. Prepare specifications                                              ======

E. Construction Phase
   1. Advertise for Construction                                                ====
   2. Receive bids and award contracts                                              ===
   3. Construction                                                                      ==============================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 11.7
WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 7

Needed: Now
Location: Treated Water From BCWCID to Rising Star/Cross Plains
Capacity: 482 af/yr
Cost: $6,144,000

```
                                    #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                     J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                    ------------------------ ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)       ===============
   2. Decision to proceed                  x
   3. Deed composite mapping                                  ===
   4. Easements                                                 ========

B. Initial Engineering
   1. Decision to proceed                  x
   2. Aerial photos                         ==
   3. Preliminary design                    ========
   4. Cost estimate                               ===

C. Financial
   1. Financial evaluation                          ====
   2. Evaluation by S&P and Moody's                   ==

D. Final Engineering
   1. Issue and sell bonds                              ======
   2. Survey                                                  ======
   3. Detailed design
      a. Pipe line                                            ==============
      b. Pump station                                           ============
   4. Owner review                                                        ====
   5. Prepare specifications                                            ======

E. Construction Phase
   1. Advertise for Construction                                              ====
   2. Receive bids and award contracts                                            ===
   3. Construction                                                                    ==============================
```

Note: Negotiations with the supplying enity
could be from a few months to several years.

Figure 11.8

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 8

Needed: Now
Location: Treated Water From Coleman to Rising Star/Cross Plains
Capacity: 482 af/yr
Cost: $5,786,000

```
                                     #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                      J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                     ------------------------ ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)        ===============
   2. Decision to proceed                    x
   3. Deed composite mapping                                   ===
   4. Easements                                                  ========

B. Initial Engineering
   2. Decision to proceed                    x
   2. Aerial photos                          ==
   3. Preliminary design                     ========
   4. Cost estimate                                ===

C. Financial
   1. Financial evaluation                           ====
   2. Evaluation by S&P and Moody's                    ==

D. Final Engineering
   1. Issue and sell bonds                               ======
   2. Survey                                                   ======
   3. Detailed design
      a. Pipe line                                             ==============
      b. Pump station                                             ============
   4. Owner review                                                         ====
   5. Prepare specifications                                             ======

E. Construction Phase
   1. Advertise for Construction                                             ====
   2. Receive bids and award contracts                                           ===
   3. Construction                                                                   =============================
```

Note: Negotiations with the supplying enity
could be from a few months to several years.

Figure 11.9

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 9

Needed: Now
Location: Hubbard Creek Water For Woodson
Capacity: 67 af/yr
Cost: $1,655,000

```
                                    #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                     J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                    ------------------------ ----------------------- ----------------------- ------------------------
A. Legal
   1. Negotiations (see note)       ================
   2. Decision to proceed                   x
   3. Deed composite mapping                                  ==
   4. Easements                                                  =====

B. Initial Engineering
   1. Decision to proceed                   x
   2. Aerial photos                          ==
   3. Preliminary design                     ========
   4. Cost estimate                               ===

C. Financial
   1. Financial evaluation                          ====
   2. Evaluation by S&P and Moody's                   ==

D. Final Engineering
   1. Issue and sell bonds                              ======
   2. Survey                                                   ==
   3. Detailed design
      a. Pipe line                                            ========
      b. Pump station                                            ========
   4. Owner review                                                   ====
   5. Prepare specifications                                         =====

E. Construction Phase
   1. Advertise for Construction                                           ====
   2. Receive bids and award contracts                                         ===
   3. Construction                                                                 ================
```

Note: Negotiations with the supplying enity
could be from a few months to several years.

Figure 11.10

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 10

Needed: Now (only partial solution)
Location: Sweetwater Creek to Lake Sweetwater
Capacity: 790 af/yr
Cost: $2,865,000

```
                                    #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                     J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                    ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Decision to proceed          x
   2. Deed composite mapping                          ==
   3. Easements                                         ====

B. Initial Engineering
   1. Decision to proceed          x
   2. Aerial photos                 ==
   3. Preliminary design            ======
   4. Cost estimate                     ===
   5. Permitting                    ============

C. Financial
   1. Financial evaluation                ====
   2. Evaluation by S&P and Moody's           ==

D. Final Engineering
   1. Issue and sell bonds                      ======
   2. Survey                                          ==
   3. Detailed design
      a. Diversion structure & pipe line              =======
      b. Pump station                                   =======
   4. Owner review                                          ====
   5. Prepare specifications                                =====

E. Construction Phase
   1. Advertise for Construction                                  ====
   2. Receive bids and award contracts                                ===
   3. Construction                                                        ===================
```

Figure 11.11

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 11

Needed: Now
Location: Raw Water Line from Abilene NE WTP to Lake Sweetwater
Capacity: 4,342 af/yr
Cost: $19,445,000

```
                                      #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                       J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                      ------------------------ ------------------------ ------------------------ ------------------------
A. Legal
   1. Negotiations                    ===============
   2. Decision to proceed                    x
   3. Deed composite mapping                                    ====
   4. Easements                                                   =========

B. Initial Engineering
   1. Decision to proceed                    x
   2. Aerial photos                           ==
   3. Preliminary design                      ==========
   4. Cost estimate                                 ====

C. Financial
   1. Financial evaluation                            ====
   2. Evaluation by S&P and Moody's                     ==

D. Final Engineering
   1. Issue and sell bonds                                ======
   2. Survey                                                    ======
   3. Detailed design
      a. Pipe line                                              ==============
      b. Pump stations                                             ==========
   4. Owner review                                                         ====
   5. Prepare specifications                                             =======

E. Construction Phase
   1. Advertise for Construction                                                 ====
   2. Receive bids and award contracts                                             ===
   3. Construction                                                                     ==========================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 11.12

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 12

Needed: Now
Location: Raw Water Line from Lake Coleman to Oak Creek Res. (Sweetwater)
Capacity: 4,342 af/yr
Cost: $25,924,000

```
                                        #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                         J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                        ------------------------ ------------------------ ------------------------ ------------------------
A. Legal
   1. Negotiations (see note)           ===============
   2. Decision to proceed                      x
   3. Deed composite mapping                                      ====
   4. Easements                                                     =========

B. Initial Engineering
   1. Decision to proceed                      x
   2. Aerial photos                             ==
   2. Preliminary design3                       ===========
   4. Cost estimate                                     ===

C. Financial
   1. Financial evaluation                              ====
   2. Evaluation by S&P and Moody's                       ==

D. Final Engineering
   1. Issue and sell bonds                                  ======
   2. Survey                                                      ======
   3. Detailed design
      a. Pipe line                                                ===================
      b. Pump stations                                              ===============
   4. Owner review                                                              ====
   5. Prepare specifications                                                  =======

E. Construction Phase
   1. Advertise for Construction                                                      ====
   2. Receive bids and award contracts                                                  ===
   3. Construction                                                                          ==========================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 11.13

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 13

Needed: Now
Location: Raw Water Line from Lake Spence to Oak Creek Res. (Sweetwater)
Capacity: 4,342 af/yr
Cost: $15,390,000

```
                                    #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                     J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                    ------------------------ ------------------------ ------------------------ ------------------------
A. Legal
   1. Negotiations (see note)       ===============
   2. Decision to proceed                  x
   3. Deed composite mapping                                 ====
   4. Easements                                                 =======

B. Initial Engineering
   1. Decision to proceed                  x
   2. Aerial photos                         ==
   3. Preliminary design                    =========
   4. Cost estimate                               ===

C. Financial
   1. Financial evaluation                          ====
   2. Evaluation by S&P and Moody's                   ==

D. Final Engineering
   1. Issue and sell bonds                              ======
   2. Survey                                                  ====
   3. Detailed design
      a. Pipe line                                            ============
      b. Pump stations                                          ============
   4. Owner review                                                    ====
   5. Prepare specifications                                          =======

E. Construction Phase
   1. Advertise for Construction                                              ====
   2. Receive bids and award contracts                                          ===
   3. Construction                                                                  ============================
```

Note: Time for negotiations with the suppling entity could be from a few months to several years.

Figure 11.14

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 14

Needed: Now
Location: Raw Water Line from Lake Coleman to Cisco
Capacity: 665 af/yr
Cost: $6,741,500

```
                                    #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                     J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                    ----------------------- ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)       ================
   2. Decision to proceed                  x
   3. Deed composite mapping                                  ====
   4. Easements                                                 ========

B. Initial Engineering
   1. Decision to proceed                  x
   2. Aerial photos                         ==
   3. Preliminary design                    ==========
   4. Cost estimate                                 ===

C. Financial
   1. Financial evaluation                          ====
   2. Evaluation by S&P and Moody's                   ==

D. Final Engineering
   1. Issue and sell bonds                              ======
   2. Survey                                                  ======
   3. Detailed design
      a. Pipe line                                            ================
      b. Pump stations                                          ==============
   4. Owner review                                                        ====
   5. Prepare specifications                                              ======

E. Construction Phase
   1. Advertise for Construction                                                ====
   2. Receive bids and award contracts                                            ===
   3. Construction                                                                    =====================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 11.15

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 15

Needed: Now
Location: Raw Water Line from Lake Brownwood to Cisco
Capacity: 665 af/yr
Cost: $6,407,000

```
                                        #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                         J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                        ------------------------ ----------------------- ----------------------- -----------------------
A. Legal
   1. Negotiations (see note)           ===============
   2. Decision to proceed                      x
   3. Deed composite mapping                                      ====
   4. Easements                                                     ========

B. Initial Engineering
   1. Decision to proceed                      x
   2. Aerial photos                             ==
   3. Preliminary design                        ==========
   4. Cost estimate                                     ===

C. Financial
   1. Financial evaluation                              ====
   2. Evaluation by S&P and Moody's                       ==

D. Final Engineering
   1. Issue and sell bonds                                  ======
   2. Survey                                                      ======
   3. Detailed design
      a. Pipe line                                                ================
      b. Pump stations                                              ==============
   4. Owner review                                                            ====
   5. Prepare specifications                                                ======= 

E. Construction Phase
   1. Advertise for Construction                                                   ====
   2. Receive bids and award contracts                                                 ===
   3. Construction                                                                         ====================
```

Note: Time for negotiations with the suppling entity
could be from a few months to several years.

Figure 11.16

WEST CENTRAL TEXAS REGIONAL WATER SUPPLY STUDY
MAJOR ACTION ITEMS

System No. 16

Needed: Now
Location: From Battle Creek to Lake Cisco
Capacity: 500 af/yr
Cost: $3,676,000

```
                                    #********YEAR #1********#********YEAR #2********#********YEAR #3********#********YEAR #4********
                                     J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
                                    ------------------------ ------------------------ ------------------------ ------------------------
A. Legal
   1. Decision to proceed          x
   2. Deed composite (none needed)
   3. Easements (none needed)

B. Initial Engineering
   1. Decision to proceed          x
   2. Aerial photos (none needed)
   3. Preliminary design            ======
   4. Cost estimate                     ===

C. Financial
   1. Financial evaluation                ====
   2. Evaluation by S&P and Moody's           ==

D. Final Engineering
   1. Issue and sell bonds                      ======
   2. Survey                                          ==
   3. Detailed design
      a. Diversion structure                          ========
      b. Pump station                                   =====
   4. Owner review                                        ====
   5. Prepare specifications                              ====

E. Construction Phase
   1. Advertise for Construction                              ====
   2. Receive bids and award contracts                            ===
   3. Construction                                                    ==================
```

Each of the entities which will be performing treatment of surface water will need to review the changes in treatment regulations dictated by the 1986 Safe Drinking Water Act. The potential effects of the regulations is discussed thoroughly in Chapter 4. None of the costs that may be incurred for update of the existing facilities to meet the new regulations are included in the estimated costs of expansion listed in Chapter 10.

11.4 <u>Summary of Legal Issues</u>

One of the tasks of this report was to review legal issues as identified by West Central Municipal Water District. A list of questions were developed in conjunction with the District and these were submitted to the law office of Davidson, Troilo and Booth for responses. Appendix D in Volume III includes a letter dated July 10, 1991 which provides an opinion in three parts. The first part deals with answers to 18 legal questions which were developed in the planning effort, the second deals with general observations and recommendations, and the third deals with qualifications and assumptions.

The following is a summary of the key points from this letter. However, it should be noted that the response in Volume III should be referred to for a full and proper interpretation of the legal issues.

- Water rights are defined, and limited, to the conditions of the certificate of adjudication. The water use is also limited by existing water supply contracts.
- Title to state water in Texas belongs to the state according to

common understanding. Generally, under the usufruct doctrine, the state retains title to public or state water insofar as the molecules are concerned and the appropriator has a right to use the water in accordance with the certificate of adjudication. Water supply contracts such as those the District has with its customers provide that title passes from the supplier to the customer at a specified delivery point. This provision is designed to clarify the legal liabilities involved in operations and means that the district retains control and liability for damages, etc., up to the delivery point and then the customer assumes the control and liability.

- The District's contracts with its member cities pertaining to Hubbard Creek Reservoir each provide that the "city agrees to purchase water for its own use and for distribution to all of the customers served by the city's distribution system."
- The Stacy "O.H. Ivie Reservoir" contracts between the District and Abilene provide that all water from Stacy is for Abilene's use. There are no contractual limitations on Abilene's use of Stacy water, except that the contracts cannot be assigned to others.
- Water rights to use state water have been adjudicated and are not subject to future adjudication under the Texas Water Code. All such water rights are subject to cancellation, in whole or in part, for ten years nonuse of water or failure to construct

facilities required to be built under the particular adjudicated water right. These Water Code provisions contain certain limitations and defenses to cancellation.

- In the absence of contracts which address ownership or use of additional yield created by conjunctive or system operations of multiple reservoirs, any net increase in yield would be owned and controlled by the entity(ies) developing the system operation. The method used to finance conjunctive use facilities ordinarily will determine use of increased yields in the contracts made to secure issuance of tax or revenue bonds.
- Development of a regional water supply feasibility study and report in the planning process involves developing the technical data relating to areas of water supply demand, presently available water supplies, potential developable future water supplies and economic feasibility. Such a study also involves consideration of interlocal governmental relationships and legal constraints. Where necessary, assumptions must be made that interlocal governmental relationships can be resolved by mutual agreement. The assumptions should be made that other legal constraints can be avoided or legislation enacted to authorize development of regional water supplies, if constrained by existing laws.

11.5 Role of the West Central Texas Municipal Water District

The West Central Texas Municipal Water District (WCTMWD), which operates Hubbard Creek Reservoir and supplies raw water to its member cities of Abilene, Anson, Albany, and Breckenridge, is listed only as an indirect supplier for some of the viable water supply alternatives. This is because the entire long-term yield in Hubbard Creek Reservoir is apportioned by contract to the member cities. However several of the alternatives called for the purchase of raw water from one of the member cities. The existing contracts with the member cities preclude the sale of raw water by the receiving entity. These cities can currently only sell potable water. It has been assumed, for the purposes of this report, that the member cities of WCTMWD, if needed in order to supply a new entity with raw water, would be able to renegotiate their contracts with the WCTMWD in order that WCTMWD could supply the new entity with raw water without increasing the actual contracted amount supplied by WCTMWD.

The District could also play a major role in the development of needed supply alternatives. Their potential would include assistance in financing, development, implementation, and operation of water supply alternatives. Their assistance would be beneficial to many of the smaller entities because of their size, financial capabilities, and experience in developing and managing water resources.

In evaluating the potential role of WCTMWD, the role of the various state agencies may have strong influence. State efforts to encourage sharing present resources as completely as possible in order to delay more expensive alternatives to future years suggests that the surplus suppliers of WCTMWD member cities will be under increasing pressure to be shared with neighboring communities having water supply deficits. Additionally, a regional effort should be made to maintain realistic water costs. Water should not be priced below cost nor contracted at fixed rates for time periods beyond the sellers ability to adequately determine costs and water needs. WCTMWD, to the extent that circumstances place additional duties on the District (WCTMWD), should be aware of these cost of water concerns and seek to avoid untenable situations. In the present need situations named in the report, WCTMWD could be asked to become a contract party. Any such action should be presupported by Board action. Since a general board policy regarding water resources management has been considered, final policy action may become widely considered and bind the Board by precedent. Therefore, an initial step for the WCTMWD in the near future is to complete the future oriented policy choices developed in the water management (audit) committee. Other roles may evolve on request of member cities or cities/entities with water needs.

WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT
IN CONJUNCTION WITH THE
TEXAS WATER DEVELOPMENT BOARD

REGIONAL WATER SUPPLY PLAN

VOLUME THREE - APPENDICES

PREPARED FOR

WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT

IN CONJUNCTION WITH THE

TEXAS WATER DEVELOPMENT BOARD
AND PARTICIPATING ENTITIES

STATE OF TEXAS
M. L. NICHOLS
54600
REGISTERED PROFESSIONAL ENGINEER

FREESE AND NICHOLS, INC.
JACOB AND MARTIN, INC.
TODD ENGINEERING, INC.

STATE OF TEXAS
JOHN LEE RUTLEDGE
65045
REGISTERED PROFESSIONAL ENGINEER

12-11-91
Michael L. Nichols, P.E.

12-11-91
John Lee Rutledge, P.E.

Table of Contents

Volume Three - Appendices

APPENDIX A

WATER AUDIT SUPPLEMENT FORM

A. Population

1. Yearly Population Data

Instructions: On the left, enter the population, as determined by local government, for each of the last 20 years. On the right, enter the population, as determined by census data, for each census taken during the last 20 years (most of the lines on the right will be blank).

Year	*Local Government* Population	*Census* Population

Completed by ______________________ Date ____________

A. Population

2. Population Projections

Instructions: List the population projected by local government for the next 35 years, in 5-year increments.

Year	Projected Population

Completed by ______________________________ Date ____________

A. Population

3. Factors Contributing to Population Growth

Instructions: If your community is involved in a program to accelerate population growth, give details of the program on this form.

Year ___________

a) Advertising campaign. ______________________________________

____

____

____

b) Tax incentives. ______________________________________

____

____

____

c) Water or other utility incentives. ______________________________

____

____

____

d) Inexpensive land. ______________________________________

____

____

____

e) Other. ____

____

____

____

Completed by ______________________________ Date ____________

A. Population

4. Other Factors Influencing Population

Instructions: If there are other circumstances that might influence future population growth, describe them on this form.

Year ____________

a) Military base (expansion or reduction). ____________________________

b) Oil or minerals (new findings or depletion). ____________________________

c) Industries (new or changing). ____________________________

d) Other. ____________________________

Completed by ____________________________ Date ____________

A. Population

5. Effect of Growth Factors on Population

Instructions: List the expected increases or decreases in population related to each factor entered on the preceding two forms (I.A.3 and I.A.4). For each factor, give the rate of growth and the period for which it will occur. Be sure to indicate varying growth rates—for example, "+500/year for 1989–91, then –100/year for 1992–93."

Growth Related to General Factors (Form I.A.3)

a) ______________________________

b) ______________________________

c) ______________________________

d) ______________________________

e) ______________________________

a) ______________________________

b) ______________________________

c) ______________________________

d) ______________________________

e) ______________________________

Growth Related to Other Factors (Form I.A.4)

a) ______________________________

b) ______________________________

c) ______________________________

d) ______________________________

a) ______________________________

b) ______________________________

c) ______________________________

d) ______________________________

Completed by ______________________________ Date ______________

A. Population

6. Population Growth Map

Instructions: Obtain a map of your municipality from your engineering consultant. Locate and number areas that are now experiencing growth and areas in which growth is expected.

Completed by ______________________________ Date ____________

B. Water Use

1. Total Annual Output, as Recorded by Master Meter(s)

Instructions: Enter the total annual output (mil gal) of the water supply system, as recorded by the master meter(s), for each of the last 10 years.

Year	Output (mil gal)

Completed by ______________________ Date ____________

B. Water Use

2. Total Annual Output, as Recorded by Individual Account Meters

Instructions: Enter the total annual output (mil gal) of the water supply system, as recorded by all individual account meters, for each of the last 10 years.

Year	Output (mil gal)

Completed by ______________________ Date __________

B. Water Use

3. Monthly Output, as Recorded by Master Meter(s)

Instructions: For the last four years, enter the monthly output (mil gal), as recorded by the master meter(s).

Year ____________

January ____________
February ____________
March ____________
April ____________
May ____________
June ____________
July ____________
August ____________
September ____________
October ____________
November ____________
December ____________

Year ____________

January ____________
February ____________
March ____________
April ____________
May ____________
June ____________
July ____________
August ____________
September ____________
October ____________
November ____________
December ____________

Year ____________

January ____________
February ____________
March ____________
April ____________
May ____________
June ____________
July ____________
August ____________
September ____________
October ____________
November ____________
December ____________

Year ____________

January ____________
February ____________
March ____________
April ____________
May ____________
June ____________
July ____________
August ____________
September ____________
October ____________
November ____________
December ____________

Completed by ______________________ Date ____________

B. Water Use

4. Daily Output, as Recorded by Master Meter(s)

Instructions: Enter the daily output (gal) of the water system, as recorded by the master meter(s), for a recent four-week period.

	Date	Output (gal)
Monday	____/____/____	________
Tuesday	____/____/____	________
Wednesday	____/____/____	________
Thursday	____/____/____	________
Friday	____/____/____	________
Saturday	____/____/____	________
Sunday	____/____/____	________
Monday	____/____/____	________
Tuesday	____/____/____	________
Wednesday	____/____/____	________
Thursday	____/____/____	________
Friday	____/____/____	________
Saturday	____/____/____	________
Sunday	____/____/____	________
Monday	____/____/____	________
Tuesday	____/____/____	________
Wednesday	____/____/____	________
Thursday	____/____/____	________
Friday	____/____/____	________
Saturday	____/____/____	________
Sunday	____/____/____	________
Monday	____/____/____	________
Tuesday	____/____/____	________
Wednesday	____/____/____	________
Thursday	____/____/____	________
Friday	____/____/____	________
Saturday	____/____/____	________
Sunday	____/____/____	________

Completed by ______________________ Date __________

B. Water Use

5. Hourly Consumption, as Recorded by Master Meter(s)

Instructions: Enter the hourly consumption (gal), as recorded by the master meter(s), for a recent seven-day period.

Week Starting ____/____/____

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
12–1 a.m.							
1–2 a.m.							
2–3 a.m.							
3–4 a.m.							
4–5 a.m.							
5–6 a.m.							
6–7 a.m.							
7–8 a.m.							
8–9 a.m.							
9–10 a.m.							
10–11 a.m.							
11–12 noon							
12–1 p.m.							
1–2 p.m.							
2–3 p.m.							
3–4 p.m.							
4–5 p.m.							
5–6 p.m.							
6–7 p.m.							
7–8 p.m.							
8–9 p.m.							
9–10 p.m.							
10–11 p.m.							
11–12 mid.							

Completed by ______________________________ Date ____________

B. Water Use

6. Average Daily Per Capita Use, by Year

Instructions: Enter the average daily per capita use (gpcd) for each of the past 10 years. To calculate per capita use, divide total system output (Form I.B.1) by population for that year (Form I.A.1), then divide by 365.

Year	Per Capita Use (gpcd)
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______

Completed by ______________________ Date __________

B. Water Use

7. Average Daily Per Capita Use, by Month

Instructions: Enter the average daily per capita use (gpcd) for each month for the last four years. To calculate per capita use for each month, divide the total system output for each month (Form I.B.3) by the population for that year (Form I.A.1), then divide by the number of days in the month.

Year ____________

January ________________
February ________________
March ________________
April ________________
May ________________
June ________________
July ________________
August ________________
September ________________
October ________________
November ________________
December ________________

Year ____________

January ________________
February ________________
March ________________
April ________________
May ________________
June ________________
July ________________
August ________________
September ________________
October ________________
November ________________
December ________________

Year ____________

January ________________
February ________________
March ________________
April ________________
May ________________
June ________________
July ________________
August ________________
September ________________
October ________________
November ________________
December ________________

Year ____________

January ________________
February ________________
March ________________
April ________________
May ________________
June ________________
July ________________
August ________________
September ________________
October ________________
November ________________
December ________________

Completed by ________________________________ Date ____________

B. Water Use

8. Per Capita Use Projections

Instructions: Enter the per capita use (gpcd) projections, if available from your consultant or a governmental agency.

Year	Projected Per Capita Use (gpcd)
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________

Sources of projections: ______________________________

____

____

Completed by ____ Date ________________

B. Water Use

9. Total Water Use Projections

Instructions: Enter the total water use projections (gpd), if available from your consultant or a governmental agency.

Year	Projected Total Water Use (gpd)
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________
____________	________________________

Sources of projections: ____________________________

____

____

Completed by ____________________________ Date ______________

B. Water Use

10. Maximum Daily Demand

Instructions: Enter the maximum daily demand (gpd) for each of the last 10 years.

Year	Demand (gpd)
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________
________	________

Completed by ______________________ Date ____________

B. Water Use

11. Average Daily Demand

Instructions: Enter the average daily demand (gpd) for each of the last 10 years. To calculate average daily demand, divide total system output (Form I.B.1) by 365.

Year	Demand (gpd)
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______

Completed by ______________________ Date ____________

B. Water Use

12. Peaking Factor

Instructions: Enter the peaking factor for each of the last 10 years. To calculate peaking factor, divide the maximum daily demand (Form I.B.10) by the average daily demand (Form I.B.11) for each year.

Year	Peaking Factor
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______
______	______

Completed by ____________________ Date __________

C. Water Production

1. Surface-Water Supplies

Instructions: Enter the information requested for each water source, except groundwater wells and springs.

Name of source ______________________

a) Volume of water provided for each of the last 10 years.

Year	Volume (gpm)

b) Upper limits on the yearly supply, if known. ______________________

____

c) Cost of producing or buying the water ($/1000 gal). ______________________

____

d) Length of time the supply is expected to remain available. ______________________

____

e) Expected changes in volume to be available. ______________________

____

Completed by ______________________ Date ______________________

C. Water Production

2. Groundwater Supplies

Instructions: Enter the information requested for each producing well or spring.

Well / spring location and / or identifying number ____________________

____

____

a) Year when put into production. ____________________

____

b) Average daily output (gpm). ____________________

____

c) Maximum daily output (gpm). ____________________

____

d) Cost of producing the water ($/1000 gal). ____________________

____

e) Cost of putting the well into production. ____________________

____

f) Years the well is expected to remain productive. ____________________

____

g) Changes in the amount of water produced. ____________________

____

Completed by ____________________ Date ____________________

C. Water Production

3. Untapped Water Sources

Instructions: If your community has rights to any untapped water sources, enter the information requested for each source.

Name of source ______________________________

____

____

a) Average amount of water that could be brought on line (gpm). ______

____

b) Years the source will be available. ______________________________

____

c) Time required to bring the supply on line. ______________________________

____

d) Cost of producing the water ($/1000 gal). ______________________________

____

Completed by ______________________________ Date ______________

C. Water Production

4. Projected Water Supply

Instructions: Create a graph showing projected water supply. Refer to the graphing example in Appendix A.

Completed by ______________________________ Date ____________

C. Water Production

5. Demand Greater Than Supply

Instructions: Plot the projected demand from Form I.B.9, if available, on the graph created for Form I.C.4. List any years when the demand will be greater than the supply and by how much.

Year	Amount of Deficit

Completed by ______________________ Date __________

C. Water Production

6. Maximum Daily Output

Instructions: Enter the maximum daily output (gpd) your water system has been capable of producing for the last 10 years. As additional sources and/or pumps are added to the system, record the new capacity.

Year	Output (gpd)
____________	__________________
____________	__________________
____________	__________________
____________	__________________
____________	__________________
____________	__________________
____________	__________________
____________	__________________
____________	__________________
____________	__________________
____________	__________________
____________	__________________
____________	__________________

Completed by ______________________________________ Date _______________

D. Distribution System

1. Distribution System Map

Instructions: On a map from your engineering firm, identify the location of each size of pipe in the distribution system by using a different colored highlighter for each size. Note the ages of pipes in different areas of the community, as well as the pipe materials. Also note areas where the streets have settled, which could lead to the cracking of water mains.

Completed by ______________________________ Date ____________

D. Distribution System

2. Pumps

Instructions: Enter the information requested for each pump in your system. Attach a copy of the pump curve, if available. Fill out a separate work sheet for each pump at each pump station.

Pump station: address and general location. ______________________

____

____

Pump information.

a) Size and type. ______________________________

b) Manufacturer and address. ______________________

____

____

c) Horsepower. ______________________________

d) Rated capacity. ______________________________

e) Model number. ______________________________

f) Serial number. ______________________________

g) Year of purchase. ______________________________

h) Normal schedule of use. ______________________

____

____

Completed by ______________________ Date ____________

D. Distribution System

3. Storage Tanks

Instructions: Enter the information requested for each storage tank in your system.

Type of tank: Ground ______ Elevated ______

a) Location. ____

____

____

b) Trends in water demands in the area. ______________________

____

____

c) Capacity. ____

d) Elevation of tank. Top ________ Bottom ________

e) Manufacturer and address. __________________________

____

____

f) Model number. ____

g) Serial number. ____

h) Year of purchase. ______________________________________

Completed by ______________________________ Date ____________

D. Distribution System

4. Mains Connecting Pumping Stations

Instructions: Draw a simple map showing pumping stations and the mains that interconnect them. Indicate the size of each main.

Completed by ______________________ Date __________

D. Distribution System

5. Valve Inspection Schedule

Instructions: If valves are inspected periodically to ensure that they work properly, enter the information requested.

a) How often are valves checked? ______________________________

____

____

b) Date valves last checked. ______________________________

____

____

c) Who has the authority to adjust valves? ______________________________

____

____

Completed by ______________________________ Date ______________

D. Distribution System

6. Areas of Growth

Instructions: Enter the information requested for each area of growth or expected growth, as determined in Form I.A.6.

Location and/or Name of Area	Size of Mains Leading to Area	Number of Mains
____________	________	________
	________	________
	________	________
	________	________
	________	________
____________	________	________
	________	________
	________	________
	________	________
	________	________
____________	________	________
	________	________
	________	________
	________	________
	________	________
____________	________	________
	________	________
	________	________
	________	________
	________	________

Completed by ______________________ Date ____________

E. Distribution Sectors and User Class Demands

1. Distribution Sectors

Instructions: Divide the community into sectors. The community may be divided according to the area that is included in one meter book or several small meter books. Neighborhoods or subdivisions may also be considered as sectors. Enter the demand (mil gal) for each sector for the last four years.

	Year ______	*Year* ______	*Year* ______	*Year* ______
Sector Location	Demand (mil gal)			
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______

Completed by ______________________ Date __________

E. Distribution Sectors and User Class Demands

2. User Class Demands

Instructions: Enter the demand (mil gal) for each user class for the last four years. Include percent of total demand created by each user class.

	Year ______	*Year* ______	*Year* ______	*Year* ______
User Class	Demand (mil gal), %			
Residential	______,___	______,___	______,___	______,___
Commercial	______,___	______,___	______,___	______,___
Industrial	______,___	______,___	______,___	______,___
Parks, etc.	______,___	______,___	______,___	______,___
City buildings	______,___	______,___	______,___	______,___
Nonpaying	______,___	______,___	______,___	______,___
Other	______,___	______,___	______,___	______,___

Completed by ______________________________ Date ______________

F. Leakage Data

1. Unaccounted-for Water

Instructions: Find the percentage of unaccounted-for water in your system. To calculate unaccounted-for water, divide total individual meter readings (Form I.B.2) by the total of the master meter readings (Form I.B.1), then multiply by 100. Information should be for the last four years.

Year	%
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________
____________	____________

Completed by ______________________________ Date ____________

F. Leakage Data

2. Water in Streets/Alleys

Instructions: Enter information concerning reports of water in streets or alleys that is not runoff from outdoor uses.

Possible Leak No. 1

a) Location. ______________________

b) Frequency. ______________________

c) Volume of water visible. ______________________

d) Time most likely to occur. ______________________

Possible Leak No. 2

a) Location. ______________________

b) Frequency. ______________________

c) Volume of water visible. ______________________

d) Time most likely to occur. ______________________

Possible Leak No. 3

a) Location. ______________________

b) Frequency. ______________________

c) Volume of water visible. ______________________

d) Time most likely to occur. ______________________

Possible Leak No. 4

a) Location. ______________________

b) Frequency. ______________________

c) Volume of water visible. ______________________

d) Time most likely to occur. ______________________

Completed by ______________________ Date __________

F. Leakage Data

3. Low Pressure

Instructions: Enter information concerning reports of low pressure within your system.

Low Pressure Report No. 1

a) Location. ______________________________

b) Frequency. ______________________________

c) Pressure reading. ______________________________

d) Time most likely to occur. ______________________________

Low Pressure Report No. 2

a) Location. ______________________________

b) Frequency. ______________________________

c) Pressure reading. ______________________________

d) Time most likely to occur. ______________________________

Low Pressure Report No. 3

a) Location. ______________________________

b) Frequency. ______________________________

c) Pressure reading. ______________________________

d) Time most likely to occur. ______________________________

Low Pressure Report No. 4

a) Location. ______________________________

b) Frequency. ______________________________

c) Pressure reading. ______________________________

d) Time most likely to occur. ______________________________

Completed by ______________________________ Date ______________

F. Leakage Data

4. Locations of Water in Streets/Alleys and Low Pressure

Instructions: Enter locations where there have been reports of both water in the streets/ alleys and low pressure (see Forms I.F.2 and I.F.3).

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

6. ____________________

7. ____________________

8. ____________________

9. ____________________

10. ____________________

Completed by ____________________ Date __________

F. Leakage Data

5. Inaccurate Meters

Instructions: Enter the information requested regarding any meter inaccuracies in your system.

a) Do meter readers make note of meters that record unusually small changes or that have stopped completely? ____________________

____

b) If billing is computerized, is there a check system for unusually small bills? ____

____

c) Are the meters that record small changes checked for accuracy and/or replaced? ____

____

d) If meters are not operating properly, are customers billed differently?

____

____

Completed by ______________________________ Date ______________

G. Fire Protection

1. Total Capacity of Ground Storage

Instructions: Enter total capacity of ground storage (mil gal) for the past 10 years.

Year	Capacity (mil gal)

Completed by ______________________ Date ____________

G. Fire Protection

2. Total Capacity of Elevated Storage

Instructions: Enter total capacity of elevated storage (mil gal) for the past 10 years.

Year	Capacity (mil gal)

Completed by ______________________ Date ____________

G. Fire Protection

3. Length and Size of Residential Distribution Mains

Instructions: Enter the information requested for each size of residential distribution main listed. If pipe exists for which a size is not listed, develop your own work sheet.

District	Total Length of Pipe Smaller Than 2 in.	Size of Pipe Connected to
______	______	______
______	______	______
______	______	______

District	Total Length of 2-in. Pipe	Size of Pipe Connected to
______	______	______
______	______	______
______	______	______

District	Total Length of 3-in. Pipe	Size of Pipe Connected to
______	______	______
______	______	______
______	______	______

District	Total Length of 4-in. Pipe	Size of Pipe Connected to
______	______	______
______	______	______
______	______	______

Completed by ______________________ Date __________

G. Fire Protection

4. Length and Size of Commercial Distribution Mains

Instructions: Enter the information requested for each size of commercial distribution main listed. If pipe exists for which a size is not listed, develop your own work sheet.

District	Total Length of Pipe Smaller Than 2 in.	Size of Pipe Connected to
______	______	______
______	______	______

District	Total Length of 2-in. Pipe	Size of Pipe Connected to
______	______	______
______	______	______

District	Total Length of 3-in. Pipe	Size of Pipe Connected to
______	______	______
______	______	______

District	Total Length of 4-in. Pipe	Size of Pipe Connected to
______	______	______
______	______	______

District	Total Length of 6-in. Pipe	Size of Pipe Connected to
______	______	______
______	______	______

Completed by ______________________ Date ____________

G. Fire Protection

5. Pressure Readings

Instructions: Record pressure readings (psi) from fire hydrants throughout the distribution system. Take the readings at times of heavy water usage.

Location	Date	Time of Day	Pressure (psi)

Completed by ______________________ Date ____________

G. Fire Protection

6. System Capacity

Instructions: Enter the flow rate (gpm) the system is capable of supplying to the customer classes listed. Also include the length of time the system can provide this flow rate.

Heavy Business and Industry

Location	Flow Rate (gpm)	Duration
________	________	________
________	________	________
________	________	________

Light Business and Industry

Location	Flow Rate (gpm)	Duration
________	________	________
________	________	________
________	________	________

Congested Residential

Location	Flow Rate (gpm)	Duration
________	________	________
________	________	________
________	________	________

Scattered Residential

Location	Flow Rate (gpm)	Duration
________	________	________
________	________	________
________	________	________

Completed by ______________________________ Date ____________

H. System Management

1. Water Rates

Instructions: Enter the rates charged ($/1000 gal) to the customer classes listed.

	Rate Charged ($/1000 gal)
Residential	____________
	____________
	____________
Commercial	____________
	____________
	____________
Industrial	____________
	____________
	____________
Other (specify)	____________
	____________
	____________

Completed by ______________________ Date ____________

H. System Management

2. Water Pricing Policies

Instructions: Discuss present water pricing policies.

a) Factors involved when water rates were established. ________________

b) Changes in these factors since the water rates were established.

Completed by ______________________ Date __________

H. System Management

3. Revenue Policies

Instructions: Discuss present revenue policies.

Date when revenue policies were established. ____________________

a) Was your water system set up to have its revenue supplemented by other departments, to be self-supporting, or to support other departments? ____________________

b) Factors involved in establishing revenue policies. ____________________

____

____

____

____

____

____

c) Operation of present revenue program. ____________________

____

____

____

____

____

____

Completed by ____________________ Date ____________

H. System Management

4. Water System Revenues

Instructions: Enter water system revenues collected for the past 10 years (calendar or fiscal).

Year	Revenues
____________	____________________
____________	____________________
____________	____________________
____________	____________________
____________	____________________
____________	____________________
____________	____________________
____________	____________________
____________	____________________
____________	____________________
____________	____________________
____________	____________________
____________	____________________
____________	____________________

Completed by ________________________________ Date ____________

H. System Management

5. Capital Funds

Instructions: Enter information regarding any funds that have been established to cover expenses for system renovation or expansion, or to obtain new supplies. Discuss how the money is obtained. Include information for the last five years.

a) How is money obtained for the fund? ______________________

____

____

____

____

____

b)

Year	$ Added	$ Spent	Year-End Balance

Completed by ______________________ Date __________

H. System Management

6. Financing Capital Expenses

Instructions: If your system has no special fund established to cover expenses for system renovation or expansion, or to obtain new supplies, discuss how system expenses are financed.

a) How are system expenses financed? ______________________________

____

____

____

____

____

____

____

____

____

____

Completed by ______________________________ Date ______________

H. System Management

7. Operating Costs

Instructions: Discuss the costs of operating your water supply system on a yearly basis only. Give costs for the last calendar or fiscal year.

Year ____________________

a) Total cost. ____________________

b) Cost of buying water. ____________________

c) Cost of power for groundwater wells. ____________________

d) Cost of electricity for water treatment. ____________________

e) Cost of chemicals for water treatment. ____________________

f) Cost for personnel (wages and benefits). ____________________

g) Cost of equipment (purchased and/or leased). ____________________

h) Cost of maintenance. ____________________

i) Cost of power for pump stations. ____________________

j) Cost of repaying loans. ____________________

k) Other. ____________________

____

____

Completed by ____________________ Date ____________________

H. System Management

8. Personnel

Instructions: Enter the information requested for each employee working for the water department.

Name ______________________________

a) Date hired. ______________________________

b) Position/duties. ______________________________

____

____

c) Training received and the date(s) of training. ______________

____

____

d) Certification received and the date(s) of certification. __________

____

____

e) Percent of time with water department. ______________

f) Percent of time with sewer department. ______________

g) Percent of time with maintenance department (if separate department exists). ______________________________

Completed by ______________________ Date ____________

H. System Management

9. Certification and Training

Instructions: For each position within the water department, discuss the certification and training that is required.

Position ______________________________

a) Certification. ______________________________

____

____

____

b) Training. ______________________________

____

____

____

Position ______________________________

a) Certification. ______________________________

____

____

____

b) Training. ______________________________

____

____

____

Completed by ______________________________ Date ______________

H. System Management

10. Equipment

Instructions: Enter the information requested for each piece of equipment owned by the water department.

Equipment ______________________________

a) Date of purchase. ______________________________

b) Manufacturer and address. ______________________________

____

c) Model number. ______________________________

d) Serial number. ______________________________

e) Percent of time used by water department (if equipment is used by other departments). ______________________________

f) Percent of time used by other departments (if equipment is shared with other departments). List the department. ______________________________

____

Completed by ______________________________ Date ______________

H. System Management

11. Inspection and Maintenance

Instructions: Enter the inspection schedule and maintenance schedule for the items listed.

	Inspection	Maintenance
Master meters	________	________
Customer meters	________	________
Valves	________	________
Fire hydrants	________	________
Groundwater well pumps	________	________
Pump station pumps	________	________
Water mains	________	________
Vehicles	________	________
Construction/maintenance equipment	________	________
Treatment facility	________	________
Other	________	________

Completed by ______________________ Date ____________

H. System Management

12. Repair and Maintenance History

Instructions: For each item listed on Form I.H.11, enter the item repaired or maintained, the date of repair or maintenance work, and the task performed. Record information for the last five years. Complete this form only for equipment that is not shared with the water department.

Item ______________________________

Date	Task Performed
____________	______________________________________
	______________________________________
____________	______________________________________
	______________________________________
____________	______________________________________
	______________________________________
____________	______________________________________
	______________________________________
____________	______________________________________
	______________________________________
____________	______________________________________
	______________________________________

Completed by ______________________________ Date ____________

I. Laws

1. Local Ordinances

Instructions: Describe any local ordinances controlling water use and/or water supply. Include the components of each ordinance. You may wish to include copies of the ordinances with the completed work sheet.

Ordinance ______________________________

____

____

____

a) How is the ordinance enforced? ______________________________

____

____

____

b) Who enforces the ordinance? ______________________________

____

____

____

c) What are the penalties for noncompliance? ______________________________

____

____

____

Completed by ______________________________ Date ______________

I. Laws

2. State Laws

Instructions: Describe any state laws controlling water supply or water use. A state agency should be able to provide this information. Include the components of each law. You may wish to include copies of the state laws with the completed work sheet.

State law ______________________________

____

____

____

a) How is the law enforced? ______________________________

____

____

____

b) Who enforces the law? ______________________________

____

____

____

c) What are the penalties for noncompliance? ______________________________

____

____

____

Completed by ______________________________ Date ______________

I. Laws

3. Federal Laws

Instructions: Describe any federal laws controlling water supply or water use. A state agency should be able to provide this information. Include the components of each law. You may wish to include copies of the federal laws with the completed work sheet.

Federal law ______________________________

a) How is the law enforced? ______________________________

b) Who enforces the law? ______________________________

c) What are the penalties for noncompliance? ______________________________

Completed by ______________________________ Date ______________

J. Water Treatment and Water Quality Analysis

1. Treatment Processes

Instructions: For each water source, describe the treatment processes used and enter the information requested. Use a separate copy of the work sheet for each treatment process.

Source ______________________________

Party responsible for treatment. ______________________________

Treatment process used. ______________________________

____

____

a) Number of units. ______________________________

b) Capacity. ______________________________

c) Manufacturer and address. ______________________________

____

d) Model number. ______________________________

e) Serial numbers. ______________________________

f) Year of purchase. ______________________________

g) Describe unit if it was built in place. ______________________________

____

____

Completed by ______________________________ Date ______________

J. Water Treatment and Water Quality Analysis

2. Water Quality

Instructions: List the water quality parameters that are analyzed in your system and the frequency of analysis. For the last three samplings, include the date of analysis and the value for each parameter. You may wish to include copies of the current water quality analyses with the completed data sheet.

a) Who performs the analysis? ______________________________

b)

Parameter	Frequency	Date	Value
__________	__________	________	________
		________	________
		________	________
__________	__________	________	________
		________	________
		________	________
__________	__________	________	________
		________	________
		________	________
__________	__________	________	________
		________	________
		________	________
__________	__________	________	________
		________	________
		________	________
__________	__________	________	________
		________	________
		________	________

Completed by ______________________________ Date ____________

J. Water Treatment and Water Quality Analysis

3. Meeting Water Quality Regulations

Instructions: If your system is not in compliance with the current requirements of the Safe Drinking Water Act and the 1986 amendments to the act, describe compliance problems.

a) Describe the parameter that is not in compliance, include the concentration for that parameter.

Parameter	Concentration
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________

b) Describe public notification procedures. ____________________

____

____

____

____

____

Completed by ________________________ Date __________

J. Water Treatment and Water Quality Analysis

4. Water Treatment Plant Manual

Instructions: If your system has a manual of water treatment plant operations, describe how that manual is used.

a) Are plant operators familiar with the manual and its use? __________

____

____

____

____

____

____

____

____

b) How do operators use the manual in plant operations? __________

____

____

____

____

____

____

____

____

Completed by ______________________ Date __________

K. Emergencies

1. Water Emergencies

Instructions: Discuss your system's plans for dealing with a water emergency. Define what conditions constitute a water emergency and the various stages of that emergency. For each stage of an emergency, enter the information requested.

Condition constituting an emergency. ____________________

____

____

Stage of emergency. ____________________

____

____

a) Goals. ____________________

____

____

b) Actions to be taken. ____________________

____

____

c) Penalties for noncompliance. ____________________

____

____

Completed by ____________________ Date ____________

K. Emergencies

2. High Groundwater Level

Instructions: Discuss any problems experienced with a high groundwater level (at or near the level of basements or foundations) in your community.

a) Location — Depth to Water Level From Surface (ft)

Location	Depth to Water Level From Surface (ft)

b) What is being done to cope with the problem of high groundwater levels? ______________________________

____

____

____

____

____

____

____

____

Completed by ______________________________ Date ______________

K. Emergencies

3. Rising Groundwater Level

Instructions: Discuss any problems experienced with a rising groundwater level (may or may not be near the level of basements or foundations) in your community.

a)

Year	Location	Depth to Water From Surface (ft)
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______

b) What is being done to slow or stop the rise in water level? ______

______

______

______

______

______

______

______

______

Completed by ______ Date ______

APPENDIX B

REVIEW OF EXISTING REPORTS AND STUDIES

SUMMARY OF SUBJECTS ADDRESSED
1929 to 1991

DATE	REPORT TITLE	COST EST.	DISTRI-BUTION	WATER RATES	WW REUSE	WATER SOURCE EXIST.	WATER SOURCE FUTURE	WATER SUPPLY EXIST.	WATER SUPPLY FUTURE	WATER USE EXIST.	WATER USE FUTURE	WATER QUALITY	POPULA-TION HIST.	POPULA-TION FUTURE	WATER TREAT. EXIST.	WATER TREAT. FUTURE	OTHER
5/11/29	Water Supply Report	X				X	X			X	X	X	X	X			
6/12/46	A Dam and Storage Reservoir	X	X			X	X	X	X	X	X	X				X	
1/1/47	Water Supply Report	X				X	X	X	X	X	X	X	X		X		
1/2/47	Baird, Texas - Water Supply	X				X	X	X	X	X	X	X	X			X	
1/1/48	Water Supply Report		X			X	X			X	X	X	X	X	X	X	
1/1/49	Additional Water Supply for Abilene Texas	X				X	X			X	X			X			
1/1/51	Yield of Proposed Lake on the Leon River						X										
1/1/52	Water Supply Report	X		X		X	X		X	X	X		X			X	
5/22/59	Brackish Water Demineralization Plant	X				X	X					X		X			X
9/1/59	Feasibility Report on Lytle Lake Used As Terminal Storage	X						X	X								
1/1/60	Water Distribution System - Study and Report	X	X			X					X				X		
1/2/60	Terminal Storage Facilities for Raw Water, Supplemental	X							X		X					X	
5/1/61	Water Distribution System Study		X			X	X				X		X	X	X	X	
3/2/62	Water Reclamation Plant & Irrigation Farm	X			X							X	X	X			X
6/1/62	Report on Chloride Routing Studies											X					

SUMMARY OF SUBJECTS ADDRESSED
1929 to 1991

DATE	REPORT TITLE	COST EST.	DISTRI-BUTION	WATER RATES	WW REUSE	WATER SOURCE EXIST.	WATER SOURCE FUTURE	WATER SUPPLY EXIST.	WATER SUPPLY FUTURE	WATER USE EXIST.	WATER USE FUTURE	WATER QUALITY	POPULA-TION HIST.	POPULA-TION FUTURE	WATER TREAT. EXIST.	WATER TREAT. FUTURE	OTHER
7/12/62	Hamlin City Plan					X				X	X		X	X			X
7/1/63	Water System Study		X			X				X	X				X	X	
12/1/66	Long Range Water Supply Study					X	X			X	X			X			
1/1/69	Comprehensive City Plan		X										X	X			
2/24/70	2020 Comprehensive Regional Plan, Water Quality											X					
2/25/70	2020 Comprehensive Regional Plan, Water Quality											X					
3/27/70	2020 Comprehensive Plan, Technical Appendix					X								X			X
11/1/70	Rural Comprehensive Plan					X	X				X		X	X			
12/1/71	Service Spillway Operating System																X
9/1/73	Water Supply Facility					X		X	X	X	X	X	X	X	X	X	
1/1/76	Report on Lake Fort Phantom Hill Yield					X	X										
1/1/77	Lake Abilene Spillway Adequacy and Reservoir Yield	X				X											X
3/1/77	Comprehensive Plan 1976-2000, Moran, Texas		X			X		X	X	X	X		X	X	X	X	
1/1/78	Reconnaissance Study of Diversion of California Creek	X				X	X					X					
12/15/78	Municipal Water System Analysis	X	X			X		X	X	X	X	X	X	X	X	X	

SUMMARY OF SUBJECTS ADDRESSED
1929 to 1991

DATE	REPORT TITLE	COST EST.	DISTRI-BUTION	WATER RATES	WW REUSE	WATER SOURCE EXIST.	WATER SOURCE FUTURE	WATER SUPPLY EXIST.	WATER SUPPLY FUTURE	WATER USE EXIST.	WATER USE FUTURE	WATER QUALITY	POPULA-TION HIST.	POPULA-TION FUTURE	WATER TREAT. EXIST.	WATER TREAT. FUTURE	OTHER
9/1/79	Long Range Water Study	X				X	X	X	X	X	X		X	X			
1/1/80	Coordinated Operation of Existing Raw Water Supply Sources					X		X	X								
4/28/80	Water Facilities Study	X	X	X		X		X		X	X		X	X	X	X	
10/1/80	Water Treatment Design Report	X						X	X	X	X		X	X	X	X	
10/2/80	Study of Long Range Water Supply	X				X	X		X	X	X	X	X	X			
12/1/80	Comprehensive Plan Report					X	X				X			X			
4/1/81	Water System Study, Moran, Texas	X	X			X		X							X		
6/1/81	Water Works Improvements	X	X	X		X	X	X					X	X	X		
7/1/81	Water Distribution System Study		X							X	X		X	X			X
6/1/82	Water and Sewer Rate Study			X						X	X		X	X			
12/9/82	Lake Fort Phantom Hill, Raw Water Delivery System	X						X	X	X			X	X			
8/1/83	Water Supply Alternatives					X	X		X	X	X	X					
12/1/83	Comprehensive Plan Report	X	X			X	X	X	X		X			X			
12/2/83	Water Supply Yield of Lake Colorado City and Champion Creek					X											
12/3/83	Evaluation of Water Quality in E.V. Spence Reservoir	X										X					

SUMMARY OF SUBJECTS ADDRESSED
1929 to 1991

DATE	REPORT TITLE	COST EST.	DISTRI-BUTION	WATER RATES	WW REUSE	WATER SOURCE EXIST.	WATER SOURCE FUTURE	WATER SUPPLY EXIST.	WATER SUPPLY FUTURE	WATER USE EXIST.	WATER USE FUTURE	WATER QUALITY	POPULA-TION HIST.	POPULA-TION FUTURE	WATER TREAT. EXIST.	WATER TREAT. FUTURE	OTHER
10/1/84	Use of Brackish Water and Reclaimed Wastewater	X			X		X				X	X					
11/20/84	Study of Water Transmission Facilities	X						X									
12/1/84	Cholride Control Program on the Clear Fork of the Brazos	X										X					
1/1/85	Land Use Study - Water System Study	X	X			X	X		X	X	X			X			
10/10/85	Water Supply from Stacy Reservoir					X	X		X	X	X		X	X			
1/1/86	Water System Study, Moran, Texas	X	X			X	X			X	X		X	X	X	X	
2/1/86	Water Distribution System, Water Treatment, and Water Supply	X	X			X	X	X	X				X	X	X	X	
5/31/87	Wastewater Collection System Analysis	X											X	X			
10/2/87	Groundwater Conditions in the Vicinity of Champion						X					X					
12/30/87	Wastewater Treatment Plant Evaluation	X										X					
3/1/88	Analysis of Alternate Wastewater Effluent Limits											X					
5/1/88	Water Reclamation Research Project, Summary Report	X			X		X					X					
5/2/88	Water Reclamation Research Project, Technical Memoranda				X							X	X	X			

SUMMARY OF SUBJECTS ADDRESSED
1929 to 1991

DATE	REPORT TITLE	COST EST.	DISTRI- BUTION	WATER RATES	WW REUSE	WATER SOURCE EXIST.	WATER SOURCE FUTURE	WATER SUPPLY EXIST.	WATER SUPPLY FUTURE	WATER USE EXIST.	WATER USE FUTURE	WATER QUALITY	POPULA- TION HIST.	POPULA- TION FUTURE	WATER TREAT. EXIST.	WATER TREAT. FUTURE	OTHER
7/26/88	Champion Well Field, Collection and Transmission Study	X				X	X		X	X	X	X		X			
2/7/89	Economy of System Operation					X		X		X	X						X
12/1/89	Water Management Plan					X		X		X		X					
5/1/91	Alternative Water Supply Facilities	X	X			X	X	X	X	X	X			X	X	X	

SUMMARY OF ABSTRACTS
1929 TO 1991

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
5/11/29	Sweetwater, Texas	Water Supply Report	This report provides an analysis of the City of Sweetwater's existing water supplies as of 1929. The existing sources consist of surface water from Lake Trammell and groundwater from a well field located near Roscoe, Texas. The report also provides alternatives to supply the water needs through the year 1940. The alternatives considered include the following: Construction of a new surface water source located at the Linn-Cottonwood or the Bitter Creek site. The Bitter Creek Site was ultimately recommended. In addition, the report identified 4 potential water sources which include: a reservior on Robertson Creek, Eagle Creek, Oak Creek, and/or the Lower Sweetwater Creek.
6/12/46	Baird, Texas	A Dam and Storage Reservoir	This report recommends the construction of a reservoir, pipeline, and treatment facilities to meet the current and anticipated water needs for the City of Baird. The proposed reservoir will be located approx. 1.5 mi SE of the City on Mexia Creek. The estimated yield of the Lake was determined at 500,000 gpd while treatment facility is recommended to have a capacity of 450,000 gpd.
1/1/47	Stamford, Texas	Water Supply Report	This report investigates the potential water sources for the City of Stamford. All possible sites within a feasible distance from City were analyzed and include the following (1) Clear Fork, (2) groundwater near the City of Haskell, (3) Fort Phantom Hill Reservoir, (4) California Creek, (5) Paint Creek, (6) Deadman Creek, and (7) Cottonwood Creek. The Clear Fork and Cottonwood sites were eliminated due to their water quality. The other sites were evaluated based on their yields. After consideration of several factors, the Deadman Creek site was selected. The cost of completing the project, which consists of the reservoir, supply line, and enlarging the treatment plant, is est. as $603,400. The proposed system would provide 2.5 MGD capacity which meets the anticipated needs of Stamford.
1/2/47	Baird, Texas	Baird, Texas - Water Supply	This report summarizes the need for an additional water supply for the City of Baird. The report recommends solutions to meet the anticipated water needs through the year 1977. Three potential reservoir sites are investigated and include the following: (1) Pecan Bayou, (2) Hubbard Creek tributary, and (3) Mexia Creek. The site recommended is the Mexia Creek Reservoir. This site is selected on the basis of its potential water quality, reservoir characteristics, and the physical site itself. The yield of the reservoir is estimated as 0.32 MGD for the critical drought period and 0.50 MGD under normal circumstances. The water quality for the site is briefly discussed in section 4 of the report. The cost of the structure is given as $180,670 (1947 dollars). In addition, it is recommended to construct 0.48 MGD filter plant and the main supply line with an appropriate pump station at a cost of $54,700 and $36,850, respectively.

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
1/1/48	Sweetwater, Texas	Water Supply Report	This report summarizes and recommends the construction of additional surface water supplies for the City of Sweetwater. Included in the analysis is the evaluation of the existing population, water use, and available water resources as of 1948. The report identifies 10 possible sites located within a 30 mile radius of the City. These sites includes: Bitter Creek, Lower Sweetwater Creek, Middle Sweetwater Creek, Upper Sweetwater Creek, 2nd Lower Sweetwater Creek, Cottonwood-Linn, Kildugan, Champion, and Oak Creek. All of these were new sites with the exception of Bitter Creek where the project was to raise the existing dam. The report recommends the City develop the Middle Sweetwater Creek Site with a corresponding increase in the water supply by 2.8 mgd during droughts and 5.7 mgd during normal conditions. The cost in 1947 dollars was estimated at $1,203,600. Improvements to the filter plant, pump station, and some work on the distribution system was also recommended.
1/1/49	Abilene, Texas	Additional Water Supply for Abilene Texas	This report summarizes the needs for additional water sources for the City of Abilene. The recommendations include the construction of a new resevoir on the Clear Fork of the Brazos and/or diverting water from the Clear Fork into Lake Fort Phantom. The analysis shows that an additional 50 MGD would be available from the Clear Fork resevoir while an additional 15 MGD to 25 MGD would be available with installation of the diversion pumps. The pump station is recommended immediately at an estimated cost of $522,000 (1949 dollars). The dam is recommended to be completed prior to time when the proposed diversion pump's capacity is reached, approx. 1970.
1/1/51	Eastland County Water Supply Dist.	Yield of Proposed Lake on the Leon River	The purpose of the report is to examine the safe yield of the proposed Lake Leon. The report determines the yield to be 7440, 7200, and 6900 ac-ft/yr at a dead storage (silt?) of 1417, 3000, and 4500 ac-ft respectively.
1/1/52	Eastland Co. Water Supply Dist.	Water Supply Report	The report examines the present and future needs of the Eastland Co. Water District. The recommendation is that the District construct a dam and reservoir on the Leon River with an estimated yield of 7,281 ac-ft/yr. The report also recommends the construction of a pipeline and assocaiated improvements to the treatment plant.
5/22/59	Stamford, Texas	Brackish Water Demineralization Plant	This report is prepared for the purpose of making an application to the Office of Saline Water, Department of the Interior for the construction of a demineralization plant near the town of Old Glory. The plant, if successful, could supply potable water to the communities in the immediate vicinity and would be for demonstration purposes. The water may be used by commericial or domestic interests. At the time of the report, the cities and communities are supplied by the use groundwater wells. The bulk of the report gives limited details for the supply and distribution systems of various Cities in the area. The report also cites the impacts of the demonstration plant and the various uses for the water.

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
9/1/59	Abilene, Texas	Feasibility Report on Lytle Lake Used As Terminal Storage	This report examines the possible utilization of the storage capacity of Lytle Lake as a terminal storage facility. The additional storage is necessary to provide the City of Abilene with an emergency supply of water when delivery of water to the Grimes Treatment Plant is interrupted. The report recommends the construction of a supply line and low head pumping station. The report anticipates water can be delivered to the lake by the existing pumping and supply facilities. The proposed 42" water line and pumping station would be needed to take the water from the lake to the Grimes treatment plant. The capacity of the line and pumping station will be 48 MGD and cost $263,358 in 1959 dollars.
1/1/60	Abilene, Texas	Water Distribution System - Study and Report	This report presents the results of an analysis of the distribution system for the City of Abilene. The report also briefly inventories the existing water supply. Contained in the report is the recommendation to construct a new overhead storage tank located near the intersection of Hartford Street and Danville Drive. The report also recommends various improvements to the distribution system.
1/2/60	Abilene, Texas	Terminal Storage Facilities for Raw Water, Supplemental	This report summarizes the analysis of 4 potential sites for terminal storage to be used as an emergency supply for the Grimes Treatment Plant. The 4 sites included the following: 1) Lytle Lake as it now exists, 1A) raising of the dam and spillway at Lytle Lake, 2) a site on Cedar Creek near 10th and Cockrell Streets, 3) a site on the hill just south of 10th and Washington Street, and 4) a site located adjacent to the booster pump station. Site 1 would provide 125 MG of storage, Site 1A provides 270 MG, Site 2 provides 350 MG, Site 3 provides 400 MG, while Site 4 will provide 800 MG of storage. Each of these sites will require the construction of a new supply line. The report recommends the adoption of Site 4 at an estimated cost of $894,000. The selection is based on the assumption a future Northeast Water Treatment Plant will be constructed.
5/1/61	Abilene, Texas	Water Distribution System Study	This report examines the entire water system for the City of Abilene. Included is a brief discussion of the projected water demands, the existing water supply, and future surface water sources. The existing Grimes and the proposed Northeast Treatment Plants are briefly discussed. The main emphasis, however, is the distribution system. The report recommends the construction of an additional elevated storage tank to increase the water quantity and pressures in the south, southwest, and western sections of the City. The report analyzes three sites which include: (a) the existing 1.5 MG tank at So. 19th, (b) proposed 2.0 MG tank at West Hartford, and (c) a future tank 7.5 MG tank on the far west side. The analysis was completed with state of art computer models and methodologies. The 2.0 MG tank was recommended with several improvements to the distribution system.

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
3/2/62	Abilene, Texas	Water Reclamation Plant & Irrigation Farm	This report presents an evaluation of the Wastewater Treatment Plant and the irrigation practices which utilize the treated water. The report stated that the wastewater effluent had a high BOD concentration and recommended the expansion of the plant to meet the 20 ppm criteria for the BOD. The report does not, however, recommend the expansion or any other change to the irrigation practice until the new plant renovations are implemented. At that time the irrigation farms would become unnecessary. The costs for expansion of the plant varied with the magnitude of the renovation selected. The cost for the 12 MGD plant is determined as the most expensive with and estimated cost of $2,053,200 (1962 dollars).
6/1/62	WCTMWD	Report on Chloride Routing Studies	This report analyzes the extent of chemical pollution in Hubbard Creek. The report determines the maximum chemical content of water that would avoid high concentrations in the Hubbard Creek reservoir. The chloride contamination is expected to rise above acceptable levels unless the man-made pollutants are minimized. It is recommended the District implement an aggressive program of pollution control on the Creek's drainage area. The goal of the program should be to lower the chloride content to a level below 50 ppm.
7/12/62	Hamlin, Texas	Hamlin City Plan	The report is a comprehensive plan covering the existing and anticipated land use, population, economics, school systems, utilities, public facilities, and planning tools. The report only briefly addresses the water system.
7/1/63	Sweetwater, Texas	Water System Study	The water distribution system for Sweetwater is evaluated. Recommendations are made for increasing the capacity of the water treatment plant, additional elevated storage, and improvements to the distribution system itself.
12/1/66	Abilene, Texas	Long Range Water Supply Study	The purpose of this report is to examine the various alternate sources of supply to meet the water demands for the City of Abilene. The report summarizes the existing water supplies, existing water rights, and recommendations for additional sources. The existing water supply consists of surface water stored in Lake Fort Phantom, Lake Abilene, and Lake Kirby. The yields of each of these lakes are also presented. The per capita water use is taken as 177 gpd in 1967 is expected to increases to 220 gpd in the year year 2010. Based on these uses, the water needed is projected as 58 MGD. Several alternative water sources are evaluated and include (1) the increased diversion of the Clear Fork water, (2) a new reservoir located on Mulberry Creek, (3) diversion of Mulberry Creek, and (4) a new resevoir on the Clear Fork. The additional yields for the first three alternates are 7.9 MGD, 4.9 MGD, and 4.1 MGD, respectively. The Clear Fork reservoir and the Pecan Bayou reservoir are also discussed. The report recommends the immediate construction of the Clear Fork Pumping facilities and that plans for a new source of water be made.

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
1/1/69	Stamford, Texas	Comprehensive City Plan	The report provides an analysis of the existing and anticipated developement of the City in terms of population, community facilities, water and sewer facilities, land use, growth patterns, etc. The report breifly describes the existing water distribution and treatment facilities. The sources of water are not mentioned. In addition, some general recommendations for expansions to the treatment plant and distribution system are made.
2/24/70	WCTCOG	2020 Comprehensive Regional Plan, Water Quality	The report is concerned with the factors that affect the water quality in the project area. The main emphasis of the report are: (1) to conduct planning and feasibility studies for area-wide sewage and waste collection systems and to (2) formulate a definite program to correct current and future deficiencies in collection, transportation, and treatment of waste water. The factors examined that are thought to influence water quality are population, economics, land use, and existing wastewater treatment practices. Other factors contributing to the water quality are addressed in less detail and include agricultural, industrial, oil well, and natural pollution.
2/25/70	WCTCOG	2020 Comprehensive Regional Plan, Water Quality	The report is concerned with the factors that affect the water quality in the project area. The main emphasis of the report are: (1) to conduct planning and feasibility studies for area-wide sewage and waste collection and (2) to formulate a definite program to correct current and future deficiencies in collection, transportation, and treatment of waste water. The factors examined that are thought to influence water quality are population, economics, land use, and existing wastewater treatment practices. Other factors contributing to the water quality are addressed in less detail and include agricultural, industrial, oil well, and natural pollution.
3/27/70	WCTCOG	2020 Comprehensive Plan, Technical Appendix	The report supplements the summary report and gives the technical data presented in the summary report. Included in the technical appendix is the supporting population projections, streamflows, existing treatment facilities, and proposed regional wastewater treatment plants.
11/1/70	WCTCOG	Rural Comprehensive Plan	The comprehensive plan provides guidelines for the development of regional water and sewer improvements. The plan catalogs the existing systems for the communities and unincorporated areas of the region. The report addresses water resources from a regional point of view. The existing water supplies have been inventoried and are presented with pertinent information. Information on the water quality of these reservoirs are also provided. In addition to the larger reservoirs, smaller dams are listed. Other sources, such as groundwater, are listed in the report.
12/1/71	WCTMWD	Service Spillway Operating System	The report contains the operation procedures for the service spillway at the Hubbard Creek Reservoir and provides recommendations for its improvement.

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
9/1/73	Breckenridge, Texas	Water Supply Facility	The purpose of this report is to determine the water supply, transmission facility, and distribution system to meet the anticipated demands throught the year 2000. The present water supply consists of Lake Daniel and Hubbard Creek Lake. The yield of Lake Daniel is 1300 ac-ft/yr for the year 2000. With its contractural aggreement for Hubbard Creek water, the supply is deemed adequate. The existing method of releasing water into Gonzales Creek and picking it up near the City resulta in an unaccepatable loss of water and a deterioration of the water quality. Therefore, a new transmission line and pump station capable of 3 MGD is recommended. A review of the existing treatment plant indicates that necessary improvements to the existing water treatment plant is impossible. It is recommended that a new plant be constructed with a 3.4 MGD capacity. Various improvements are also recommended to improve the operation of the distribution system.
1/1/76	Abilene, Texas	Report on Lake Fort Phantom Hill Yield	This report summarizes the findings and conclusions of an analysis of the potential yield of Fort Phantom Hill Reservoir. The analysis includes the review of existing reports and examines the feasibility of increasing the storage, the effects of diversions into the lake, and determines the feasibility of increasing the conservation storage of the lake. The study shows that none of the alternatives examined offers any appreciable increase in the safe yield of the lake. It is determined that the present safe yield of the lake is 25,100 ac-ft/yr or 22.4 MGD.
1/1/77	Abilene, Texas	Lake Abilene Spillway Adequacy and Reservoir Yield	This report gives an inventory of the existing facilities at the Lake Abilene dam site. Its purpose is to examine the adequacy of the present spillway and to provide an analysis of the expected safe yield of the reservoir. In the case where additional spillway capacity is needed or where additional conservation storage is feasible, cost estimates are provided. It is recommended to raise the existing dam 9 feet and widen the spillway to 1000 foot at an estimated cost of $1,009,000 (in 1977 dollars). In addition, the report determines the safe yield of the Lake taking into account the evaporation, municipal use, seepage, sedimentation, and the area-capacity relationship of the reservoir. The existing safe yield is determined to be 1,250 ac-ft/yr with a 1 year's supply held in reserve. Also, increasing the conservation level will not add appreciably to the yield of the Lake. No recommendation was made for the increase of flood storage based on the high cost of such an alternative.
3/1/77	Moran, Texas	Comprehensive Plan 1976-2000, Moran, Texas	This report was commissioned by the West Central Texas Council of Governments, and is intended to provide a reasonable plan for the anticipated growth of the City of Moran. The report contains a description of background information for the City as well as the trends in population, housing, land use, water resources, and capital improvements. Specifically, the section on water resources contains an analysis of the existing water distribution system, treatment facility, and the water supply.

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
1/1/78	Stamford, Texas	Reconnaissance Study of Diversion of California Creek	This report determines the feasibility of diverting water from California Creek to Lake Stamford. The determination of the diversion is based on critical factors which include the water quality, increased yield of Lake Stamford, and costs. The quality of the water in California Creek is a major concern and appropriate measures are recommended to mitigate the problems associated with it. The yield of Lake Stamford will be augmented enough to meet the anticipated needs of the City of Stamford with the diversions. It is reasonable that the yield of the Lake with the diversion will meet the demands of the City with a yield of 8,820 ac-ft/yr or 7.87 MGD in the year 2020. The cost of the proposed 22,000 ft diversion canal is est. at $3,606,000 (in 1978 dollars).
12/15/78	Abilene, Texas	Municipal Water System Analysis	The report presents an analysis of the water system for the City of Abilene. The report includes an examination of the anticipated water demands, water supplies, distribution, and the water treatment plants. Improvements in each of these areas are recommended and estimated costs of construction are provided. The average projected water use for the year 2000 is 25.2 MGD. The present water supply source is inventoried and recommendationss that Abilene begin the necessary steps to increase the water supply are made. The 47 MGD capacity of the raw water supply network is reviewed and considered as inadequate for future conditions. Various alternatives that would increase the capacity to at least 52 MGD are given. The capacities and treatment processes for the Grimes, Abilene, and Northeast plants are evaluated. The Grimes and Abilene plants are deemed inadequate for present and future flows. The report recommends improvements and/or renovations at all three plants. Improvements to the distribution systems are also recommended.
9/1/79	Sweetwater, Texas	Long Range Water Study	The report summarizes the potential water sources for the City of Sweetwater and includes an analysis of Lake Sweetwater, Oak Creek Reservoir, Lake Trammell, and the potential use of Lake Spence as a water source. The existing safe yields for Oak Creek, Trammell, and Sweetwater Lakes are determined to be 3.48 MGD, 0.10 MGD, and 0.48 MGD, respectively, for a total of 4.06 MGD. The projected water demand for the year 2010 is 6.38 MGD resulting in a deficit of 2.32 MGD (assuming no groundwater is available). The report recommends supplementing the yield of the Oak Creek Reservoir with water from Lake Spence. Improvements to the delivery systems are is evaluated. The report recommends the construction of a delivery system from E. V. Spence to Oak Creek as well as needed improvements to the other systems.
1/1/80	WCTMWD	Coordinated Operation of Existing Raw Water Supply Sources	The purpose of this report is to determine the dependable yields for Hubbard Creek Reservoir, Lake Daniel, Lake McCarty, Lake Abilene, and Fort Phantom reservoirs. In addition, the report examines methods which will optimize the yields of these reservoirs. The water quality is also addressed. In the year 2030, the yields for these lakes are anticipated as follows: (1) Hubbard -

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
1/1/80 (Con't)			35,600 ac-ft/yr, (2) Fort Phantom - 10,220 ac-ft/yr, (3) Abilene - 1,220 ac-ft/yr, (4) McCarty - 1,210 ac-ft/yr, and (5) Daniel - 3,400 ac-ft/yr. An optimization of the yields and pumping costs can be achieved by the interdependence of the lakes. The report sets forth guidelines to achieve this optimization.
4/28/80	Anson, Texas	Water Facilities Study	This report was commissioned by the City of Anson and is intended to provide an analysis of the entire water supply system. Included in the analysis is the examination of the existing water supply, water treatment facility, and the distribution system. It also includes the Engineer's estimate of existing and anticipated populations and associated water usage. It was determined that the City will require an average of 0.68 MGD of treated water by the year 2000 when the population is expected to be 3800. The existing water supply is considered adequate beyond that period, however, improvements are recommended to the Clearwell storage and to the distribution system. The cost of these improvements is estimated as $700,000. It is further recommended that the City immediately secure the necessary financing to implement the improvements. It is also anticipated that the revenue to repay the loans would be accomplished by an increase in water rates.
10/1/80	Stamford, Texas	Water Treatment Design Report	The purpose of the report is to (1) analyze the existing population and water use, (2) evaluate the raw water delivery system and the water treatment plant, and (3) to develop construction costs and scheduling of the of the proposed improvements. Based on the population projections for the year 2010, it is determined raw water demand for will be 5.0 MGD. This includes the raw water demands of Stamford and Hamlin. It is also determined the treated water demand for Stamford will be 3.0 MGD in the year 2010. This exceeds the 2.7 MGD capacity of the raw water delivery system and the 2.0 MGD capacity of treatment plant. The report recommends the construction of improvements to the plant to increase the capacity of the plant to 3.0 MGD (note the capacity is limited by the sedimentation basin) and the installation of larger pumps at the intake structure to increase the capacity to 5.0 MGD. The cost of the improvements is estimated at $900,000 (1980 dollars).
10/2/80	WCTMWD	Study of Long Range Water Supply	This report examines the need for additional water sources for the member cities of the WCTMWD. Included in the report is an analysis of the existing and historical water uses as well as the population trends. Based on this analysis, a new water source capable of delivering a minimum of 12,000 ac-ft/yr is necessary. Eight sites were examined as potential sources of additional water and include the following: 1) Possum Kingdom Reservoir, 2) Cedar Ridge Reservoir Site, 3) Clear Fork Reservoir Site, 4) California Creek Reservoir Site, 5) Mulberry Creek Reservoir Site, 6) Elm Creek Reservoir Site, 7) Clear Fork Diversion into the Fish Creek Reservoir Site, and 8) Clear Fork Diversion into the Hubbard Creek Reservoir. Of these alternatives, three were identified as being able to meet the needs of the District and include Possum Kingdom, Cedar

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
10/2/80 (Con't)			Ridge, and diversion into the Hubbard Creek Reservoir from Clear Fork. The remaining alternates were eliminated due to cost and/or poor water quality. The report recommends tighter pollution control and obtaining water from Possum Kingdom Reservoir prior to 1985.
12/1/80	Cross Plains, Texas	Comprehensive Plan Report	This report provides a comprehensive planning tool for the anticipated growth for the City of Cross Plains. It includes trends and projections in land use, traffic patterns, population, housing, community facilities, and public facilities. In reference to the public facilities, the water system was evaluated in accordance with the anticipated growth. The population and water uses are projected through the year 2000 and the facilities compared to their ability to meet the current State standards. The avg. demand was determined as 0.69 MGD at a population of 1,645. The water demand is currently met by the operation of groundwater facilities at two separate sites. The current production from these wells is shown to be 0.56 MGD. Although this production meets the current demand, a new source is needed. Existing surface water supplies for potential use by the City are (1) Lake Brownwood, (2) Lake Clyde, (3) and Lake Coleman. Alternative locations may be the construction of a reservoir on Burnt Creek, the Sabanna River with participation from Rising Star and Cisco, or a reservoir on Pecan Bayou. The distribution system is also evaulated and recommendations made for its improvement.
4/1/81	Moran, Texas	Water System Study, Moran, Texas	This report examines the operation and condition of the existing water supply, treatment, and distribution system for the City of Moran, Texas. The existing water is obtained from a small City owned lake supplemented with a diversion from Deep Creek. The treatment process and operation was briefly described with no recommendation for its improvement. The distribution system was cataloged and recommendations for the upgrading of the old and dilapidated lines were made. The estimated cost of these improvements is $180,000.
6/1/81	Sweetwater, Texas	Water Works Improvements	The overall objective of the report is to identify problem areas in the water system and provide recommendations to upgrade the system to meet the anticipated demands. An evaluation of the existing water sources and supply indicates a deficiency will occur in the near future. The report recommends the 1.65 MGD deficit be met with the acquisition and implementation of groundwater supplies. The existing treatment plant was evaluated and recommendations made to upgrade the facility to met current State design criteria. The remaining portion of the report addresses the distribution system deficiencies. Also included are cost estimates for the recommended improvements. The financing of these projects is to be accopplished at the current revenue rates and/or with alternative financing schemes.

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
7/1/81	Stamford, Texas	Water Distribution System Study	This report is intended to provide an analysis of the adequacy of the distribution system for the City of Stamford. The population and water uses were projected through the year 2000. Included in the study is current design criteria, a discussion of the existing water storage, and a discussion of the deficiencies in the water distribution system. Also included are recommendations for improvements to the system.
6/1/82	Stamford, Texas	Water and Sewer Rate Study	The purpose of the report is to recommend a rate schedule that will fund the capital improvements to the system as well as its operation and maintenance. The rates are based on the existing and projected water use for the system.
12/9/82	Abilene, Texas	Lake Fort Phantom Hill, Raw Water Delivery System	This reports examines alternatives that will increase the capacity of the raw water delivery system from Fort Phantom Hill. The results of this analysis indicates that some of the lines should be cleaned. In addition, four alternatives are developed that increase the capacity of the delivery system to either 68 MGD or 85 MGD. Each alternative would require renovation to the existing raw water pump station and the construction of a new booster pump station. Alternatives 1 and will increase the capacity of the system to 85 MGD (78 MGD firm capacity) and will consist of the construction of a parallel 45" water line. Alternate 2 will also increase the capacity to 85 MGD and consists of the construction of a parallel 45" water line and a new 36" water line. Alternatives 3A and 3B have identical design schemes and will increase the capacity to 68 MGD. Each require the construction of a an additional booster pump station and differ only by the type of pump used. The report recommends the improvements of alternate 1 at an estimated cost (1982 dollars) of $2,831,000.
8/1/83	Sweetwater, Texas	Water Supply Alternatives	The purpose of this study is to provide the City with a thorough and updated investigation of the availble water supply alternatives to meet the anticipated 2,600 ac-ft/yr shortfall. The evaluation includes an examination of the historical and anticipated trends in population and water use. In addition, the existing water supplies are cataloged and include (1) Oak Creek Reservoir, (2) Lake Sweetwater, (3) Lake Trammell, and (4) the Getty Well Field. The total safe yield from these sources is approx. 3.5, 0.5, 0.1, and 1.0 MGD, respectively, for a total of 4.8 MGD. It is anticipated the total water requirement for the year 2030 will be 10,466 ac-ft/yr. With 5,398 ac-ft/yr (ie. 4.82 MGD) available, the deficit would be 5,068 ac-ft/yr. Anticipated demands may be met by several alternatives which include: (1) Modification of current operational procedures, (2) diversion of local surface waters, (3) development of the Clear Fork Reservoir, (4) transferring water from E.V. Spence, (5) transferring water from proposed reservoirs at Justiceburg, Stacy, and Cedar Ridge, (6) wastewater and industrial reuse, and (7) development of additional groundwater supplies.

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
12/1/83	Merkel, Texas	Comprehensive Plan Report	This report presents various aspects of City planning. Included in the presentation is a discussion concerning the City's water facilities. The water system is evaluated based on the anticipated water use. The water usage for the City of Merkel is determined to be 200 gpcd for the year 1983 and is not expected to change appreciably during the planning period. The City of Merkel meets the current demands via a contract with the City of Abilene. Under terms of this contract, the City may purchase up to 183 MG/YR. However, there is a "cut back" clause which gives the City of Abilene the right to restrict the max. amount available to 133 MG/YR. The contract agreement was exceeded in 1983 and it is probable that the water usage will continue to exceed the contractual amount unless renegotiation of the contract is undertaken immediately. As an alternative, the report recommends the construction of a reservoir on Mulberry Creek. In addition, the report recommends the construction of improvements to the booster pump station as well as new distribution lines and an elevated storage tank.
12/2/83	TESCO	Water Supply Yield of Lake Colorado City and Champion Creek	The purpose of this report is to examine the dependable yield for Lake Colorado City and Champion Creek Reservoir. The report indicates that a more severe drought has occured after the previous sutdies and that a reduction in the safe yield of the resevoirs is probable. It is determined that the safe yield of Lake Colorado City, Champion Creek, and the Combined Operation of the Lakes is 510, 3920, and 4980, respectfully. The yields were found to be less than previously thought due to sedimentation and the occurrance of a more critical drought with a longer duration.
12/3/83	CRMWD	Evaluation of Water Quality in E.V. Spence Reservoir	The report examines the water quality in E.V. Spence Reservoir and outlines both short and long term methods of controlling the TDS concentrations. The report recommends the construction of several diversion facitlities to remove the poorest quality inflows.
10/1/84	Abilene, Texas	Use of Brackish Water and Reclaimed Wastewater	This report examines the potential reuse of wastewater as a supplement to the yield of Lake Fort Phantom. A comparison of the projected water use and the available water supply was made to determine a 11,640 ac-ft/yr deficit for the year 2030. The report re-examines the potential water sources addressed elsewhere and the potential of reclaiming the wastewater. The sources reviewed include (1) a new reservoir on the Clear Fork, (2) diversion of lower flows from the Clear Fork, and (3) water from Possum Kingdom Reservoir. Obstacles to the reuse of wastewater are identified and addressed in the report. It is assumed the existing wastewater treatment plant will be expanded and/or operated in such a manner as to maintain the current water quality parameters. Several current operations of wastewater recycling are presented in the report. Four alternatives are presented and include: (1) wastewater reuse, (2) Possum Kingdom Lake water with dimineralization, (3) Cedar Ridge reservoir with dimineralization, and 4) Clear Fork diversions to the Hubbard Creek Reservoir. Alternate (1) is recommended at a cost of $1.60/1000 gal.

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
11/20/84	WCTMWD	Study of Water Transmission Facilities	This report examines the condition of the major transmission pipelines and the pumping equipment owned by the WCTMWD. It is noted that there were no standby pumps and that the existing pumps are less than 100% reliable. The existing pipeline and cathodic devices are in need of general maintenance and repair. Other areas in need of repair are the instruments, control valves, and control cables. The report recommends the installation of motor driven butterfly valves as well as new control valves. Such measures will eliminate a major portion of the maintenance problems. In addition, the report recommends heating of the pumping stations and annual inspections by a competent corrosion engineer. other recommendations are estimated at $186,000 for pump station modifications, $14,000 for pipeline protection, $6,000 for upgrading the Anson pumps, and $285,000 for the standby pumps.
12/1/84	Texas Dept. of Water Resources	Cholride Control Program on the Clear Fork of the Brazos	The purpose of this report is to examine the causes of the poor water quality in Clear Fork and to recommend methods of controlling the cholide and Sulfate content of the water. The sources of the dissolved solids are determined to be a result of the regional geology and human activity associated with oil and gas production. The creeks with the highest TDS is found to be Noodle, Plum, and California Creeks. The report describes the collection and analysis of water quality data taken from 1981 to 1983. The data was used to develope a mathmatical model of the river system. Using this model, the report developes and recommends several methods of controlling the TDS in the Clear Fork. The alternatives include various combinations of low flow diversions on the three (3) creeks and plugging abandoned oil wells. The improve measures of controlling the salt would result in a 17.4% reduction in dissolved salts at Lueders and a 29.5% reduction at a point near Lusk. The cost of these measures is estimated as $332/ton and $129/ton, respectfully.
1/1/85	Tye, Texas	Land Use Study - Water System Study	This report addresses the current and anticipated land uses for the City of Tye. The report also studies the water system with particular emphasis on the water supply. The existing trends in population and water use are examined and projections made through the year 2010. The anticipated water use at that time is determined to be 0.43 MGD for a population of 3,585 persons. The City currently purchases water from the City of Merkel at the contracted rate of 72 MG/YR under normal conditions and 48 MG/YR should the City of Merkel exercise its "cut-back" option. The water use in 1983 was recorded as 57.3 MG indicating a need for additional water supplies. The report recommends the purchase of additional water either from the City of Abilene directly, or through an arrangement with the City of Merkel. In addition, the report recommends improvements to the water supply system.
10/10/85	Coleman, Texas	Water Supply from Stacy Reservoir	The purpose of this report is to present information necessary for the decision on whether the City should purchase water from the Stacy Reservoir or not. Included in the report is an evaluation of the City's existing water supply, population projections, and an estimate of the cost of 2,000 ac-ft/yr (ie 1.78 MGD) from the proposed Stacy Reservoir. Also, the 1985 safe yields of the existing lakes are provided as follows: (1) Lake Scarbourgh - minimal, (2) Lake

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
10/10/85 (Con't)			Coleman - 10,200 ac-ft/yr (9.1 MGD), and (3) Hords Creek - 774 ac-ft/yr (0.69 MGD). The report has projected the yields of these lakes to be approximately 10,174 ac-ft/yr in the year 2035. For that year, the anticipated demand for the City of Coleman would be 1,652 ac-ft/yr and 2,589 ac-ft/yr for Coleman County.
1/1/86	Moran, Texas	Water System Study, Moran, Texas	This report analyzes the existing water system for the City of Moran and recommends improvements to meet the City's demands. The 2010 population and water uses are projected as 400 people and 100 gpcd, respectfully. The raw water is provided by permit and consists of a small City owned lake supplemented with diversion of water from Deep Creek. No yield study of the lake was made, however, it does appear that the City's needs could be met with appropriate configuration of the intake. Additional water supplies are identified as groundwater and purchased water from the Shackleford Water Supply Corp. The existing treatment plant was examined and determined to be inadequate for the City's current and anticipated population. In addition, the distribution system is also deemed inadequate. The report recommends improvements to the treatment plant and the distribution system for a total cost of $750,000 (1986 dollars).
2/1/86	Albany, Texas	Water Distribution System, Water Treatment, and Water Supply	The purpose of the report is to conduct an analysis of the water supply, treatment, and distribution system for the City of Albany to determine their ablility to meet the anticipated growth in population and water use. Based on the projections found in the report, the average daily demand on the system for the year 2010 will be 0.7 MGD with a max daily demand of 1.84 MGD. At present (1986) the water supply is limited to a max. 1.68 by the WCTMWD, however, due to the banking system employed by the district the Cities demands will be meet under most rainfall conditions. In addition, the report examines the existing water treatment plant and distribution system. recommendations for improvements to the distribution and expansion of the water treament plant to a 2.6 MGD capacity were made. The report recommends the City implement water supply alternate 4 at a cost of $61,750 which utilizes the existing water district line and would require the City to pay for the power costs at the Lake McCarty pump Station. It also recommends improvements to the distribution system immediately and that the treatment plant improvements coincide with the growth of the Shackleford WSC.
5/31/87	Abilene, Texas	Wastewater Collection System Analysis	This report summarizes the results of an analysis of the City of Abilene's wastewater collection system. It provides recommendations for the solution of known problem areas and those identified as a result of the analysis. The key elements of the study includes the following: (a) a review of the existing collection system, (b) a review of the existing and projected populations, (c) a projection of the anticipated wastewater flows, and (d) development of a capital improvements plan. Recommendations included the construction of larger interceptors, the elimination of some siphons, and the construction of a west side sewer treatment plant when the flows warrant it. Costs for these improvements were also given in the report.

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
10/2/87	Sweetwater, Texas	Groundwater Conditions in the Vicinity of Champion	The purpose of the study is to determine (1) the quantity of water in the Champion well field, (2) the hydraulic characteristics of the aquifer, (3) the recoverable water and (4) the chemical quality. The report provides a detailed analysis of the aquifer. It also provides the neccessary technical support to other studies. The report indicates 1.5 MGD for 20 years is recoverable from the aquifer. The quality of this water, however, must be monitored closely and steps taken to minimize the effects of the highly mineralized water.
12/30/87	Abilene, Texas	Wastewater Treatment Plant Evaluation	This report examines the existing wasterwater treatment plant and provides recommendations to increase its capacity to 18.0 MGD. The expansion would result in the existing flow being 72 percent of the rated capacity. Three key parameters are addressed for the existing wastewater quality and includes the following: Biochemical Oxygen Demand (BOD), total Suspended Solids (TSS), and Ammonia-Nitrogen (NH3-N). The report recommends improvements that would achieve the 20/20 permit level for these parameters.
3/1/88	Abilene, Texas	Analysis of Alternate Wastewater Effluent Limits	The purpose of this report is to examine the effluent quality of the water discharged by the wastewater treatment plant. The intent is to identify several wastewater effluent levels and analyze their affects on the downstream water quality for the purpose of renewing the City of Abilene's discharge permit. The study area includes Freewater and Deadman Creek. The recommendation is that the City apply for a seasonal discharge permit with upper limits of 10/15/18/2 in the winter and 10/15/12/2 in the fall. Adoption of these limits maintain the required Dissolved Oxygen (DO) level of 3.0 mg/l.
5/1/88	Abilene, Texas	Water Reclamation Research Project, Summary Report	The summary report evaluates the technical and economic feasibility of utilizing reclaimed wastewater to supplement the City's water supply. The report examined the success of existing reclamation projects, state of the art treatment processes, impact on existing water qualities, and alternative uses of treated water. Recommendations were made for construction of a 3 MGD pilot plant at a cost of $10,000,000 with a future expansion to 7 MGD at a cost of $9,000,000. Improvements to the infrastructure are also recommended. In addition, the issue of water rights is addressed in detail.
5/2/88	Abilene, Texas	Water Reclamation Research Project, Technical Memoranda	This memoranda develops the technical information necessary for the eventual reclamation of wastewater flows for the City of Abilene. The data includes public and private input, population data and projections, wastewater quantities

and quality, water qualities of existing surface water, etc.

DATE	CITY/ENTITY	REPORT TITLE	ABSTRACT
7/26/88	Sweetwater, Texas	Champion Well Field, Collection and Transmission Study	This report examines the possibility of developing the Champion well field as an additional source of water. Several existing wells were analyzed in terms of their production and water quality. The parameters includes the total dissolved solids, sulfates, nitrates, and chlorides. The report also examined the mixing or blending of the new groundwater with the existing surface water sources. The total available water, including the existing surface sources and the Champion well site is determined as 4.067 MGD for the year 2010. The report also indicates additional sources will be needed. The report indicates a maximum of 2.074 MGD will be available from the well field but recommends a safe yield of approx. 1.5 MGD. The report also analyzed several alternative means of collection and transmission of the well water. The recommended route will cost $4,593,638 to construct with an annual O&M cost of $647,068 (both costs are in 1988 dollars).
2/7/89	WCTMWD	Economy of System Operation	This report examined the operation of Fort Phamtom Hill and Hubbard Creek Reservoir to determine how the yields of both reservoirs can be optimized. This optimization was achieved by analyzing the historical water use trends over the period 1975 to 1985. The water use for the member Cities is shown to be 18,700 ac-ft in 1975 and 24,195 ac-ft in 1985. Other uses included municipal, irrigation, and mining. The existing uses and population were compared with previous projections and were revised as necessary. The projected use for the member Cities was determined to be 41,800 ac-ft in the year 2000. Projected water uses indicate the need for additional sources of water. The report recommends the economical use of the available water in Fort Phantom and Hubbard as a means of increasing yields. The economics of the operating system are based on the known and anticipated electrical rates and water uses. The proposed plan would minimize the pumping time from the Hubbard Creek reservoir. The pumps would be triggered by the levels in Fort Phantom Lake.
12/1/89	CRMWD	Water Management Plan	The plan includes throrough descriptions of CRMWD's history, goals, objectives, customers, and water supply systems. The report includes available resevoirs and well fields. The report also contains copies of CRMWD customer contracts.
5/1/91	City of Cisco	Alternative Water Supply Facilities	The report gives an estimate of the future water supply and demands for the City of Cisco. The reports recommends alternatives for meeting the anticipated needs. The report also provides a thorough analysis of the options available at the Battle Creek diversion and provides potential treatment facility alternatives.

APPENDIX C

DETAILED WATER USE SUMMARIES BY COUNTY

Table C-1

Callahan County
Projected Population and Water Demand

Population	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	10992	12593	13301	15136	17300	19547	13316	15524	20431	23193
Baird*	1696	1689	1625	1892	1938	2179	1627	1941	2289	2586
Clyde	2562	3139	3642	4589	4701	5286	3647	4707	5552	6273
Cross Plains*	1240	1176	1148	1224	1254	1410	1150	1256	1481	1673
Total (Cities)	5498	6004	6415	7705	7893	8875	6424	7904	9322	10532
Total (Other County)	5494	6589	6886	7431	9407	10672	6892	7620	11109	12661

Per Capita Water Use: (GPCD)	Historical 1980	Historical 1985	Projected High Demand 1990	Projected High Demand 2000	Projected High Demand 2010	Projected High Demand 2020
Baird*	176	173	235	223	211	205
Clyde	110	91	132	125	118	115
Cross Plains*	151	190	209	198	187	182
Avg. (Cities)	140	134	172	160	152	147
Avg. (Other County)	105	105	139	132	125	122

Table C-1, Continued

Projected Demand (AcFt//Yr)	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	1508	1676	2308	2480	2661	2920	2311	2543	3143	3465
Baird*	334	327	428	473	458	500	428	485	541	594
Clyde	316	320	539	643	621	681	539	659	734	808
Cross Plains*	210	250	269	271	263	287	269	279	310	341

Other Water Use by Type (Ac-Ft/Yr)		Historical 1980	Historical 1985	Projected 1990	Projected 2000	Projected 2010	Projected 2020
Manufacturing	County	9	9	10	12	14	16
Irrigation	County	1249	748	1104	1104	1104	1104
Livestock	County	841	628	998	1157	1157	1157
Steam Electric	County	0	0	0	0	0	0
Mining	County	1	224	0	0	0	0
Total	County	2100	1609	2112	2273	2275	2277

Notes: 1) Projections based on TWDB projections, October 1989, High and Low Series.
2) Projected demand includes a 15% reduction due to conservation by the year 2020.

Table C-2

Coleman County
Projected Population and Water Demand

Population:	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	10439	10662	9609	9607	9657	9897	9765	10469	10611	11456
Coleman	5960	6118	5972	5970	6000	6148	6069	6506	6593	7117
Santa Anna	1535	1479	1465	1465	1472	1508	1489	1597	1618	1746
Total (Cities)	7495	7597	7437	7435	7472	7656	7558	8103	8211	8863
Total (Other County)	2944	3065	2172	2172	2185	2241	2207	2366	2400	2593

Per Capita Water Use: (GPCD)	Historical 1980	Historical 1985	Projected High Demand 1990	Projected High Demand 2000	Projected High Demand 2010	Projected High Demand 2020
Coleman	212	201	218	207	196	190
Santa Anna	212	190	237	225	213	207
Avg. (Cities)	212	199	222	211	199	194
Avg. (Other County)	105	101	140	132	125	122

Table C-2, Continued

Projected Demand: (AcFt/Yr)	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	2126	2040	2190	2079	1972	1970	2226	2265	2166	2280
Coleman	1415	1378	1458	1384	1317	1309	1482	1509	1448	1515
Santa Anna	365	315	389	369	351	350	395	403	386	405

Other Water Use by Type: (AcFt/Yr)		Historical 1980	Historical 1985	Projected 1990	Projected 2000	Projected 2010	Projected 2020
Manufacturing	County	5	6	7	11	14	18
Irrigation	County	3630	1246	2310	2310	2310	2310
Livestock	County	1038	920	1219	1400	1400	1400
Steam Electric	County	0	0	0	0	0	6000
Mining	County	0	12	0	0	0	0
Total	County	4673	2184	3536	3721	3724	9728

Notes:

1) Projections Based on TWDB Projections, Oct. 1989, High and Low Series
2) Projected demand includes a 15% reduction due to conservation by the year 2020

Table C-3

Eastland County
Projected Population and Water Demand

Population:

	Historical		Low Projected				High Projected			
	1980	1985	1990	2000	2010	2020	1990	2000	2010	2020
County	19480	20727	19422	19244	19077	19302	20303	21856	23342	24757
Cisco*	4517	4509	4169	3801	3527	3568	4359	4317	4316	4577
Eastland	3747	4226	4166	3902	3621	3663	4356	4432	4431	4699
Gorman	1258	1315	1229	1143	1061	1012	1285	1299	1299	1299
Ranger	3142	3404	3203	2915	2705	2736	3349	3311	3310	3510
Rising Star	1204	1198	1129	1070	993	948	1181	1216	1216	1216
Total (Cities)	13868	14652	13896	12831	11907	11927	14530	14575	14572	15301
Total (Other County)	5612	6075	5526	6413	7170	7375	5773	7281	8770	9456

Per Capita Water Use: (GPCD)

	Historical		Projected High Demand			
	1980	1985	1990	2000	2010	2020
Cisco*	219	197	215	203	193	187
Eastland	329	228	322	305	289	281
Gorman	134	107	132	125	118	115
Ranger	223	196	285	270	256	248
Rising Star	121	59	119	113	107	104
Avg. (Cities)	234	187	248	235	222	217
Avg. (Other County)	105	151	148	139	131	127

Table C-3, Continued

Projected Demand: (AcFt/Yr)	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	4295	4097	4777	4376	4013	3948	4994	4971	4911	5065
Cisco*	1108	995	1004	864	763	747	1050	982	933	959
Eastland	1381	1079	1503	1333	1172	1153	1571	1514	1434	1479
Gorman	189	158	182	160	140	130	190	182	172	167

Other Water Use by Type (Ac-Ft/Yr)		Historical 1980	Historical 1985	Projected 1990	Projected 2000	Projected 2010	Projected 2020
Manufacturing	County	225	238	268	340	416	508
Irrigation	County	14,155	15,000	16,048	16,048	16,048	16,048
Livestock	County	995	786	1,178	1,362	1,362	1,362
Steam Electric	County	0	0	0	0	0	0
Mining	County	110	432	172	154	146	137
Total	County	15,485	16,456	17,666	17,904	17,972	18,055

Notes: 1) Projections based on TWDB Projections, October 1989, High and Low Series.
2) Projected demand includes a 15% reduction due to conservation by the year 2020.

Table C-4

Fisher County
Projected Population and Water Demand

Population:	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	5891	5592	5360	5315	5366	5469	5386	5564	5687	5854
Roby	814	885	870	863	870	887	875	904	923	950
Rotan	2284	2217	2158	2139	2159	2201	2169	2240	2289	2356
Total (Cities)	3098	3102	3028	3002	3029	3088	3044	3144	3212	3306
Total (Other County)	2793	2490	2332	2313	2337	2381	2342	2420	2475	2548

Per Capita Water Use: (GPCD)	Historical 1980	Historical 1985	Projected High Demand 1990	Projected High Demand 2000	Projected High Demand 2010	Projected High Demand 2020
Roby	141	72	164	155	147	143
Rotan	163	114	182	173	164	159
Avg. (Cities)	158	103	177	168	159	154
Avg. (Other County)	105	182	223	212	201	195

Table C-4, Continued

Projected Demand: (GPCD)	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	877	866	1183	1114	1066	1053	1189	1166	1129	1127
Roby	129	71	160	150	143	142	161	157	152	152
Rotan	417	283	440	415	397	392	442	434	421	420

Other Water Use by Type: (AcFt/Yr)		Historical 1980	Historical 1985	Projected 1990	Projected 2000	Projected 2010	Projected 2020
Manufacturing	County	119	276	332	460	601	771
Irrigation	County	2880	3157	3846	3692	3654	3616
Livestock	County	602	853	711	821	821	821
Steam Electric	County	0	0	0	0	0	0
Mining	County	598	362	376	153	116	79
Total	County	4199	4648	5265	5126	5192	5287

Notes:

1) Projections based on TWDB Projections, Oct. 1989, High and Low Series
2) Projected demand includes a 15% reduction due to conservation by the year 2020

Table C-5

Jones County
Projected Population and Water Demand

Population:	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	16763	17317	16495	17292	17976	19438	16537	18075	19523	22806
Anson*	2831	2968	2797	2846	2988	3229	2804	2980	3232	3750
Hamlin*	3248	3121	2931	3009	3159	3414	2939	3151	3417	3965
Stamford*	4497	4300	4051	4197	4314	4659	4062	4398	4669	5414
Total (Cities)	10576	10389	9779	10052	10461	11302	9805	10529	11318	13129
Total (Other County)	6187	6928	6716	7240	7515	8136	6732	7546	8205	9677

Per Capita Water Use: (GPCD)	Historical 1980	Historical 1985	Projected High Demand 1990	Projected High Demand 2000	Projected High Demand 2010	Projected High Demand 2020
Anson*	185	127	180	171	162	157
Hamlin*	264	168	238	226	214	207
Stamford*	231	79	208	197	186	181
Avg. (Cities)	228	122	209	198	187	182
Avg. (Other County)	219	101	147	153	153	170

Table C-5, Continued

Projected Demand: (AcFt/Yr)	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	4219	2204	3395	3470	3479	3854	3404	3629	3777	4520
Anson*	587	422	564	545	542	568	565	571	587	660
Hamlin*	961	587	781	762	757	792	784	798	819	919
Stamford*	1164	381	944	926	899	945	946	971	973	1098

Other Water Use by Type: (AcFt/Yr)		Historical 1980	Historical 1985	Projected 1990	Projected 2000	Projected 2010	Projected 2020
Manufacturing	County	360	375	377	416	421	441
Irrigation	County	7900	3425	9743	9353	9257	9162
Livestock	County	687	727	815	944	944	944
Steam Electric	County	1479	1256	1300	1500	1500	1500
Mining	County	36	322	107	96	97	97
Total	County	10462	6105	12342	12309	12219	12144

Notes: 1) Projections based on TWDB Projections, Oct.1989, High and Low Series
2) Projected demand includes a 15% reduction due to conservation by the year 2020

Table C-6

Nolan County
Projected Population and Water Demand

Population:	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	17359	17644	17317	17949	18974	20717	17353	18613	20372	23462
Roscoe	1628	1628	1603	1695	1798	1873	1607	1758	1931	2122
Sweetwater*	12242	12605	12508	12629	13407	13972	12535	13097	14395	15824
Total (Cities)	13870	14233	14111	14324	15205	15845	14142	14855	16326	17946
Total (Other County)	3489	3411	3206	3625	3769	4872	3211	3758	4046	5516

Per Capita Water Use: (GPCD)	Historical 1980	Historical 1985	Projected High Demand 1990	Projected High Demand 2000	Projected High Demand 2010	Projected High Demand 2020
Roscoe	100	146	142	135	128	124
Sweetwater*	264	167	262	249	235	229
Avg. (Cities)	245	165	249	235	223	216
Avg. (Other County)	240	156	191	181	171	167

Table C-6, Continued

Projected Demand: (AcFt/Yr)	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	4745	3227	4622	4506	4520	4745	4632	4672	4853	5374
Roscoe	182	266	255	256	258	260	256	266	277	295
Sweetwater*	3620	2358	3671	3523	3529	3584	3679	3653	3789	4059

Other Water Use by Type: (AcFt/Yr)		Historical 1980	Historical 1985	Projected 1990	Projected 2000	Projected 2010	Projected 2020
Manufacturing	County	581	605	722	993	1287	1643
Irrigation	County	2824	2516	2820	2707	2680	2652
Livestock	County	746	807	883	1021	1021	1021
Steam Electric	County	0	0	0	0	0	0
Mining	County	824	497	761	615	461	307
Total	County	4975	4425	5186	5336	5449	5623

Notes: 1) Projections based on TWDB Projections, Oct. 1989, High and Low Series
2) Projected demand includes a 15% reduction due to conservation by the year 2020

Table C-7

Runnels County
Projected Population and Water Demand

Population:	Historical		Low Projected				High Projected			
	1980	1985	1990	2000	2010	2020	1990	2000	2010	2020
County	11872	12521	11689	11692	11704	11873	11691	12040	12086	12798
Ballinger	4207	4530	4476	4399	4402	4231	4477	4530	4546	4561
WinterS	3061	3179	3244	3262	3266	3140	3245	3360	3373	3385
Total (Cities)	7268	7709	7720	7661	7668	7371	7722	7890	7919	7946
Total (Other County)	4604	4812	3969	4031	4036	4502	3969	4150	4167	4852

Per Capita Water Use: (GPCD)	Historical		Projected High Demand			
	1980	1985	1990	2000	2010	2020
Ballinger	161	111	200	190	179	174
Winters	118	136	202	191	181	176
Avg. (Cities)	143	122	201	191	180	175
Avg. (Other County)	105	107	120	114	108	105

Table C-7, Continued

Projected Demand (AcFt/Yr)	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	1706	1630	2272	2154	2034	1975	2272	2218	2101	2128
Ballinger	759	563	1003	936	883	825	1003	964	912	889
Winters	405	484	734	698	662	619	734	719	684	667

Other Water Use by Type (AcFt/Yr)		Historical 1980	Historical 1985	Projected 1990	Projected 2000	Projected 2010	Projected 2020
Manufacturing	County	95	93	104	131	159	192
Irrigation	County	7000	8479	10769	10337	10231	10127
Livestock	County	837	1130	983	1129	1129	1129
Steam Electric	County	0	0	0	0	0	0
Mining	County	0	24	0	0	0	0
Total	County	7932	9726	11856	11597	11519	11448

Notes: 1) Projections based on TWDB Projections, Oct. 1989, High and Low Series
2) Projected demand includes a 15% reduction due to conservation by the year 2020

Table C-8

Shackelford County
Projected Population and Water Demand

Population:	Historical		Low Projected				High Projected			
	1980	1985	1990	2000	2010	2020	1990	2000	2010	2020
County	3915	3986	3455	3470	3424	3308	3518	3534	3489	3373
Albany*	2450	2418	2068	2076	2049	1978	2106	2115	2088	2017
Moran*	344	380	0	0	0	0	380	400	400	400
Total (Cities)	2794	2798	2068	2076	2049	1978	2486	2515	2488	2417
Total (Other County)	1121	1188	1387	1394	1375	1330	1032	1019	1001	956

Per Capita Water Use: (GPCD)	Historical		Projected High Demand			
	1980	1985	1990	2000	2010	2020
Albany*	215	174	211	200	189	184
Moran*	0	0	0	0	0	0
Avg. (Cities)	199	159	192	185	178	173
Avg. (Other County)	111	102	175	171	169	168

Table C-8, Continued

Projected Demand: (AcFt/Yr)	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	762	634	717	697	669	634	737	716	686	648
Albany*	590	471	489	465	434	408	498	474	442	416
Moran*	0	0	0	0	0	0	0	0	0	0

Other Water Use by Type: (AcFt/Yr)		Historixal 1980	Historixal 1985	Projected 1990	Projected 2000	Projected 2010	Projected 2020
Manufacturing	County	0	0	0	0	0	0
Irrigation	County	514	166	660	660	660	660
Livestock	County	474	726	564	654	654	654
Steam Electric	County	0	0	0	0	0	0
Mining	County	212	365	155	98	84	71
Total	County	1200	1257	1379	1412	1398	1385

Notes: 1) Projections based on TWDB Projections, Oct. 1989, High and Low Series
2) Projected demand includes a 15% reduction due to conservation by the year 2020

Table C-9

Stephens County
Projected Population and Water Demand

Population:	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	9926	10438	9897	10660	11428	12318	10162	11346	12233	13900
Breckenridge*	6921	7345	6847	7368	7910	8454	7031	7843	8468	9540
Total (Cities)	6921	7345	6847	7368	7910	8454	7031	7843	8468	9540
Total (Other County)	3005	3093	3050	3292	3518	3864	3131	3503	3765	4360

Per Capita Water Use: (GPCD)	Historical 1980	Historical 1985	Projected High Demand 1990	Projected High Demand 2000	Projected High Demand 2010	Projected High Demand 2020
Breckenridge*	210	147	215	203	193	187
Avg. (Cities)	210	147	215	203	193	187
Avg. (Other County)	105	111	146	139	131	128

Table C-9, Continued

Projected Demand: (AcFt/Yr)	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	1982	1594	2148	2188	2226	2325	2205	2329	2383	2624
Breckenridge*	1628	1209	1649	1675	1710	1771	1693	1784	1831	1998

Other Water Use by Type: (AcFt/Yr)		Historical 1980	Historical 1985	Projected 1990	Projected 2000	Projected 2010	Projected 2020
Manufacturing	County	13	9	11	15	19	23
Irrigation	County	1684	466	1485	1485	1485	1485
Livestock	County	617	712	732	848	848	848
Steam Electric	County	0	0	0	0	0	0
Mining	County	4795	826	3036	1205	888	570
Total	County	7109	2013	5264	3553	3240	2926

Notes: 1) Projections based on TWDB Projections, Oct. 1989, High and Low Series
2) Projected demand includes a 15% reduction due to conservation by the year 2020

Table C-10

Taylor County
Projected Population and Water Demand

Population:

	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	111435	123118	126514	136521	147168	161197	127285	138058	152579	175533
Abilene*	98315	110050	113514	123112	133457	146223	114209	124541	138442	159392
Merkel	2493	2957	2842	3072	3338	3670	2860	3107	3462	3999
Tye*	1394	2036	2112	2292	2490	2738	2125	2318	2583	2984
Total (Cities)	102202	115043	118468	128476	139285	152631	119194	129966	144487	166375
Total (Other County)	9233	8075	8046	8045	7883	8566	8091	8092	8092	9158

Per Capita Water Use: (GPCD)

	Historical 1980	Historical 1985	Projected High Demand 1990	Projected High Demand 2000	Projected High Demand 2010	Projected High Demand 2020
Abilene*	207	138	203	192	182	177
Merkel	202	119	187	178	168	163
Tye*	81	78	139	132	125	122
Avg. (Cities)	206	137	201	191	181	175
Avg. (Other County)	271	139	140	132	125	122

Table C-10, Continued

Projected Demand: (AcFt/Yr)	Historical 1980	Historical 1985	Low Projected 1990	Low Projected 2000	Low Projected 2010	Low Projected 2020	High Projected 1990	High Projected 2000	High Projected 2010	High Projected 2020
County	26387	18913	27936	28678	29345	31092	28107	29004	30429	33867
Abilene*	22797	17012	25813	26479	27209	28992	25971	26786	28225	31604
Merkel	564	394	595	613	628	670	599	620	652	730
Tye*	126	178	329	339	349	374	331	343	362	408

Other Water Use by Type: (AcFt/Yr)		Historical 1980	Historical 1985	Projected 1990	Projected 2000	Projected 2010	Projected 2020
Manufacturing	County	1796	2001	2401	3387	4249	5305
Irrigation	County	2184	1098	5640	5415	5359	5304
Livestock	County	1743	2703	2069	2397	2397	2397
Steam Electric	County	19	89	90	0	0	0
Mining	County	36	233	49	50	57	62
Total	County	5778	6124	10249	11249	12062	13068

Notes: 1) Projections based on TWDB Projections, Oct.1989, High and Low Series
2) Projected demand includes a 15% reduction due to conservation by the year 2020

Water Use Projections for the Water Supply Corporations Within the Study Area

System	Home County	No. of Meters			Projected Number of Meters			1988 Water Usage (MG)	1988 Avg. Water Usage Per Meter (GPD)	Projected Water Usage (MG)			2020 Proj. Peak Day Rate (18hr. Day, GPM)	Primary Existing Source
		1987	1988	1989	2000	2010	2020			2000	2010	2020		
Eula WSC (1)	Callahan	353	352	436	700	750	800	30.173	235	69.00	74.00	79.00	370	Clyde
Coleman Co. WSC (2)	Coleman	850	1,275	1,265	1,800	1,850	1,900	85.039	250	188.89	194.13	199.38	830	Coleman
Burkett WSC (3)	Coleman	65	65	65	0	0	0	5.961	251	0.00	0.00	0.00	0	Burkett
Westbound WSC	Eastland	458	458	458	478	500	525	35.896	215	43.14	45.12	47.38	243	Cisco
Staff WSC	Eastland	567	567	570	620	670	720	43.550	210	54.65	59.06	63.47	333	Eastland
Morton-Valley WSC (4)	Eastland	168	168	168	175	182	190	24.984	407	25.90	26.00	26.75	89	Ranger
Olden WSC	Eastland	234	240	247	265	285	300	18.567	212	23.60	25.36	26.70	140	Eastland
Sylvester McCauley	Fisher	220	220	220	225	230	235	23.485	293	26.47	27.06	27.65	108	Roby
DPR WSC	Fisher	203	180	175	190	205	225	13.550	206	16.43	17.73	19.46	104	Roby
Paint Creek WSC (5)	Haskell	342	357	357	467	540	560	20.358	156	30.58	35.36	36.67	260	Stamford
Sagerton WSC	Haskell	121	117	118	125	135	150	10.800	253	12.70	13.71	15.24	69	Stamford
Hawley WSC	Jones	1,390	1,565	1,643	1,693	1,773	1,853	117.674	206	146.39	153.31	160.23	858	Abilene
Ericksdahl WSC	Jones	265	250	250	250	245	245	26.612	291	25.20	24.72	24.72	114	Stamford
Bitter Creek WSC (6)	Nolan	900	910	921	950	1,000	1,050	125.961	379	121.36	127.75	134.14	486	Sweetwater
North Runnels WSC	Runnels	663	625	650	675	650	640	65.217	285	73.73	71.00	69.90	296	Winters
Rowena WSC	Runnels	210	200	150	170	170	170	14.072	193	19.44	19.44	19.04	79	Ballinger
Millersview-Doole (7)	Concho	237	237	237	240	240	235	17.700	205	20.65	20.65	20.22	109	Water Well
Shackelford WSC (8)	Shackelford	931	931	908	933	953	960	45.808	135	52.87	54.00	54.40	444	Albany
Stephens Co. WSC	Stephens	745	725	750	785	820	850	64.072	242	79.74	83.30	86.34	394	Breckenrid
Blair WSC	Taylor	224	227	227	250	275	300	15.308	185	19.41	21.35	23.30	139	Abilene
Hamby WSC	Taylor	596	599	599	635	670	700	44.169	202	53.84	56.81	59.35	324	Abilene
Potosi WSC	Taylor	945	965	953	1,025	1,075	1,125	84.072	239	102.83	107.84	112.87	521	Abilene
Steamboat Mt. WSC (9)	Taylor	830	826	812	850	900	950	70.570	234	83.49	88.40	93.31	550	Abilene
Sun WSC	Taylor	850	850	850	880	920	950	66.743	215	76.71	79.42	83.03	530	Abilene
View Caps WSC	Taylor	365	365	400	425	450	500	59.003	443	76.40	84.89	93.38	450	Abilene
			Totals: (MG)		14,806	15,488	16,133	1,129		1,443	1,510	1,576		
			Totals: (Acre-Feet)					3,466		4,430	4,635	4,836		

Notes:

(1) Includes projections for Callahan County WSC
(2) Includes projections for Burkett WSC
(3) Will be served by Coleman County WSC
(4) Includes 10 MG/yr to gas plant
(5) Has large number of lake lots-recreation customers
(6) Also has well production
(7) Has 1357 customers (237 in Runnels County)
(8) Includes 164 meters in the city of Moran
(9) Includes water sold to Tuscola (315 meters)

APPENDIX D

EVALUATION OF LEGAL AND FINANCIAL ISSUES

LAW OFFICES OF
DAVIDSON, TROILO & BOOTH
A PROFESSIONAL CORPORATION
FORMERLY SAWTELLE, GOODE, DAVIDSON & TROILO AND BOOTH & NEWSOM

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July 10, 1991

VIA FACSIMILE NO. 817/877-4267

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Mr. Mike Nichols
Freese & Nichols, Inc.
811 Lamar Street
Fort Worth, Texas 76102

RE: West Central Texas Municipal Water Authority; Freese & Nichols, Inc., Account No. WCT89130

Dear Mike:

In connection with a Regional Water Supply Study your firm is conducting for the West Central Texas Municipal Water Authority and others, you request our opinion concerning various matters relating to legal issues which may impact on the conclusions and recommendations your firm will make concerning the development of future water supply for the area involved in the study. This opinion consists of three parts. The first deals with answers to 18 legal questions which have been developed in the planning effort, the second deals with general observations and recommendations, and the third part deals with qualifications and assumptions.

PART 1. SPECIFIC QUESTIONS

Question No. 1:

What is the nature of the district's rights to impound, divert and appropriate water from Hubbard Creek Lake?

Answer:

By virtue of its certificate of adjudication, the district has the legal right to impound, divert and appropriate for beneficial use water impounded in Hubbard Creek Lake. Exercise of this right is defined by, and limited to, the conditions of the certificate of adjudication. The right is recognized in water law as a right of use or a usufruct. The right is a vested property right subject to cancellation for non-use as provided in the Texas Water Code. The district's right to appropriate water in Hubbard Creek Lake for beneficial purposes is further limited by its existing outstanding water supply contracts with its member cities and others, if any.

Question No. 2:

If there were any unappropriated and available water from Hubbard Creek Lake, by whom would such water be owned, or if not "owned," who would control the disposition of such water?

Answer:

Surface water in Texas belongs to the state. An appropriator is one who obtains a right to impound, divert and use state water for beneficial use and who thereafter perfects the right by construction of the approved facilities and actually using the water for beneficial purposes as authorized in the water permit or certificate of adjudication. If water is available from Hubbard Creek Lake in amounts in excess of the diversion rights specified in the certificate of adjudication, such water would be unappropriated. The district could obtain an amendment to its certificate of adjudication to appropriate such water and would control disposition and use of such water, limited only by the terms of the amendment, the act creating the district, as amended, and water supply contracts in existence and outstanding.

If water is available from Hubbard Creek Lake within the amounts authorized the certificate of adjudication, but in excess of the amounts required to be provided by the district's existing water supply contracts, this excess amount is appropriated water subject to the district's disposition, limited only by the certificate of adjudication, the district's existing water supply contracts and the act creating the district. The district is authorized to acquire, own and dispose of water in excess of the amounts contracted to its member cities and others, if any, limited by its member city contracts which provide that the district will not sell water to any customer now being served by the city or reasonably capable of being served by the city's distribution system without the city's consent. The 1985 amendment to the act creating the district appears to have removed the original area limitation for providing water and now states the district may sell water inside and outside its boundaries.

Question No. 3:

Is all Hubbard Creek Lake water authorized to be diverted by the certificate of adjudication contracted for in the district's water supply contracts with its member cities and others, if any?

Answer:

The district's water supply contracts, as amended, with its member cities of Abilene, Albany, Anson and Breckenridge each require, subject to the district's ability to provide and according to a formula, an average specified million gallons per day. The district's engineers can calculate the formula's impact on the district's commitment to provide water under its various contracts and compare that with the water available for diversion from Hubbard Creek Lake. If the contract amounts are less than the authorized diversion amount, the district has additional water to sell to others. Caution should be exercised in making such a determination and relevant issues to be considered are the yield of Hubbard Creek Lake with a safety factor for municipal water supply and loss of storage capacity and yield overtime due to siltation. Theoretically, both long-term and short-term contracts might be possible.

Question No. 4:

By existing contract, "title" to water from Hubbard Creek Lake passes to a member city or other purchaser of water at the "specified point of delivery." Title to state water in Texas belongs to the state according to common understanding. What is the legal resolution and implications of this possible conflict?

Answer:

There is case authority conflict and confusion in Texas concerning the "title" issue. Generally, under the usufruct doctrine, the state retains title to public or state water insofar as the molecules are concerned and the appropriator has a right to use the water in accordance with the permit or certificate of adjudication. Confusion exists concerning the Texas Water Commission's view that the state retains title to public water after it is reduced to possession by the appropriator by actual diversion. This issue normally occurs where reuse of return flows from irrigation and treated sewage effluent is proposed. The TWC generally has resolved the issue in its reuse rules and by permit or certificate of adjudication amendment where reuse is proposed for a purpose not authorized in the permit or certificate of adjudication.

Water supply contracts such as those the district has with its customers provide that title passes from the supplier to the customer at a specified delivery point. This provision is designed to clarify the legal liabilities involved in operations and means that the district retains control and liability for damages, etc., up to the point of delivery and then the customer assumes the control and liability.

Some contracts and one statute applicable to the Trinity River Authority of Texas provide that title to treated sewage effluent returns to the supplier when discharged or, in TRA's case, when the sewage is introduced into TRA's sewage collection system. At the present time, the district's customers retain title to their treated sewage effluent up to the time the same is abandoned by discharge into a public watercourse.

Question No. 5:

May a member city of the district, with or without the consent of the district, sell, trade, exchange or otherwise transfer any portion of its "banked water" or water withdrawal rights under the existing contracts between the district and its member cities?

Answer:

The district's contracts with its member cities are silent on this issue. Since title remains in the district to the delivery point, we believe the contractual rights acquired by the district's member cities is the right for the city to receive water at that point. "Banked water" appears to us to be an operating part of the formula for delivery of water and creates no independent right in the member cities. While not absolutely free from disagreement, we believe the contract provision whereby the district agreed to provide, and the member cities agreed to purchase for their own use, and for distribution to all of the customers served by the cities' distribution system, precludes the member cities from transferring all or part of its contract to anyone else.

Question No. 6:

Do the existing water contracts between the district and its four member cities expressly authorize, or permit by clear implication, any of the following:

a. Sale of water by one member city to another member city;

b. Sale of water by a member city to a non-member city, or to another water district, water supply corporation or other private person, firm or corporation; or

c. Transfer or exchange, with or without the consent of the district, of any water contract or permit right; whether obtained from the district with respect to Hubbard Creek water or any other source from which a member presently obtains water?

Answer:

The district's contracts with its member cities pertaining to Hubbard Creek Lake each provide that the "city agrees to purchase water for its own use and for distribution to all of the customers served by the city's distribution system." This provision precludes the sale of Hubbard Creek Lake water to others, whether member cities or not, unless the customer is served by the city's distribution system. This conclusion is supported by other contract provisions which provide that the district will not serve water to any customer served by a city or reasonably capable of being served by the city and that any contract to supply water by the district shall be subordinated to the district's obligation to provide water to its member cities. The 1971 contract series precluded the member cities from selling water for mining and oil field flooding. These contracts appear to have terminated and the limitation was not carried forward in the 1985 amendments. As stated in the answer to question number 5, we conclude that the Hubbard Creek Lake contracts preclude the district's member cities from transferring all or any part of their contracts to anyone else.

To the extent that the district's member cities obtain water from sources other than Hubbard Creek Lake, with but one exception, we find no contract provision which precludes the member city from selling water or conveying contract rights or water rights to others without the district's consent. The Stacy contracts between the district and Abilene provide that all water from Stacy is for Abilene's use. There are no contractual limitations on Abilene's use of Stacy water, except that the contracts cannot be assigned to others.

Question No. 7:

Are the existing water rights of the district and/or other cities, towns, water supply corporations and other entities within the area covered by the Regional Water Supply Study subject to future adjudication, cancellation or reduction under existing law or future legislation?

Answer:

Water rights to use state water have been adjudicated and are not subject to future adjudication under the Texas Water Code. All such water rights are subject to cancellation, in whole or in part, for ten years nonuse of water or failure to construct facilities required to be built under the particular adjudicated water right. These Water Code provisions contain certain limitations and defenses to cancellation. Subject to certain constitutional arguments, future legislation could reduce the amount of water authorized to be appropriated under an adjudicated water right or subsequently issued water permit.

Section 7 of the district's enabling act authorizes the Texas Water Commission, upon application of the district or at the will of the Commission, to modify the district's water rights to increase or decrease the amount of water that may be impounded or diverted. This section provides certain criteria that the Commission must consider before modifying the water rights.

Question No. 8:

May the State of Texas, under existing or future legislation, transfer presently vested water rights from one entity to another, either in the same basin area or between different water basins?

Answer:

The Texas Water Code authorizes the Texas Water Commission, upon appropriate petition, to compel anyone who has conserved state water not used or committed to others to provide water to anyone who is entitled to use the water upon reasonable terms and price. There is little case authority defining the limits of the Commission's jurisdiction under these provisions of the Water Code. If water is to be transferred from one river basin to another, the Texas Water Code precludes such a transfer unless the benefits to the receiving basin outweigh the detriment to the losing basin. Where Texas Water Development Board financing is involved, state water may not be transferred from one river basin except on a temporary basis if the water is reasonably needed in the river basin of origin during the next 50 years.

Question No. 9:

Under what conditions could the district be expanded to include additional cities, towns and municipal corporations and what legislative and legal procedures would be required?

Answer:

The 1955 amendment to the act creating the district, as amended in 1959, authorizes the district to annex other territory situated in Taylor, Jones, Shackelford and Stephens Counties by following the annexation procedures contained in the Act, as amended. The legislature could amend the act creating the district to provide different procedures for annexation or to annex areas directly. A 1985 amendment to the district's enabling act removed the previous area limitations on the district's service area and the district now may provide water to cities and others for municipal, domestic, industrial and mining purposes inside or outside the boundaries of the district. With the 1985 amendment, there is no particular reason the district needs to annex additional territory, except to make the annexed territory subject to the district's ad valorum tax.

Question No. 10:

If the difference between short-term and long-term safe yield of Hubbard Creek or other area reservoir available for sale to member cities, non-member cities, water supply districts or corporations, or other private entities?

Answer:

The yield of a reservoir is not a legal limitation upon sale of water from the reservoir. The amount of water authorized to be diverted for beneficial purposes is the legal constraint. Where water is provided by contract on a dependable basis, prudence dictates consideration of dependable and/or safe yields. Where water is contracted for on a long-term basis, but the current demand is less than the contracted amount, the district may sell the unused water under short-term contracts, subordinated to the long-term contracts, unless precluded by the long-term contracts. We find no provision in the district's member city contracts which preclude short-term sales from Hubbard Creek Lake. The Stacy contracts are an exception and the district may not sell Stacy water to anyone other than Abilene without Abilene's consent.

Question No. 11:

Could a water sales contract be written to effectively allow unilateral termination of water delivery upon expiration of the contract term? Would the purpose of water use (e.g. municipal, industrial, irrigation) affect the ability to unilaterally terminate the contract?

Answer:

Short-term or surplus water contracts for water supply are not precluded in law. When the Texas Water Commission's jurisdiction to compel water service under certain circumstances and politics are considered, experience demonstrates that it sometimes is difficult to terminate service under a short-term contract for municipal or domestic use where the user has no other source of water. These kinds of contracts should be carefully structured and include provisions which compel the municipal and domestic customers to acquire an additional source of water prior to the termination date of the short-term contract.

Question No. 12:

Does any present law, or could any future legislation, prohibit unilateral termination of water delivery, even if permitted or required by contact, on the basis of public policy, public interest or similar grounds?

Answer:

Except as qualified in the answer to question number 11, there is no present law which prohibits termination of water supply in accordance with the provisions of the contract. The Texas Water Code recognizes surplus water contracts by certain irrigation districts such as water control and improvement districts. Whether future legislation could abrogate existing short-term contracts presents a complex constitutional issue. Case authority on this subject is not determinative at this time whether political subdivisions of the state have constitutionally protected rights.

Question No. 13:

Can the City of Cisco legally trade or exchange its permitted water rights on Battle Creek. Could the district or one of its member cities contract for water rights from Hubbard Creek in exchange for similar water volumes from the existing Cisco permit?

Answer:

Cisco could trade or exchange its water rights on Battle Creek provided the Texas Water Commission authorized, by certificate of adjudication amendment, any change of place or purpose of use. Member cities of the district cannot contract for water rights from Hubbard Creek Lake in exchange for similar volumes of water from the Cisco permit without the district's consent.

Question No. 14:

Does the current district policy of releasing water from Hubbard Creek Lake in order to maintain the lake level below the 1183 ft. msl conservation level affect the rights of the member cities under their existing water purchase contracts?

Answer:

The district's member cities have a contractual right to receive specified volumes of water from Hubbard Creek Lake. To the extent that district operations of the lake do not prevent the district from supplying the daily and annual amounts the member cities are entitled to under their contracts, the contract rights of the cities are not impaired.

Where district reservoir operations reduce the amount of water a member city is entitled to at the time the city desires the water, a somewhat more complicated problem arises. Recognizing the possibility of a difference of opinion, our qualified answer is that reasonable lake operations are within the district's prerogative, even if the same impairs its ability to provide water to its member cities in the amounts and at the times provided in the contracts.

Question No. 15:

If any governmental entity (e.g., the district) develops a water resale policy of requiring full back payment of all water system costs that have been contributed by its own members or constituents, would any purchasing entity be able to establish a legal claim that it should be, or has a right to be considered and treated as, a member of equal standing and equity to the existing members of the selling entity?

Answer:

Generally, the answer to this question is no. The right to receive water and the price to be paid for water may be an exception to the answer. Tarrant County WCID No. 1 has a contract with certain of its customers which provides for an equitable surcharge to benefit Fort Worth's contributions to certain pre-existing reservoirs and a premium to be paid by subsequent customers to recognize the contributions of existing customers. This is a form of equitable buy in to an existing system. Various rate designs are recognized in some jurisdictions which address the rate equity problem. Great care should be taken when developing such a service and rate design concept, because the Texas Water Commission has jurisdiction over the subject matter and heretofore its actions have been inconsistent when presented with a specific rate case.

Question No. 16:

If the yield of a reservoir is enhanced by conjunctive reservoir use (with another reservoir), who owns the additional yield? How can this enhanced additional yield be utilized by the above-determined owners for use or transfer?

Answer:

In the absence of contracts which address ownership or use of additional yield created by conjunctive or system operations of multiple reservoirs, any increase in yield would be owned and controlled by the entity developing the system operation. For example, if the district owned or controlled two or more sources of water, whether two or more reservoirs or conjunctive use of a single reservoir with groundwater supply, the increased yield would belong to the district and available to the district to supply water by contract to existing or new customers within or without the district's boundaries. The method used to finance conjunctive use facilities ordinarily will determine use of increased yields in the contracts made to secure issuance of tax or revenue bonds.

If the entity developing conjunctive reservoir use does not own both conjunctive use sources, the answer is different. For example, should Abilene be able to use Hubbard Creek Lake conjunctively with its Fort Phantom Hill Reservoir so as to increase the available water supply from Fort Phantom Hill, the additional supply would belong to Abilene because it owns Fort Phantom Hill and has a contract with the district which does not restrict Abilene's conjunctive use.

Question No. 17:

What are the legal issues and liabilities that must be considered prior to, and as part of, any weather modification program?

Answer:

The Texas Water Code authorizes the Texas Water Commission to grant annual permits for weather modification under certain conditions. Texas Water Commission rules amplify the procedure. While there remains some possibility for liability to landowners who allege injury or damage due to too little or too much rainfall or from hail damage, the case law on the subject is not developed in any positive sense. Legal issues involved are negligence and inverse condemnation. Sovereign immunity may be available as a defense to the district in tort actions, depending upon the court's construction of the Texas Tort Claims Act in this respect. An argument can be made that sovereign immunity is not waived under the Tort Claims Act. Inverse condemnation involves constitutional protection from damages to, or taking of, real property and is outside the sovereign immunity doctrine. Inverse condemnation involves specific fact issues and probably would involve allegations of damage to real property rather than taking. No case authority is dispositive of these issues and most likely persons who allege such damage would have difficulty in their proof of fact. While there appears to be no real statistical correlation between weather modification efforts and weather changes, Colorado River Municipal Water District, for example, has had an ongoing weather modification project for several years.

Question No. 18:

Under what conditions could community use of point of entrance (home) treatment satisfy the requirements of the Texas Department of Health, or other regulatory authority, regarding community water supplies?

Answer:

Regulatory agencies with jurisdiction in the area of domestic water supply are the Texas Health Department, the U.S. Environmental Protection Agency and the Texas Water Commission. EPA promulgates national drinking water standards. The Texas Health Department regulates furnishing public drinking water. The Texas Water Commission regulates the furnishing of potable drinking water by issuance of certificates of convenience and necessity and by tariff regulates the conditions of service and price.

Regulation of point of entry supply and treatment is poorly developed. The Texas Health Department considers such activities on a case-by-case basis and appears to avoid regulation where possible under particular facts. There appears to be some difference of opinion between the Texas Health Department and the Regional EPA as to the minimum criteria necessary to result in regulation. Depending upon the specific facts of a system providing untreated water for home entrance treatment, regulation can occur or may be avoided.

PART 2. GENERAL OBSERVATIONS AND RECOMMENDATIONS

Development of a regional water supply feasibility study and report in the planning process involves developing the technical data relating to areas of water supply demand, presently available water supplies, potential developable future water supplies and economic feasibility. Such a study also involves consideration of interlocal governmental relationships and legal constraints. Where necessary, assumptions must be made that interlocal governmental relationships can be resolved and existing contractual restraints can be resolved by mutual agreement. The assumptions should be made that other legal constraints can be avoided or legislation enacted to authorize development of regional water supplies, if constrained by existing laws. The approach should recognize existing institutional arrangements and assume the same can be resolved, if they constrain implementation of the plan. Once specific implemental problems are identified, the assumption should be made that each can be resolved as the specific implementation details are addressed.

PART 3. QUALIFICATIONS AND ASSUMPTIONS

The foregoing opinion is expressly limited by the following qualifications and assumptions:

A. The opinions expressed are based upon documents furnished, facts assumed or furnished, as noted in the opinion and are limited to the same.

B. This opinion is supplied solely for your information and use in connection with the matter described above and should not be quoted or otherwise referred to in any financial statement or any other documents, in whole or in part, or furnished to any other person or agency without our prior written consent.

C. This opinion reflects our current opinion on the legal and factual issues addressed, and it is based on current applicable legal authorities. Future court decisions, legislation, and other relevant developments, however, can change the law. Before applying this opinion in the future, therefore, it is essential to determine whether the law has changed in any respect that would necessitate a revision of the opinion expressed.

D. The opinions expressed are limited to the matters expressly stated. No opinion is implied, and none should be inferred, beyond the opinions expressly stated.

E. The opinions herein expressed are intended for planning purposes and are not intended to be dispositive of matters which are, or may become, disputed issues between third parites Should disputes between third parties exist or arise, resolution of such disputes by opinion must focus more specifically on the particular facts as the same relate to applicable law.

Very truly yours,

Frank R. Booth

Frank R. Booth

cc: David Bell
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June 21, 1991

JOSEPH W. SMITH
SENIOR VICE PRESIDENT

(915) 672-8432

Mr. David E. Bell
General Manager
West Central Texas Municipal Water District
P. O. Box 2362
Abilene, Texas 79604

Re: Regional Water Study
Financing Alternatives

Dear Mr. Bell:

As requested by you the following is a general review of financing alternatives available to the participants in the Regional Water Study (the "Study") being conducted by the West Central Texas Municipal Water District (the "District").

The Study encompasses a 10-county area and participants that include 13 incorporated cities, 2 Water Supply Corporations, 1 Fresh Water Supply District and the District.

Potential souces of water supply include the City of Coleman, a non-participant, and Brown County Water Improvement District which owns and operates Lake Brownwood and is not in the 10-county study area.

The 13 participant cities include several cities that operate under Home Rule Charters and others that are organized and operate under the general laws of the State.

<u>General Direct Financing Alternatives Available to Cities</u>

The sources available to cities for securing debt obligations issued for waterworks system improvements, including water supply, are generally ad valorem taxes and the net revenues of the City's Waterworks System, or, as is more common, the combined Waterworks and Sewer System (the "System").

General Obligation Bonds (ad valorem tax pledge) Issued by Cities

General obligation bonds are a pledge of the full faith and credit of the city. Cities can authorize the issuance of general obligation bonds, other than refunding bonds, only by approval at an election by the qualified voters of a specific proposition, such as waterworks improvements, for a designated dollar amount of bonds.

Home Rule Charter Cities and General Obligation Bonds

Home Rule Charter cities, such as the City of Abilene, have a constitutional maximum tax rate of $2.50 per $100 assessed valuation, but this maximum rate may be further limited in the Charter. In the Abilene example the Charter adopts the Constitutional maximum tax rate.

The State Attorney General uses a "rule-of-thumb" in approving general obligation bonds of Home Rule Charter cities. As an example, Abilene must be able to demonstrate that it can provide for total annual debt service of all of its general obligation debt from a $1.50 tax rate based on 90% collection. Due to the State Property Tax Code requirement that all taxable property be appraised at market value this test has become largely academic but must still be met based on an allocation of the maximum tax rate permitted by the Charter.

Debt service on general obligation bonds issued for waterworks purposes, while backed by an ad valorem tax, is often in practice fully provided from surplus net revenues of the City's System making the bonds "self-supporting". Even so debt service of "self-supporting general obligation bonds" must be included in the test described in the preceding paragraph.

General Law Cities

General Law cities, such as the City of Hamlin, have a constitutional maximum tax rate of $1.50 per $100 assessed valuation. The Attorney General's rule-of-thumb test for general law cities is the same as for Home Rule Charter cities except the calculation must be based on a $1.00 tax rate at 90% collection.

Revenue Bonds Issued by Cities

Revenue bonds are a special obligation of the city payable solely from a source of pledged revenues and not from ad valorem taxes.

The most common revenue bond examples among the participating cities are Waterworks and Sewer System Revenue Bonds with proceeds used for System improvements and debt service secured by a pledge of the net revenues of the System remaining after operations. The pledge of net revenues may be junior or otherwise subordinate to other System revenue bond issues.

Revenue bonds can usually be authorized by proper notice and if no protest (petition, 10% of qualified voters) is received an election is not required.

Since the credit integrity of a revenue bond is the net revenue of the System, a rate structure adequate for operations, debt service and a surplus for capital expenditures is essential.

As a rule, water purchases by a city under contractual agreements with a district or another city are an operating expense of the city's System and rank in priority ahead of its revenue bonds.

Certificates of Obligation ("Certificates") Issued by Cities

Certificates have become a useful tool of city System financing, often taking the form of being secured by a combination of an ad valorem tax and a lien (usually subordinate to that held by System revenue bonds) on the net revenues or surplus net revenues of the System.

Certificates secured in this manner are evaluated by analysts for rating agencies, the Attorney General and the market as a general obligation of the City regardless of the actual source of sinking fund support, such as surplus System net revenues, since the ad valorem tax pledge provides basic credit integrity.

Certificates do not require an election unless a protest (petition, 5% of qualified voters) is received after proper notice.

Other Methods Available to Cities

Cities can enter into contractual agreements with water districts/authorities for the purchase of water and the construction of water supply facilities either as a project of the district/authority itself or as a special project of the district/authority on behalf of the city.

These financing mechanisms are discussed below.

Water District Financing

In general water districts are authorized to issue bonds for permitted district water system construction and improvements. The bonds can be payable from taxes, from revenues, from a combination of taxes and revenues or, in the case of a special project, a pledge by a city to secure the bonds by payments to the district of the required amounts for operations and debt service.

As a general rule any bonds wholly or partially payable from ad valorem taxes must be authorized at an election.

Water districts created under Article XVI, Section 59 of the Constitution and some other water districts are subject to supervision by the Texas Water Commission.

The two water districts that may play a role in financing water supply alternatives visualized under the Regional Water Study are the West Central Texas Municipal Water District and Brown County Water Improvement District No. 1.

West Central Texas Municipal Water District

For general District projects, such as the construction of Hubbard Creek Reservoir and the District's water supply transmission system, the District can issue bonds payable wholly or in part from ad valorem taxes, bonds payable from ad valorem taxes and revenues, or bonds payable solely from revenues.

Section 8a (c), Article 8280-162, West Central Texas Municipal Water District, as amended, states:

> "The District may acquire, construct, finance, or otherwise provide any kind or type of water facilities, water pollution control facilities, waste disposal facilities, and pollution control facilities in any area
>
> (1) within the Clear Fork of the Brazos River Watershed and its tributaries;
>
> (2) within Jones, Shackelford, Stephens, and Taylor Counties; and
>
> (3) inside or outside the boundaries of the areas described in Subdivisions (1) and (2) of this subsection with respect to water facilities designed primarily to serve inhabitants within those areas except as otherwise limited by this section".

The District's System was financed through the issuance of bonds payable from ad valorem taxes and the net revenues of the System; the bonds were authorized by election. In practice, debt service on the bonds has been paid from ad valorem taxes.

Special Project Revenue Bonds Issued by the District

The District can issue bonds for specific water projects on behalf of a city or other entity, whether a member of the District or not, provided the project serves an area as described in the preceding paragraph.

The Special Project Revenue Bonds would be secured by contractual agreements with a city or cities to make the necessary payments to the District for operating expense and debt service. The contracting city or cities are the sole source of these payments and the District or its member cities have no liability, except to the extent that one of them may be a contracting party of the Special Project.

An example of Special Project Revenue Bond financing is the Water Transmission Line Contract Revenue Bonds (City of Abilene Project) originally issued by the District in 1986 for construction of the parallel pipeline to Hubbard Creek Reservoir.

Special project revenue bonds can be secured by revenues of the city's System, as in the Abilene example, or, in certain cases, by revenues and ad valorem taxes.

Brown County Water Improvement District No. 1

Brown County Water Improvement District No. 1 comprises 24,965 acres in Brown County and includes a majority of the area of the City of Brownwood. The District owns and operates Lake Brownwood. The District does not have member cities; the City of Brownwood is its principal customer; other Contracting Parties include the Cities of Early, Bangs and Santa Anna, two water supply corporations and others. The District delivers treated and untreated water under water supply contracts with its customers. Generally the District has the same ability to issue bonds as West Central Texas Municipal Water District.

However, in recent decades, all District bond financing for District projects such as Lake Brownwood Dam improvements, main gravity line construction, auxiliary pump station construction and treatment plant expansion has been accomplished with bonds payable solely from revenues received from water supply contracts with the City of Brownwood and other Contracting Parties.

The District has reserved the right in the Resolutions authorizing issuance of its outstanding bonds "to issue Special Project Bonds to acquire or construct a separate project which is expected to be self-liquidating". These Special Project Bonds would be payable from revenues received pursuant to contractual agreements with no liability to the District or any other city or entity.

Whether the District has any interest in the issuance of Special Project Revenue Bonds is a matter for consideration by the Board of Directors.

Sources of Funding for Proposed Debt Financing

The Public Market

The City of Abilene and the West Central Texas Municipal Water District have had regular and successful access to public tax-exempt bond markets for many years as needed. Strong finances and management together with population and other strengths have resulted in high level investment grade ratings from the rating agencies. Brown County Water Improvement District No. 1 successfully marketed $5,250,000 Series 1985 Revenue Bonds to finance treatment plant expansion.

Public marketing remains a sound option for any financing plan, but the magnitude of costs involved in some of the System segment alternatives may well mean that other sources must be considered.

Local Financing

Several participating cities have successfully sold debt obligations to their local depository bank or local banks. Financing of this type is generally with a short-term maturity schedule (10 years or less) and would be difficult for a long-term, high cost water supply project.

Texas Water Development Board (the "TWDB")

For many years, the TWDB has offered a water supply loan program for Texas cities and water districts, and, in recent years, has added a program for water supply corporations.

The water supply program has been broadened in scope significantly by the regional facility rule which means that the applicant's system incorporates multiple service areas or serves an area that is other than a single county, city, special district or other political subdivision of the State. A regional system does not have to prove hardship; facilities not determined to be regional in scope must prove hardship.

Several participants have greatly benefited in the past from TWDB water supply loans.

Generally, water supply loans mature over a 20-25 year period at an interest rate set by TWDB that is usually calculated at the average interest rate of TWDB's last State bond sale for water supply plus 1/2 of 1%.

The recipient of a water supply loan delivers a legally issued debt obligation such as bonds or certificates of obligation to TWDB as evidence of the loan.

The TWDB is a significant and valid consideration under any financing plan developed from the Regional Water Study. The TWDB loan program is highly efficient and has been of proven worth to the State of Texas and its citizens.

Farmers Home Administration ("FmHA")

The FmHA Water and Waste Disposal loan and grant program includes loans to cities and water districts for water supply improvements and facilities. There is a loan program for water supply corporations.

Eligibility in general is based on a population, as in a city, of not exceeding 10,000 with priority given to public entities of less than 5,500 population.

The program is available to applicants who are unable to obtain funds from other sources at reasonable rates and terms.

FmHA loans can mature over a maximum of 40 years with interest rates tied to three levels; two of these levels are below the market rate (the third level) with eligibility determined by median household income as determined from the latest U.S. census compared to State median household income levels.

The lowest interest rate program, the Poverty line rate, currently 5%, is also tied to the correction of a defined standards violation through construction of the project. An example is deficient water treatment for which a city has been notified or cited for a violation by the State Department of Health. The poverty line program also brings eligibility for FmHA grant consideration which could be significant if projected water rates are driven measurably over those of surrounding cities of similar population.

Several cities and other entities in the study area have received long-term FmHA loans for various water and sewer system projects in the past.

As with the TWDB program evidence of a FmHA loan is by delivery of legally issued debt obligations such as bonds or certificates of obligation. Loan pre-applications are initiated with the FmHA District Office (District #8 is located in Abilene).

Where applicable the FmHA Loan Program may have definite advantages that must be considered. The combination of a low interest rate combined with an extended maturity schedule of up to 40 years could make a difference in project feasibility.

This review has been designed to discuss financing alternatives in general terms. Please let me know if I can assist you in answering specific questions.

Yours very truly,

Joe W. Smith

JWS:gc

ADDITIONAL NOTE ON FINANCING ALTERNATIVES

In addition to the loan program for regional facilities indicated on Page 6 of the letter from the First Southwest Company, the Texas Water Development Board also participates in projects involving conversion from groundwater to surface water supply.

APPENDIX E

WATER CONSERVATION PLAN

WEST CENTRAL TEXAS REGIONAL WATER STUDY

Conservation and Drought Contingency Plan

Study Sponsored
by the

WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT

FREESE AND NICHOLS, INC.

December 1991

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1. INTRODUCTION

1.1 Description of the Planning Area

On August 8, 1989 a contract was entered into between the West Central Texas Municipal Water District (WCTMWD) and three engineering firms - Jacob & Martin, Inc.; Todd Engineering, Inc.; and Freese and Nichols, Inc. to undertake a 10-county regional water study. The counties included in the study are: Callahan, Coleman, Eastland, Fisher, Jones, Nolan, Runnels, Shackelford, Stephens, and Taylor Counties. Other participating entities include the following cities and water supply corporations: Abilene, Albany, Anson, Baird, Breckenridge, Cisco, Cross Plains, Hamlin, Hawley Water Supply Corporation, Moran, Shackelford Water Supply Corporation, Stamford, Sweetwater, Tuscola, Taylor County Fresh Water Supply District #1, Tye, and Woodson. Figure 1.1 and 1.2 in the main text (Vol. II) are maps of the study area showing the participants.

Created in 1955, the West Central Texas Municipal Water District(WCTMWD) was formed to meet anticipated future demands within the cities of Abilene, Albany, Anson, and Breckenridge. The four member cities each own at least one surface water reservoir which is capable of meeting only a portion of their water needs. Therefore, it is the goal of the WCTMWD to provide the member cities a supplemental water source for municipal, domestic, industrial, and mining use, as well as to provide transportation of this raw water to member cities.

1.2 Utility Evaluation Data

Rather than provide a separate discussion of each participant with regard to their current utility status, a summary is provided in Table 1. A review of the information presented in the table reveals that the city of Abilene represents slightly more than 72 percent of the region based on population. The 1990 estimate for Abilene indicates a population of 114,209 persons. The second largest city, according to their population, is the city of Sweetwater with an estimate of 12,535 persons. The smallest city in the region as far as participants are concerned is the city of Woodson with 291 persons which represents less than 1 percent of the study area's population. The 10 county region's total participants' population estimate for 1990 is 235,316 persons. The total population for the 10-county area based on 1985 Census figures indicated 234,558 persons.

The sum total of all connections during 1988 for the region was 48,055 residential connections, 5,207 commercial and 45 industrial connections. The city of Sweetwater indicated the second highest number of residential connections below Abilene with 4,843 connections. Only five entities contained any industrial connections - Abilene, Breckenridge, Cisco, Hawley Water Supply Corporation (WSC), and Sweetwater. The lowest number of residential connections was shown to be in the city of Woodson (137) and the fewest commercial connections was found in Shackelford WSC (11).

The rate of connections per year is derived from information

TABLE 1

UTILITY EVALUATION SUMMARY FOR THE 10-COUNTY STUDY AREA

Entity	1989 Pop. Estimate	1988 Connections Res.	1988 Connections Com.	1988 Connections Ind.	Average Rate of Connections/Year Res.	Average Rate of Connections/Year Com.	Average Rate of Connections/Year Ind.	Annual Consumption Rate by Customer (MG) Res.	Annual Consumption Rate by Customer (MG) Com.	Annual Consumption Rate by Customer (MG) Ind.	Total Annual Consumption 1988, (MG)
Abilene	108,386	29,794	3,903	21	(139.00)	87.00	0.25	3,938.00	1,228.00	1,285.50	7,373.00
Albany	1,800	1,150	30		(50.00)	I		I	I		231.00
Anson	2,650	1,073	120		5.00	(3.50)		162.51	16.43		182.60
Baird	1,740	690	75		11.25	3.75		I	I		108.00
Breckenridge	6,538	2,366	390	14	(59.25)	(10.00)	(1.00)	309.00	62.00	21.00	533.00
Cisco	4,628	1,576	119	6	(11.00)	(1.50)		189.20	I	0.70	226.00
Cross-Plains	1,100	500	93		(1.25)	1.75		0.04	0.01		70.50
Hamlin	3,281	1,096	128		(0.75)	(0.50)		77.40	39.60		234.00
Hawley WSC	I	1,531	30	4	95.26	3.75		I	I		85.34
Moran	303	150	18		(4.25)	(0.25)		7.07	0.82		8.00
Shackelford WSC	I	755	11		0.75	I		I	I		44.40
Stamford	4,500	1,652	183		(24.25)	2.25		I	I		430.30
Sweetwater	12,600	4,843			(13.50)	I		I	I	I	1,458.62
Tuscola, Taylor Co. FWSD	650	309	16		1.50	0.75		I	I		26.70
Tye	1,300	433	66		(93.00)	(0.50)		I	I		50.53
Woodson	291	137	25		(1.50)	(1.00)		8.47	5.85		15.40
TOTALS	149,767	48,055	5,207	45							11,077.40

Table 1 (continued)

Entity	Avg. Daily Per Capita Use 1988, (GPCD)	Avg. Daily Demand 1988, (MGPD)	Maximum Daily Demand (MGPD)	Max.-Average Day Ratio	Avg. Mo. Prod. for last 2 yrs May-Sept. (MG)	Peak Daily Capacity (MGD)	Conservation Practices	Water Rate Structure Uni-form	Water Rate Structure Increasing Block	Water Rate Structure Declining Block
Abilene	172.30	20.200	40.117	2.00	722.880	52.00	Since 1983		*	
Albany	351.60	0.630	1.584	2.51	24.061	1.70	None		*	
Anson	182.63	0.560	0.721	1.30	19.581	1.4	Minimal	*		
Baird	188.81	0.296	0.500	1.70	9.000	0.46	None	*		
Breckenridge	174.00	1.459	2.989	2.05	53.789	3.40	None			*
Cisco	193.00	0.621	1.197	1.93	22.508	4.50	Adapted-Abilene		*	
Cross-Plains	133.98	0.125	0.296	2.37	4.000	0.65	Minimal	*		
Hamlin	175.70	0.641	1.735	2.71	22.785	1.62	None	*		
Hawley WSC	161.83	I	I	I	I	I	Adapted-Abilene		*	
Moran	72.34	0.022	0.064	2.91	0.736	I	None	*		
Shackelford WSC	I	0.122	0.256	2.10	5.000	I	None	*		
Stamford	262.00	1.180	2.193	1.86	45.980	3.00	None		*	
Sweetwater	317.16	3.996	7.189	1.80	122.026	7.50	Minimal		*	
Tuscola, Taylor Co. FWSD	110.40	0.073	0.157	2.15	2.560	0.20	None	*		
Tye	88.40	0.138	0.212	1.54	4.732	I	Follows Abilene	*		
Woodson	145.00	0.042	0.103	2.44	1.630	0.16		None	*	
Totals						76.59				

Note: I=Insufficient Data

provided in the various water audits and is based on growth within the last five years. As noted in the table, many cities have experienced major declines in their rate of connections perhaps due to an increase of out-migration occurring due to the downturn in the oil industry.

The total annual consumption in 1988 for the regional study area was 11,077 MG or 33,995 acre-feet for the study's participants.The city of Abilene was the highest with 7,373 MG while Sweetwater was second with 1,458 MG. Moran consumed the least amount of water in 1988 with 8.0 MG. The average daily per capita use is calculated by dividing the total system output by the population, and then dividing by 365. As a region, 170.57 gpcd was an average daily per capita use. The city of Albany far exceeded this average at 351.60 gpcd and Moran was well below the average at 72.34 gpcd. The average daily demand and maximum daily demand figures are combined to form a maximum to average day ratio which for the region was 1.96 overall. The city of Moran was the highest with a ratio of 2.91 and the city of Anson was the lowest with a 1.30 ratio.

Considering the highest demand periods during the year from May to September an average monthly production was determined across the region with the highest production level identified by the city of Abilene with 722.880 MG and the lowest the city of Moran at 0.736 MG.

Additional information discussed in Table 1 is the peak daily capacity for each city or water supply corporation, the conservation practices followed by each entity, and the water rate structures utilized by each. As noted in the table, many of the participants do not currently have conservation plans developed which explains the need for one to be endorsed by the region and the entities to subsequently adapt it according to their water demand situation and future needs.

1.3 Need For and Goals of the Program

The objective of a water conservation program is to reduce the quantity required for each water using activity, insofar as is practical, through the implementation of efficient water use practices. A drought contingency program provides procedures for voluntary and mandatory actions to be put into effect to temporarily reduce the demand placed upon a water supply system during a water shortage emergency. Drought contingency procedures include conservation but may also include prohibition of certain uses. Both programs are tools that water purveyors should have available to operate effectively in all situations. The establishment of program goals will depend on the reason for developing a conservation program. The reason for a program is usually to address a specific need or set of needs. The water audit, which each participant has completed for this regional study, is a first important step in determining needs. Expressed in simple terms, the function of the audit is to define the current utility situation. The next step is to define the problems or other needs identified through the audit and to determine those areas where conservation can help. By following this procedure, the city or utility is able to bring together information, much of which was previously unavailable to utility officials, and establish the goals of a conservation program. In other words, the intended results or accomplishment from conservation activities for the city's or utility's unique set of needs or problems must be formally stated.

Water conservation goals are usually selected and expressed in terms of (a) the period of effect, (b) the level of reduction desired, and (c) the type of user demand impacted. A short-term reduction in use, usually limited to one year or less, is generally employed in an emergency situation such as a drought. A long-term reduction is the result of a conservation program continuing for more than one year. The percentage reduction should be expressed numerically. A range of one to ten percent reduction usually is considered low, a range of 10 to 20 percent reduction is considered medium (the TWDB projections used extensively throughout this study, considered a reduction of 15 percent in their water use projections through 2020), and over 20 percent is considered high. Most water supply problems are limited to either peak or average use. However, depending on the goals of the program, the conservation goal may need to be directed toward reducing both uses.

2. WATER CONSERVATION PLAN

(Portions of the following were adapted from primarily three sources, all of which are approved by the Texas Water Development Board. Included are: (1) A Water Conservation and Drought Contingency Plan for the city of Nederland, Texas; and (2) Guidelines for Municipal Water Conservation and Drought Contingency Planning and Program Development; TWDB; April, 1986; and (3) Water Conservation and Drought Contingency Plan Development Procedures; TWDB; June, 1986.)

A water conservation plan and a drought contingency plan specify and explain the actions a specific city or utility will take to implement a water conservation program. The implementation of the water conservation plan is considered to be the water conservation program. In most cases a plan is typically intended to be directed towards just one or two entities whereas in this situation it is benefiting an entire region. Therefore, much of the coordinating and implementation efforts for this plan which are identified below could perhaps be assumed by one of the more experienced, well organized organizations, i.e. the city of Abilene or the WCTMWD. The success of a water conservation plan across such an expansive area with many diverse groups participating can only be accomplished through the support and encouragement of one or both of these concerns.

2.1 Plan Elements

a. Education and Information Program

The most readily available and lowest cost method of promoting water conservation is to inform water users about ways to save water inside homes and other buildings, in landscaping and lawn uses, and in recreational uses. In-home water use accounts for an average of 65 percent of total residential use, while the remaining 35 percent is used for exterior residential purposes such as lawn watering and car washing. Average residential in-home water use data indicate that about 40 percent is used for toilet flushing, 35 percent for bathing, 11 percent for kitchen uses, and 14 percent for clothes washing. A city should inform its users of various recommended methods for implementing a reduction in water consumption. The target area for educational information is to be the majority user, namely the residential customer, and also contract customers.

- First year program or activities will consist of eight activities.

    1. A Fact Sheet explaining the Conservation Plan will be developed and distributed. For the region, the city of Abilene or the WCTMWD might want to assume the role as the coordinating body in this effort and obtain some general information brochures from the TWDB to distribute.

2. An article will be placed in the area's newspaper and correlated with the Fact Sheet distribution.
3. Provide each new customer with the "Homeowners Guide to Water Use and Water Conservation."
4. Publish a newspaper article advising water customers that the Homeowners Guide is available at City Hall.
5. Mail out one brochure to water customers. "Water...Half-A-Hundred Ways to Save It."
6. Publish a news article elaborating on the brochure items.
7. Mail out one brochure to water customers either "How to Save Water Outside the Home," or "How to Save Water Inside the Home."
8. Publish a news article in the local newspaper highlighting certain methods for saving water.

- Long-term program will consist of five activities each year after the first year:
  1. Mail out new brochures emphasizing new or innovative means for conserving water.
  2. Publish newspaper articles targeting one particular household water using utility or item and methods for conserving water (dishwater, shower, toilet, laundry).
  3. Distribute a brochure relating to outside household

use, car washing, lawn watering, time of day correlated to weather predictions.

4. Publish a newspaper item in connection with the brochure mail out.

5. Continue distribution of Homeowners Guide to customers.

- New customers will be advised of the Conservation Program and provided with a copy of the Homeowners Guide.

b. Water Conservation Plumbing Code

Cities of 5,000 population or more and utilities and cities with general plumbing codes will need to adopt water saving plumbing codes for new construction and for replacement of plumbing in existing structures. The standards for residential and commercial fixtures should be:

- Tank-type toilets - No more than 3.5 gallons per flush
- Flush valve toilets - No more than 3.0 gallons per flush
- Tank-type urinals - No more than 3.0 gallons per flush
- Flush valve urinals - No more than 1.0 gallons per flush
- Shower heads - No more than 3.0 gallons per minute
- Lavatory and kitchen faucets - No more than 2.75 gallons per minute
- All hot water lines - Insulated
- Swimming pools - New pools must have recirculating filtration equipment

Utilities and cities that do not have a plumbing code will need to adopt a water saving plumbing code or distribute information to their customers and builders to guide them in purchasing and installing water saving plumbing devices.

c. Water Conservation Retrofit Program

A city or utility should make information available through its education program for plumbers and customers to use when purchasing and installing plumbing fixtures, lawn watering equipment, or water using appliances. Information regarding retrofit devices such as low-flow shower heads or toilet dams that reduce water use by replacing or modifying existing fixtures or appliances should also by provided. This information may be disseminated to the public through mailouts and/or publication of newspaper articles, emphasizing the importance of these items. A city or utility may wish to provide certain devices (toilet dams, low-flow shower heads, faucet aerators, etc.) for free or at a reduced cost to the customer.

d. Conservation-Oriented Water Rate Structure

A city or utility should adopt a conservation-oriented water rate structure. Such a rate structure usually takes the form of an increasing block rate, a continuously increasing rate structures, peak or seasonal load rates, excess use fees, and other rate forms can be used. The increasing block rate structure is the most commonly used water conservation rate structure. Across the region, six cities and Hawley Water Supply Corporation use this form of rate structure, as indicated in Table 1. This pricing structure is based on the idea that the rates for larger quantities of water consumed are considerably higher in order to discourage additional use.

The majority of the cities in the water study however use a uniform rate structure whereby there is only one additional block beyond the base rate. The city of Breckenridge is the only city with a declining block rate structure which is highly discouraged because there is an incentive to use higher quantities of water. In this instance, the more water consumed the cheaper it is per gallon.

In the event that increased prices place an excessive burden on the poor, life-line rates may need to be established.

e. <u>Universal Metering and Meter Repair and Replacement</u>

All water users, including the utility, city, and other public facilities, should be metered. In addition, the utility should have a master meter. For new multi-family dwellings that are easily metered individually (such as duplexes and fourplexes) or apartments with more than five living units or apartments, each living unit should be metered separately. A regularly scheduled maintenance program of meter repair and replacement will need to be established in accordance with the following time intervals.

- Production (master) meters - test once a year
- Meters larger than 1" - test once a year
- Meters 1" or smaller - test every 10 years

An implementation plan for a maintenance program will consist of a city adopting a universal metering policy within six months after adoption of this Conservation Plan. Meter readers will classify the apparent condition of all city meters during the following six months. During this same period, all meters larger than one inch will be tested, and retested according to the intervals mentioned above. The second year will involve testing of all meters one inch or smaller. Repairing is to begin in areas with poor classification as rated by meter readers. The annual testing of large meters as well as routine maintenance and necessary replacement of inoperative meters will enable water consumption to be tracked; thus providing a more efficient conservation plan.

f. <u>Water Conserving Landscaping</u>

As stated previously, annual in-home water use accounts for an average of 65 percent of total residential use, while the remaining 35 percent is used for exterior residential purposes, such as lawn watering and car washing. However, during the summer months, as much as 50 percent of the water used in urban areas is applied to lawns and gardens and adds greatly to the peak demands experienced by most water utilities. In order to reduce the demands placed on a water system by landscape watering, the city or utility should consider methods that either encourage, by education and information, or require, by code or ordinance, water conserving landscaping by residential customers and commercial establishments engaged in the sale or installation of landscape plants or watering equipment. Some methods that should be considered include the following.

- Establish platting regulations for new subdivisions that require developers, contractors, or homeowners to use only adapted, low water using plants and grasses for landscaping new homes.
- Initiate a Xeriscape or Texscape program that demonstrates the use of adapted, low water using plants and grasses. The main principles to consider when creating a Xeriscape are as follows.

1. Reduction of Turf area
2. Use of water-conservation plant materials
3. Grouping of plants with similar water requirements
4. An irrigation system designed to meet plant needs

- Encourage or require landscape architects to use adapted, low water using plants and grasses and efficient irrigation systems in preparing all site and facility plans.
- Encourage or require licensed irrigation contractors to always use drip irrigation systems when possible and to design all irrigation systems with water conservation features, such as sprinklers that emit large drops rather than fine mist and a sprinkler layout that accommodates prevailing wind direction.
- Encourage or require commercial establishments to use drip irrigation for landscape watering when possible and to install only ornamental fountains that recycle and use the minimum amount of water.
- Encourage or require nurseries and local businesses to offer adapted, low water using plants and grasses and efficient landscape watering devices, such as drip irrigation systems.

g. Water Audits and Leak Detection

A continuous leak detection, location, and repair program can be an important part of a water conservation plan. An annual water accounting or audit should be part of the program. Sources of unaccounted for water include defective hydrants, abandoned services, unmetered water used for fire fighting or other municipal uses, inaccurate or leaking meters, illegal hook-ups, unauthorized use of fire hydrants, and leaks in mains and services. Once located, corrective repairs or actions need to be undertaken. The national average for unaccounted water is 12 percent, with 5 percent being excellent. An effective leak detection, location , and repair program will generally pay for itself, especially in many older systems.

Leak detecting surveys can be obtained from the TWDB if a city needs some assistance. The TWDB has portable leak detection equipment available for loan to cities and can provide personnel for demonstration of equipment and assist in planning survey programs. A good detection program consists of the following.

- Leaks reported by citizens.
- Leak detection by meter readers
- Continual checking and servicing of production, pumping and storage facilities.
- Quick response by the maintenance department and staff to reported problems.

h. <u>Recycling and Reuse</u>

A city or utility should evaluate the potential of recycling and reuse because these methods may be used to increase water supplies in the applicant's service area. Reuse can be especially important where the use of treated effluent from an industry or a municipal system or agricultural return flows replace an existing use that currently requires fresh water from a city's or utility's supply. Recycling of in-plant processing or cooling water can reduce the amount of fresh water required by many industrial operations.

i. <u>Means of Implementation and Enforcement</u>

The city manager or similar representative of the city will, through his staff, implement this Plan in accordance with City Council adoption of the Plan. Enforcement at a regional level is obviously difficult to accomplish due to the various jurisdictions involved; therefore, the following are suggested measures which may be enacted at the city level.

- Refuse to provide taps for customers who do not meet requirements for Water Conservation fixtures as established by this Plan or by the Plumbing Code.
- Nonpayment of water bills will initiate prompt discontinuation of service. Service will subsequently be disconnected.

- Analysis of water rates and adjusting rates to eliminate Conservation Plan abuse.

3. DROUGHT CONTINGENCY PLAN

Developing a Drought Contingency Plan for a regional water study such as this is a rather difficult undertaking considering the number of entities involved and varying degrees of water demand needs and objectives. Therefore the following is an example of a plan as well as guidelines which can be adapted by a city or water supply corporation based upon their particular water needs and demands.

3.1 Trigger Conditions

Once again realizing the difficulty in drafting a regional drought contingency plan, the following are intended to provide guidelines for cities and others to follow when determining trigger conditions.

The city or utility will need to establish a set of trigger or threshold conditions, such as lake or well levels or peak use volumes, that will indicate when drought contingency measures need to be put into effect. Since each city and utility has different circumstances, trigger conditions will be unique for each system. In most cases, several trigger levels will be needed to distinguish among mild, moderate, or severe drought conditions.

For example, mild conditions may include the following situation.

- Water demand is approaching the safe capacity of the system.
- Lake levels are still high enough to provide an adequate supply, but the levels are low enough to disrupt some other beneficial activity, such as recreation.
- The water supply is still adequate, but the water levels or

reservoir capacities are low enough that there is a real possibility that the supply situation may become critical if the drought or emergency continues. (An example is a reservoir that has an 18-month supply in storage, if no more rains occur.)

Moderate conditions may include the following situations.

- Water levels are still adequate, but they are declining at such a rapid rate that a more serious problem will result in the very near future if some type of formal action is not taken.
- Water demand occasionally reaches what has been determined to be the safe limit of the system, beyond which the failure of a pump or some other piece of equipment could cause a serious disruption of service to part or all of the system.
- Reservoir levels, well levels, or river flows are low enough to disrupt some major economic activity or cause unacceptable damage to a vital ecosystem.

Severe conditions could include a number of situations ranging from the inability to provide certain services to the impairment of health and safety. Some examples include.

- The imminent or actual failure of a major component of the system which would cause an immediate health or safety hazard.
- Lake, river, or well levels are so low that diversion or pumping equipment will not function properly.
- Water levels are low enough in the distribution system storage

reservoirs to hinder adequate fire protection.

- Water demand is exceeding the system's capacity on a regular basis, thus presenting the real danger of a major system failure.

Trigger conditions for the phase-out or a downgrade of the condition's severity should also be considered. Further, unforeseen events can occur so as to require the initiation of an emergency demand management response program for which no trigger condition has been established.

3.2 Drought Contingency Measures

The Water Conservation and Drought Contingency Ordinance adopted and included as part of this plan, enables the City Manager (or other city appointed representative) to initiate action that will effectively implement the Plan. The following steps are recommended.

Step I — Step I measures are related to mild drought conditions and will initiate the following listed actions. Listed action by user is voluntary.

- Develop an Information Center and designate an information person.
- Advise public of condition and publicize availability of information from Center.
- Encourage voluntary reduction of water use.
- Contact commercial and industrial users and explain necessity for initiation of strict conservation

methods.

- Implementation of system oversite and make adjustments as required to meet changing conditions.

<u>Step II</u> Step II curtailment is to be initiated by the City Manager on his/her identifying moderate drought conditions. Listed action is compulsory on users and is intended to prohibit water waste. ("Water Waste" is defined as washing house windows, sidings, eaves, and roof with hose, without the use of a bucket; washing driveways, streets, curbs & gutters, washing vehicles without cutoff valve and bucket, and unattended sprinkling of landscape shrubs and grass; draining and filling swimming pools and flushing water system.)

- Outdoor residential use of water will be permitted on a 4-5 day watering schedule. The schedule could be based on a sector of town or house number. Outdoor residential uses consist of washing vehicles, boats, trailers, landscape sprinkler systems and irrigation, recreational use of sprinklers, outside showers (in parks) and water slides.
- The City Manager will monitor the system function and establish hours for outside water use, depending upon the system's performance.

- The Information Center and publicity elements shall keep the public advised of curtailment status.
- Commercial and industrial users will be visited to insure volunteered conservation has been initiated.

<u>Step III</u> Step III curtailment shall be initiated upon the existence of severe conditions as determined by the City Manager.

- Ban the use of water for vehicle washing, window washing, outside watering (lawn, shrubs, faucet dripping, garden, etc.).
- Ban the use of public water uses which are not essential for health, safety and sanitary purposes. These users include: Street washing, fire hydrant flushing, filling pools, athletic fields and courses and dust control sprinkling.
- Commercial uses not listed and industrial uses will be controlled to the extent dictated by the City Manager. Businesses requiring water as a basic function of the business, such as nurseries, commercial car wash, laundromats, high pressure water cleaning, etc. will obtain written permission from the City Manager for intended water use.
- The System Priority for water service shall be made on the following basis.

  1. Hospitals

2. Residential

3. Schools

4. Industrial

5. Commercial

6. Recreational

3.3 Information and Education

The public will be made aware of conservation and drought conditions by information and data transfer through the City's annual program. During periods of drought curtailment, Step I conditions establishes an information center, an information person, and utilizes the most effective methods developed for information dissemination on a daily basis. Close observation of the first year information program should develop the most effective ways to communicate with customers. Posting notices, newspaper articles, radio coverage and direct mail to customers will be used during the first year activities.

3.4 Initiation Procedures

Initiation procedures employed at any period is described in this Plan. Each condition will be met with corresponding action by the City Manager and the City Manager will affect curtailment, give notice, publicize and follow with implementation of curtailment.

3.5 Termination of Curtailment

Termination of each drought condition will begin when that specific condition has been improved to the extent that an upgraded condition can be declared by the City Manager. This process will be employed until full service can be provided. The system priority will be considered in return to an upgraded condition, returning hospitals, schools, etc. in priority order. Termination will be initiated by the City Manager by giving notice, etc. as was given to enact a drought curtailment.

3.6 Modification, Deletion, and Amendment

The City Manager can add, delete, and amend rules, regulations and implementation as needed/desired, and shall advise the City Council of such amendments at its next regular or called meeting.

3.7 Means of Implementation

Adoption of this Plan, the Drought Contingency Ordinance, and modification of the Plumbing Code Ordinance will enable the City to implement and carry out enforcement of enacted ordinance to make the Plan effective and workable.

APPENDIX A:CONSERVATION TIPS

A. In the Bathroom, Customers Should Be Encouraged to:

1. Take a shower instead of filling the tub and taking a bath. Showers usually use less water than tub baths.
2. Install a low-flow shower head which restricts the quantity of flow at 60 psi to no more than 3.0 gallons per minute.
3. Take short showers and install a cutoff valve or turn the water off while soaping and back on again only to rinse.
4. Try not to use hot water when cold will do. Water and energy can be saved by washing hands with soap and cold water; hot water should only be added when hands are especially dirty.
5. Reduce the level of the water being used in a bathtub by one or two inches if a shower is not available.
6. Turn water off when brushing teeth until it is time to rinse.
7. Do not let the water run when washing hands. Instead, hands should be wet, and water should be turned off while soaping and scrubbing and turned on again to rinse. A cutoff valve may also be installed on the faucet.
8. Shampoo hair in the shower. Shampooing in the shower takes only a little more water than is used to shampoo hair during a bath and much less than shampooing and bathing separately.
9. Hold hot water in the sink when shaving instead of letting the faucet continue to run.

10. Test toilets for leaks. To test for a leak, a few drops of food coloring can be added to the water in the tank. The toilet should not be flushed. The customer can then watch to see if the coloring appears in the bowl within a few minutes. If it does, the fixture needs adjustment or repair.

11. Use a toilet tank displacement device. A one-gallon plastic milk bottle can be filled with stones or with water, recapped, and placed in the toilet tank. This will reduce the amount of water in the tank but still provide enough for flushing. (Bricks which some people use for this purpose are not recommended since they crumble eventually and could damage the working mechanism, necessitating a call to the plumber.) Displacement devices should never be used with new low-volume flush toilets.

12. Install faucet aerators to reduce water consumption.

13. Never use the toilet to dispose of cleansing tissues, cigarette butts, or other trash. This can waste a great deal of water and also places an unnecessary load on the sewage treatment plant or septic tank.

14. Install a new low-volume flush toilet that uses 3.5 gallons or less per flush when building a new home or remodeling a bathroom.

B. In the Kitchen, Customers Should Be Encouraged to:

1. Use a pan of water (or place a stopper in the sink) for rinsing

pots and pans and cooking implements when cooking rather than turning on the water faucet each time a rinse is needed.

2. Never run the dishwasher without a full load. In addition to saving water, expensive detergent will last longer and a significant energy saving will appear on the utility bill.

3. Use the sink disposal sparingly, and never use it for just a few scraps.

4. Keep a container of drinking water in the refrigerator. Running water from the tap until it is cool is wasteful. Better still, both water and energy can be saved by keeping cold water in a picnic jug on a kitchen counter to avoid opening the refrigerator door frequently.

5. Use a small pan of cold water when cleaning vegetables rather than letting the faucet run.

6. Use only a little water in the pot and put a lid on it for cooking most food. Not only does this method save water, but food is more nutritious since vitamins and minerals are not poured down the drain with the extra cooking water.

7. Use a pan of water for rinsing when hand washing dishes rather than a running faucet.

8. Always keep water conservation in mind, and think of other ways to save in the kitchen. Small kitchen savings from not making too much coffee or letting ice cubes melt in a sink can add up in a year's time.

C. In the Laundry, Customers Should Be Encouraged to:

1. Wash only a full load when using an automatic washing machine (32 to 59 gallons are required per load.)

2. Use the lowest water level setting on the washing machine for light loads whenever possible.

3. Use cold water as often as possible to save energy and to conserve the hot water for uses which cold water cannot serve. (This is also better for clothing make of today's synthetic fabrics.)

D. For Appliances and Plumbing, Customers Should Be Encouraged to:

1. Check water requirements of various models and brands when considering purchasing any new appliance that uses water. Some use less water than others.

2. Check all water line connections and faucets for leaks. If the cost of water is $1.00 per 1,000 gallons, one could be paying a large bill for water that simply goes down the drain because of leakage. A slow drip can waste as much as 170 gallons of water EACH DAY, or 5,000 gallons per month,and can add as much as $5.00 per month to the water bill.

3. Learn to replace faucet washers so that drips can be corrected promptly. It is easy to do, costs very little, and can represent a substantial amount saved in plumbing and water bills.

4. Check for water leakage that the customer may be entirely

unaware of, such as a leak between the water meter and the house. To check, all indoor and outdoor faucets should be turned off, and the water meter should be checked. If it continues to run or turn, a leak probably exists and needs to be located.

5. Insulate all hot water pipes to avoid the delays (and wasted water) experienced while waiting for the water to "run hot."
6. Be sure the hot water heater thermostat is not set too high. Extremely hot settings waste water and energy because the water often has to be cooled with cold water before it can be used.
7. Use a moisture meter to determine when house plants need water. More plants die from over-watering than from being on the dry side.

E. For Out-of-Door Use, Customers Should Be Encouraged to:

1. Water lawns early in the morning during the hotter summer months. Much of the water used on the lawn can simply evaporate between the sprinkler and the grass.
2. Use a sprinkler that produces large drops of water, rather than a fine mist, avoid evaporation.
3. Turn soaker hoses so the holes are on the bottom to avoid evaporation.
4. Water slowly for better absorption, and never water on windy days.
5. Forget about watering the streets or walks or driveways. They

will never grow a thing.

6. Condition the soil with compost before planting grass or flower beds so that water will soak in rather than runoff.
7. Fertilize lawns at least twice a year for root stimulation. Grass with a good root system makes better use of less water.
8. Learn to know when grass needs watering. If it has turned a dull grey-green or if footprints remain visible, it is time to water.
9. Never water too frequently. Too much water can overload the soil so that air cannot get to the roots and can encourage plant diseases.
10. Do not overwater. Soil can absorb only so much moisture and the rest simply runs off. A timer will help, and either a kitchen timer or an alarm clock will do. An inch and one-half of water applied once a week will keep most Texas grasses alive and healthy.
11. Operate automatic sprinkler systems only when the demand on the town's water supply is lowest. Set the system to operate between four and six a.m.
12. Do not scalp lawns when mowing during hot weather. Taller grass holds moisture better. Rather, grass should be cut fairly often, so that only 1/2 to 3/4 inch is trimmed off. A better looking lawn will result.
13. Use a watering can or hand water with the hose in small areas

of the lawn that need more frequent watering (those near walks or driveways or in especially hot, sunnyspots.)

14. Learn what types of grass, shrubbery, and plants do best in the area and in which parts of the lawn, and then plant accordingly. If one has a heavily shaded yard, no amount of water will make roses bloom. In especially dry sections of the state, attractive arrangements of plants that are adapted to arid or semi-arid climates should be chosen.
15. Consider decorating areas of the lawn with rocks, gravel, wood chips, or other materials now available that require no water at all.
16. Do not "sweep" walks and driveways with the hose. Use a broom or rake instead.
17. Use a bucket of soapy water and use the hose only for rinsing when washing the car.

APPENDIX B: LEGAL AND REGULATORY COMPONENT

A SAMPLE CONSERVATION/DROUGHT CONTINGENCY PLAN ORDINANCE

ORDINANCE NO. ____________

AN ORDINANCE ADOPTING A CITY OF WATER CONSERVATION/AND DROUGHT CONTINGENCY PLAN: PROVIDING A PENALTY OF NOT LESS THAN $10 PER DAY NOT MORE THAN $200 PER DAY FOR EACH DAY OF NON-COMPLIANCE AND/OR DISCONNECTION OF WATER SERVICES TO SUCH USERS BY THE CITY: A PUBLIC NEED OF AN EMERGENCY NATURE FOR THE ADOPTION HEREOF ON ONE READING: PROVIDING FOR PUBLICATION AND ORDAINING OTHER MATTERS RELATED TO THE FOREGOING. BE IT ORDAINED BY THE CITY OF__________, TEXAS:

WHEREAS, the City Council has determined there is an urgent need in the best public interest of the city of____________, Texas to adopt a Water Conservation Plan and Drought Contingency Plan, and the City Council further determines that such public need is of an emergency nature and the legal requirement of two required separate readings of the subject ordinance be dispensed with and waived; and

WHEREAS, the City Council of the city now desires to evidence its approval of the Water Conservation/Drought Contingency Plan and adopt such plan as an official policy of the City; Now, Therefore,

BE IT ORDAINED BY THE CITY OF __________, TEXAS:

SECTION I: Approval of the Plan: The City Council hereby approves and adopts as the City's Water Conservation Plan, the Water Conservation/ Drought Contingency Plan attached hereto as Exhibit "A" to be included in full as a part of this Ordinance as if recited verbatim herein. The City commits to implement the program according to the procedures set forth in the adopted plan.

SECTION II: The City shall report to the Texas Water Development Board annually on the implementation and effectiveness of the plan in accordance with the outline set forth in the plan.

SECTION III: In regards to implementation and enforcement of the Conservation/Drought Contingency Plan the City Manager or appointed representative is designated as the official responsible for implementation and enforcement, and the following guidelines are adopted:

1. Mild Drought occurs when:
   a. Average daily water consumption reaches 90 percent of production capacity.
   b. Consumption (90 percent) has existed for a period of three days.
   c. Weather conditions are to be considered in drought classification determination. Predicted long, cold, or dry periods are to be considered in impact analysis.
2. Moderate Drought conditions are reached when:
   a. Average daily water consumption reaches 100 percent of rated production capacity for three day period.
   b. Weather conditions indicate mild drought will exist five days or more.
   c. One Ground Storage Tank or one Clear Well is taken out of

service during mild drought.

d. Storage capacity (water level) is not being maintained during period of 100 percent rated production period.

e. Existence of any preceding conditions listed above for a duration of 36 hours.

3. Severe Drought Classification is reached when:

a. Average daily water consumption reaches 110 percent of production capacity for a 24 hour period.

b. Average daily water consumption will not enable storage levels to be maintained.

c. System demand exceeds available high service pump capacity.

d. Any two conditions listed in Moderate Drought Classification occurs for a 24-hour period.

e. Water system is contaminated either accidentally or intentionally. Severe condition is reached immediately upon detection.

f. Water system fails - from acts of God (tornados, hurricanes) or man. Severe condition is reached immediately upon detection.

In the event severe classification conditions persist (item 3 above) for an extended period of time, the City may ration water usage and/or terminate service to selected users of the system in accordance with the following sequence:

1. Recreational Users
2. Commercial Users
3. Industrial Users
4. School Users
5. Residential Users
6. Hospitals, Public Health and Safety Facilities

SECTION IV: Users of City water except for the City that do not comply with Section III of this Ordinance shall be subject to a penalty and fine of not less than $10.00 per day nor more than $200.00 per day for each day of non-compliance and/or disconnection or discontinuance of water services to such users by the City.

SECTION V: The City Council finds and declares that a sufficient written notice of the date, hour, place and subject of this meeting of the City Council was posted at a designated place convenient to the public at the City Hall for the time required by law preceding this meeting and that such place of posting was readily accessible at all times to the general public; that all of the foregoing was done as required by law; and that this meeting has been open to the public as required by law at all times during which the Ordinance and the subject matter thereof has been discussed, considered and formally acted upon. The City Council further rectifies, approves and confirms such written notice and the contents and posting thereof.

PASSED AND APPROVED THIS ______ DAY OF ________________, 199_.

____
MAYOR

____
CITY SECRETARY

APPENDIX F

EVALUATION OF THE O. H. IVIE RESERVOIR PIPELINE ROUTING TO THE CITY OF ABILENE

Freese
AND
Nichols, INC.
CONSULTING ENGINEERS

July 10, 1990

Mr. David Bell, P.E.
West Central Texas Municipal
Water District
P.O. Box 2362
Abilene, Texas 79064

Re: 10 County Regional Water Study
O.H. Ivie Reservoir Pipeline Route
Evaluation WCT89130

Dear Mr. Bell:

As part of the referenced study we have reviewed several pipeline routes from the City of Abilene's pump station site on the O.H. Ivie Reservoir to the City of Abilene. The routes evaluated are as shown in the attached Figure 1 and listed below:

ROUTE 1 - From the existing raw water pump station site NNW to a point just east of Table Mountain then to Ovalo and then along an abandoned railroad route to a point just north of Tuscola.

ROUTE 2 - From the existing raw water pump station site NW to a point just north of Ballinger then in a northerly direction along an abandoned railroad route through Winters, Ovalo, and stopping just north of Tuscola.

ROUTE 3 - From the existing raw water pump station site NNW straight to Lake Abilene.

ROUTE 4 - From the existing raw water pump station site due north and near Okeen turning to FM382 and then north to a point NE of Tuscola near the intersection of U.S.83 and U.S.84.

TELEPHONE 817 336-7161 811 LAMAR STREET FORT WORTH, TEXAS 76102-3683 METRO 817 429-1900
FAX 817 877-4267

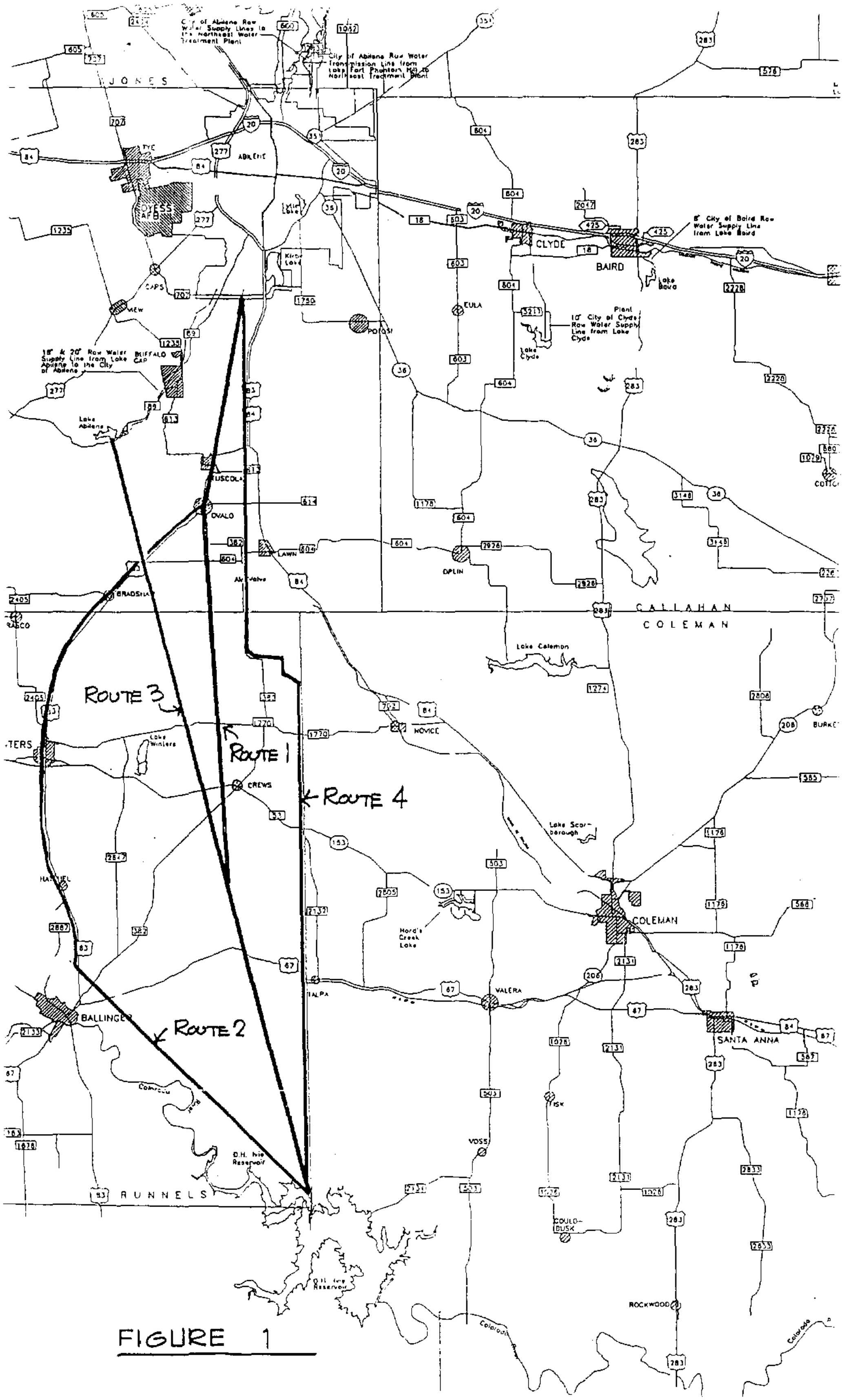

ROUTE 3
ROUTE 1
ROUTE 4
ROUTE 2
CALLAHAN
COLEMAN
JONES
RUNNELS
ABILENE
CLYDE
BAIRD
COLEMAN
SANTA ANNA
BALLINGER
VALERA
NOVICE
TUSCOLA
OVALO
LAWN
CREWS
TALPA
ROCKWOOD
Lake Coleman
Lake Abilene
O.H. Ivie Reservoir

FIGURE 1

In a previous study prepared by Freese and Nichols in May 1988, the routing shown above as Route 1 was established, except that the line was terminated at Lake Abilene. This termination point was used at that time in order to provide a base for comparing pumpstation sites at the O.H. Ivie Reservoir. The actual termination point which may be selected in the future will depend on several items; such as, the water quality at O.H. Ivie Reservoir, the future growth pattern for the City of Abilene, the future water plant capacities and locations, and the future development of the Cities water distribution system. Some of the possible options available in the future are as described below along with some of the advantages and disadvantages of each option:

OPTION 1 - Discharge directly into Lake Abilene

Advantages:

A. Provides terminal storage.

B. If water treatment plant was built at Lake Abilene the treated water could flow directly into the upper pressure plane without repumping.

C. Could possibly gravity flow from Lake Abilene to Fort Phantom Hill down Elm Creek. However, this would have to be coordinated with the flood control along this route.

Disadvantages:

A. There would be a limited amount of blending water available at Lake Abilene, which could be necessary depending on the water quality of O.H. Ivie Reservoir.

B. It is anticipated that water will be taken from the O.H. Ivie Reservoir only when water is required in excess of that which is available from Fort Phantom Hill and Hubbard Creek Reservoir. This would not be practical if a new water treatment plant were built at Lake Abilene.

C. Gravity flow from Lake Abilene to Fort Phantom Hill along Elm Creek would be subject to losses due to evaporation and infiltration. There may also be future flood control projects along Elm Creek which would affect this option.

OPTION 2 - Discharge directly into Lake Kirby

Advantages:

A. Provides terminal storage.

B. If water treatment plant was built at Lake Kirby the treated water could be blended with water at the Maples Street Pump Station.

C. Could possibly gravity flow from Lake Kirby to Fort Phantom Hill down Cedar Creek.

Disadvantages:

A. As noted previously, it is anticipated that water will be taken from the O.H. Ivie Reservoir only when water is required in excess of that which is available from Fort Phantom Hill and Hubbard Creek Reservoir. This would not be practical if a new water treatment plant were built at Lake Kirby.

B. Gravity flow from Lake Kirby to Fort Phantom Hill along Cedar Creek would be subject to losses due to evaporation and infiltration and would have to be coordinated with flood control along this route.

C. Additional pipeline cost is required.

OPTION 3 - Discharge into Cedar Creek and flow by gravity into Lake Kirby

Advantages:

A. Provides terminal storage.

B. If water treatment plant was built at Lake Kirby the treated water could be blended with water at the Maples Street Pump Station.

C. Could possibly gravity flow from Lake Kirby to Fort Phantom Hill down Cedar Creek.

D. Less additional pipeline required.

Disadvantages:

A. As noted previously, it is anticipated that water will be taken from the O.H. Ivie Reservoir only when water is required in excess of that which is available from Fort Phantom Hill and Hubbard Creek Reservoir. This would not be practical if a new water treatment plant were built at Lake Kirby.

B. Gravity flow to Lake Kirby or Fort Phantom Hill along Cedar Creek would be subject to losses due to evaporation and infiltration and coordination with flood control would have to be addressed.

OPTION 4 - Deliver Raw Water to the existing Northeast Water Treatment Plant

Advantages:

A. Water would be available for blending.

B. The existing (or expanded) water treatment plant could be used for existing sources as well as the O.H. Ivie Reservoir.

Disadvantages:

A. A terminal storage facility would be needed at or north of Oval, which would serve the same function as the District's existing High Point Tanks on the Hubbard Creek lines.

B. Much more pipeline required.

Therefore at some time in the future an evaluation of these options and other possible options should be made to determine the final raw water delivery point. It would be impractical to evaluate these options at this time due to the many unknown parameters. Therefore the routes listed, except ROUTE 3, have been terminated at points which would reasonably allow selection of any of these options in the future, without any major impact on the right-of-way purchased at this time.

The evaluation of each Route was based on the following criteria:

1. Maximum pumping rate of 20 MGD.

2. A 36-inch concrete cylinder pipeline having a maximum velocity of 4.38 feet per second at 20 MGD.

3. One booster pump station between the O.H. Ivie Reservoir and the City of Abilene, having a 2 MG welded steel tank.

4. Maintaining an average Hazen Williams C-factor of 120.

Since conditions will change between now and actual construction of the pipeline the diameter of the pipeline should be re-evaluated during the detailed design phase of the project. Some of the considerations which could affect the final pipe diameter selected would be increased power and construction cost, anticipated system operations, and changes in materials of construction.

A profile for each Route is shown in the attached Figures 2 through 5. On each of these profiles the hydraulic grade line is shown for the 20 MGD pumping rate. The hydraulic grade line shown is based on having to terminate at Lake Abilene which is the highest termination point of the options previously mentioned. If any other delivery point were selected the total pumping heads required alternates 1, 3 and 4 could be reduced by approximately 110, 60 and 140 feet, respectively. A comparison of each route is shown in Tables 1 and 2. The preliminary estimate of probable construction cost shown in Table 1 does not include the cost associated with the lake or booster pump stations, since these cost would be relatively consistent regardless of the route selected. The estimates shown, also do

TABLE 1

ITEM	UNIT	PRICE	QUANTITY	COST	QUANTITY	COST	QUANTITY	COST	QUANTITY	COST
36" pipe, Class 275	L.F.	$81.00	0	$ 0	38,300	3,102,300	0	0	0	0
36" pipe, Class 250	L.F.	$75.00	4,200	315,000	36,000	2,700,000	15,000	1,125,000	3,800	285,000
36" pipe, Class 225	L.F.	$69.00	5,000	345,000	21,000	1,449,000	30,000	2,070,000	45,000	3,105,000
36" pipe, Class 200	L.F.	$63.00	45,000	2,835,000	29,000	1,827,000	45,000	2,835,000	27,000	1,701,000
36" pipe, Class 150	L.F.	$54.50	52,500	2,861,250	45,800	2,496,100	100,000	5,450,000	116,600	6,354,700
36" pipe, Class 100	L.F.	$49.00	135,700	6,649,300	84,500	4,140,500	92,200	4,517,800	54,800	2,685,200
Subtotal			242,400	$13,005,550	254,600	$15,714,900	282,200	$15,997,800	247,200	$14,130,900
Related Items at 15%				1,950,550		2,357,235		2,399,670		2,119,635
Subtotal				$14,956,383		$18,072,135		$18,397,470		$16,250,535
Contingencies and Engineering at 20%				2,991,277		3,614,427		3,679,494		3,250,107
TOTAL				$17,947,659		$21,686,562		$22,076,964		$19,500,642

Table 2

ALTERNATE	LENGTH (miles)	PUMPING HEAD REQ'D AT 20 MGD L.P.S. (feet)	B.P.S. (feet)	TOTAL (feet)	TOTAL HP REQ'D AT 20 MGD (horsepower)
1	45.9	548.5	457	1005.5	5,111
2	48.2	614.5	584	1198.5	6,092
3	53.4	557.5	527	1084.5	5,513
4	46.8	555.5	428	1013.5	5,152

not take into account the possibility of additional rock excavation which might be required, in particular for Routes 3 and 4.

Route 1 remains the lowest initial cost and would also have the lowest power cost due to the lower pumping head requirements. Two additional considerations were reviewed which could potentially affect the selection of Route 1 versus Route 2. The two additional considerations are the possibility of supplying raw water to the cities of Ballinger and/or Winters. The estimated probable cost of construction to serve the City of Ballinger at a rate of 1789 gpm is $1,805,000. The estimated probable cost of construction to serve the City of Winters at a rate of 1,550 gpm is $726,000. Even with these cost added to Route 1 at $20,500,000, it is still less expensive than Route 2 at $21,700,000.

After determining that Route 1 is still the appropriate route, we reviewed the location and number of booster pump stations required on this route. The possibility of not having a booster pump station at all was also reviewed. If no booster pump station were provided, the pumping head at the lake pump station would be approximately 1005 feet (435psi), which in our opinion is unnecessarily high for a raw water transmission line. The possibility of having two booster pump stations, on the other hand, is a reasonable possibility. We have reviewed the possibility of two sets of locations for 2 booster pump stations on Route 1. In one scenario (A) we tried to split the maximum head requirements into three nearly equal amounts. In the other scenario (B) the length of the pipeline was split into three nearly equal amounts. The advantage of scenario (A) is that the maximum pressures in the system is minimized; however, the advantage of scenario (B) is that since the friction head loss is proportional to the length of line, when one pump is turned off the reduction in flow would be more consistent between pump station. The reduction in pipe pressure classes will not be sufficient to offset the additional cost associated with an additional booster pump station and the addition of a booster pump station will have to be based on criteria other than just capital cost, such as operational advantages and lower stress levels on the system. The two scenarios reviewed were based on a static created by the route to Lake Abilene, as noted previously the head could be reduced significantly if a different termination point were selected. This reduction in head would also affect the selection of booster pump station sites. Due to the uncertainty of the termination point, we recommend that the number and location of booster pump stations be delayed until the detailed design of the project.

In summary, we recommend that the District begin acquisition of a 100-ft right-of-way along Route 1 and that selection of booster pump station sites be delayed until detailed design of the project or at least until the termination point for the system has been established in the future. It is also recommended that if a reasonable price can be obtained for the right-of-way along the old railroad route from Tuscola to FM 707, that it be done at this time. It is anticipated that it will be simpler and less expensive to obtain this right-of-way now than it will be in the future.

If you have any questions or require additional information, please call.

Yours Sincerely,

FREESE AND NICHOLS,INC.

Michael L. Nichols, P.E.

xc: Roy McDaniel
Dwayne Hargisheimer
James R. Nichols
Billy Jacobs
David Todd

APPENDIX G

SCHEMATICS OF EXISTING TREATMENT PLANTS

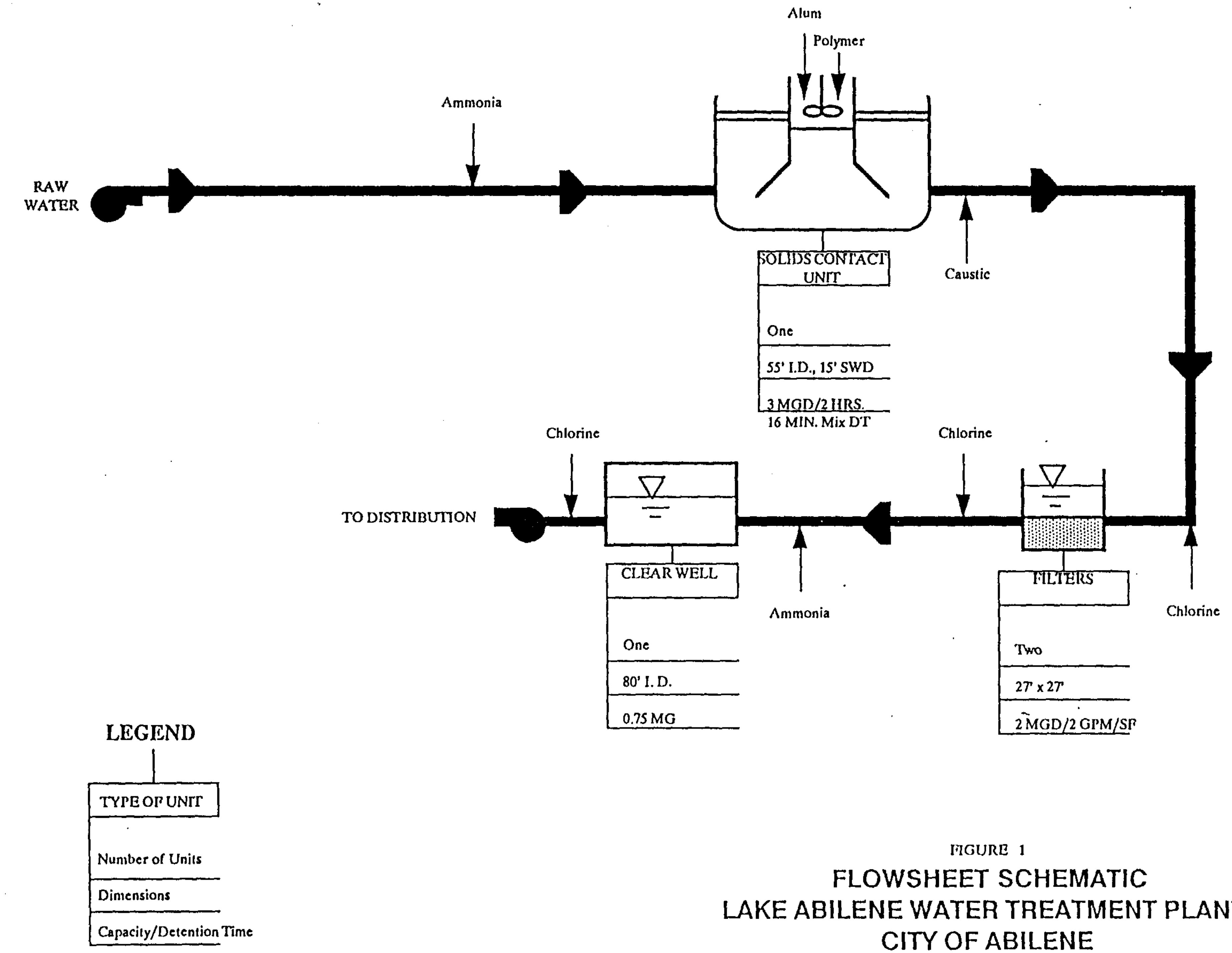


FIGURE 1

FLOWSHEET SCHEMATIC
LAKE ABILENE WATER TREATMENT PLANT
CITY OF ABILENE

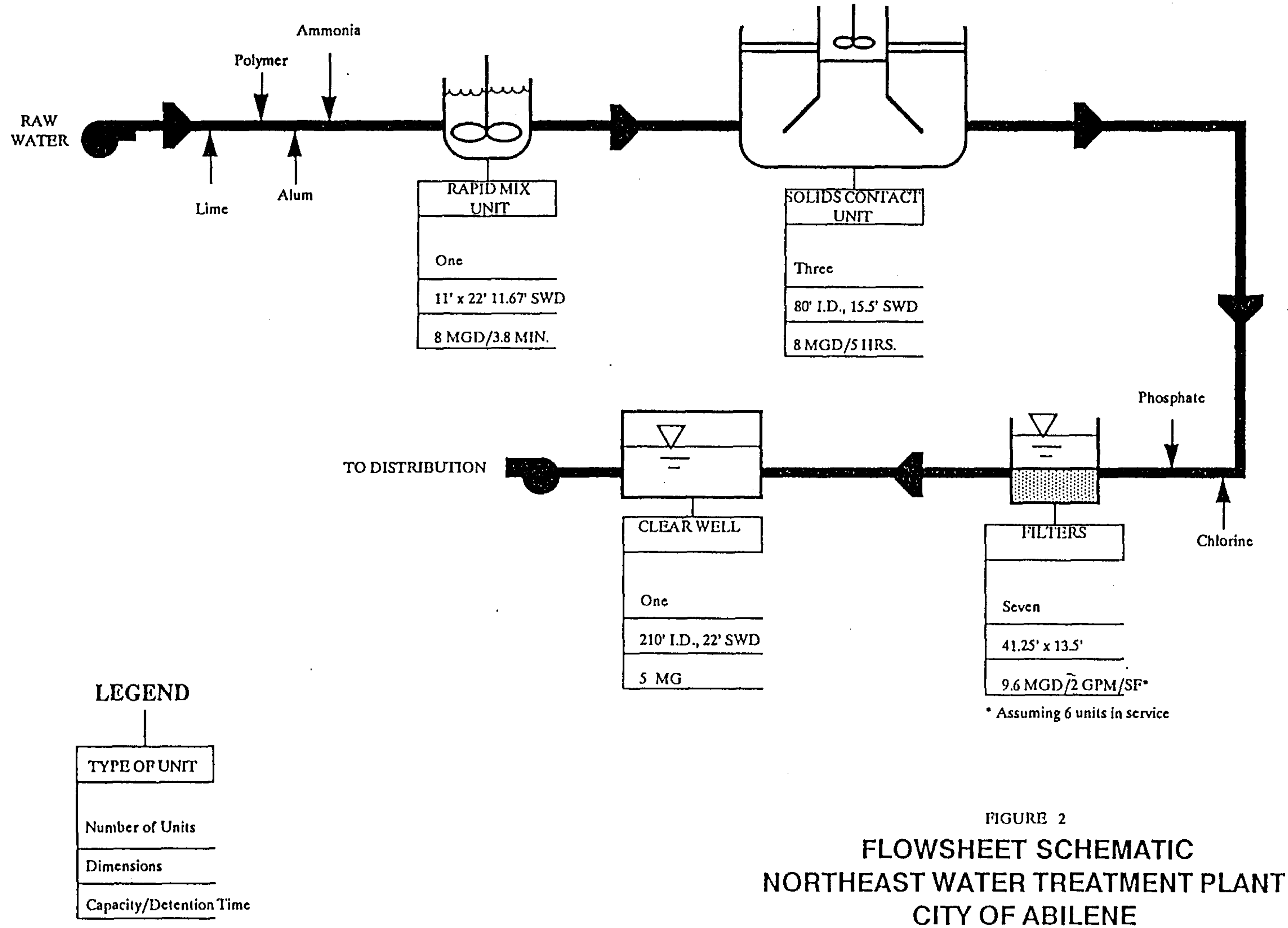


FIGURE 2

FLOWSHEET SCHEMATIC
NORTHEAST WATER TREATMENT PLANT
CITY OF ABILENE

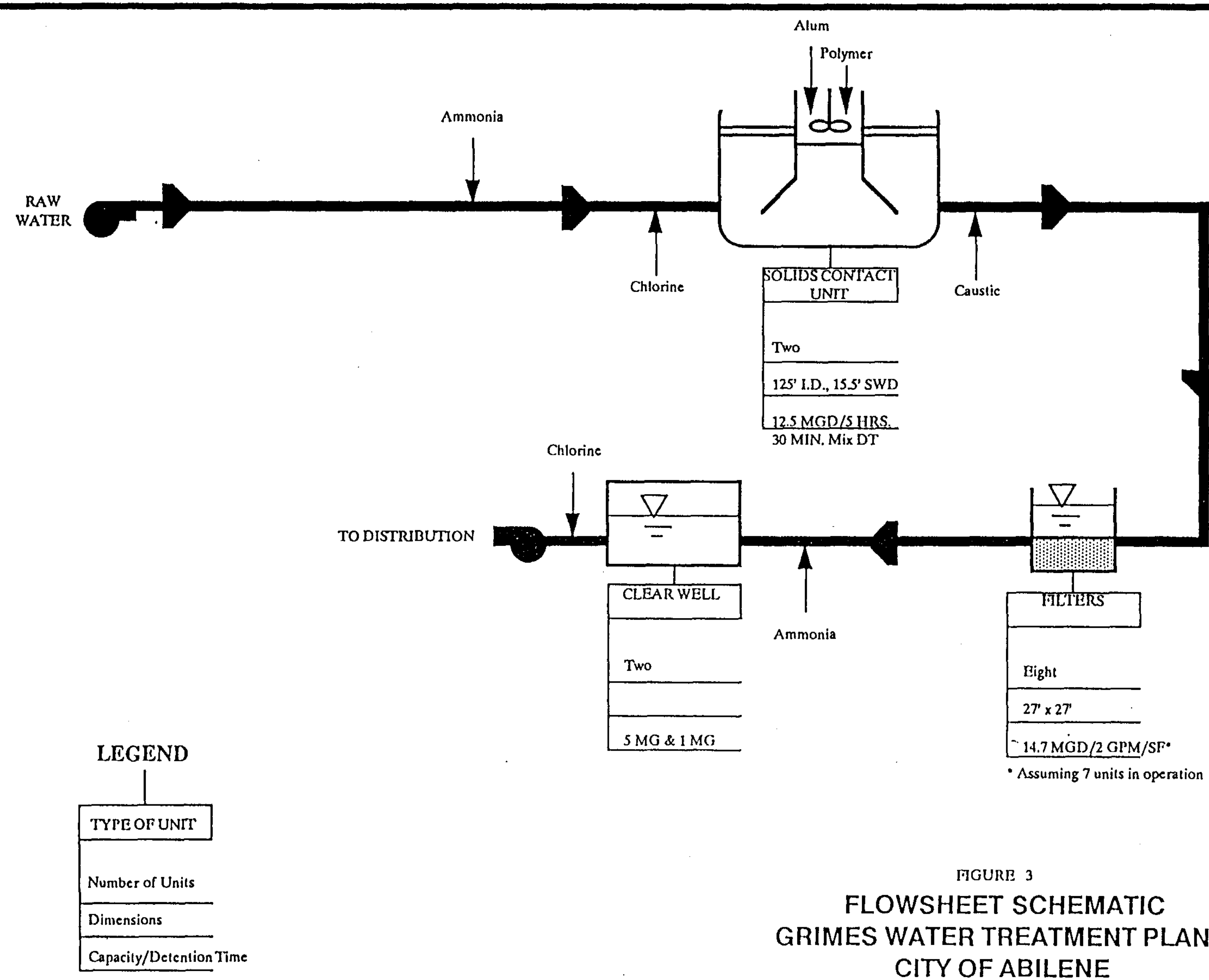


FIGURE 3

FLOWSHEET SCHEMATIC
GRIMES WATER TREATMENT PLANT
CITY OF ABILENE

FREESE AND NICHOLS, INC.

PCD NO 2

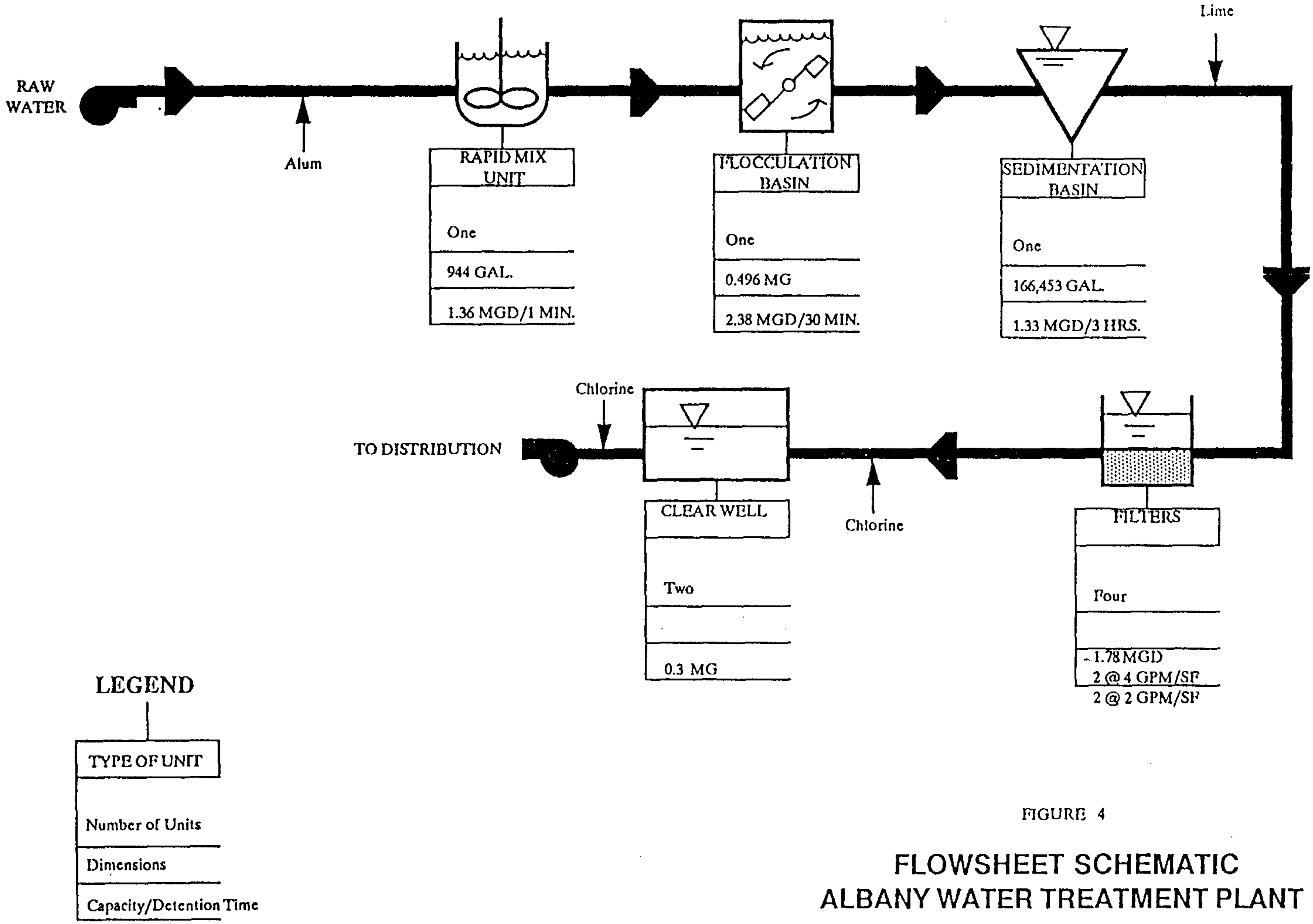


FIGURE 4

FLOWSHEET SCHEMATIC
ALBANY WATER TREATMENT PLANT

PCD No.2

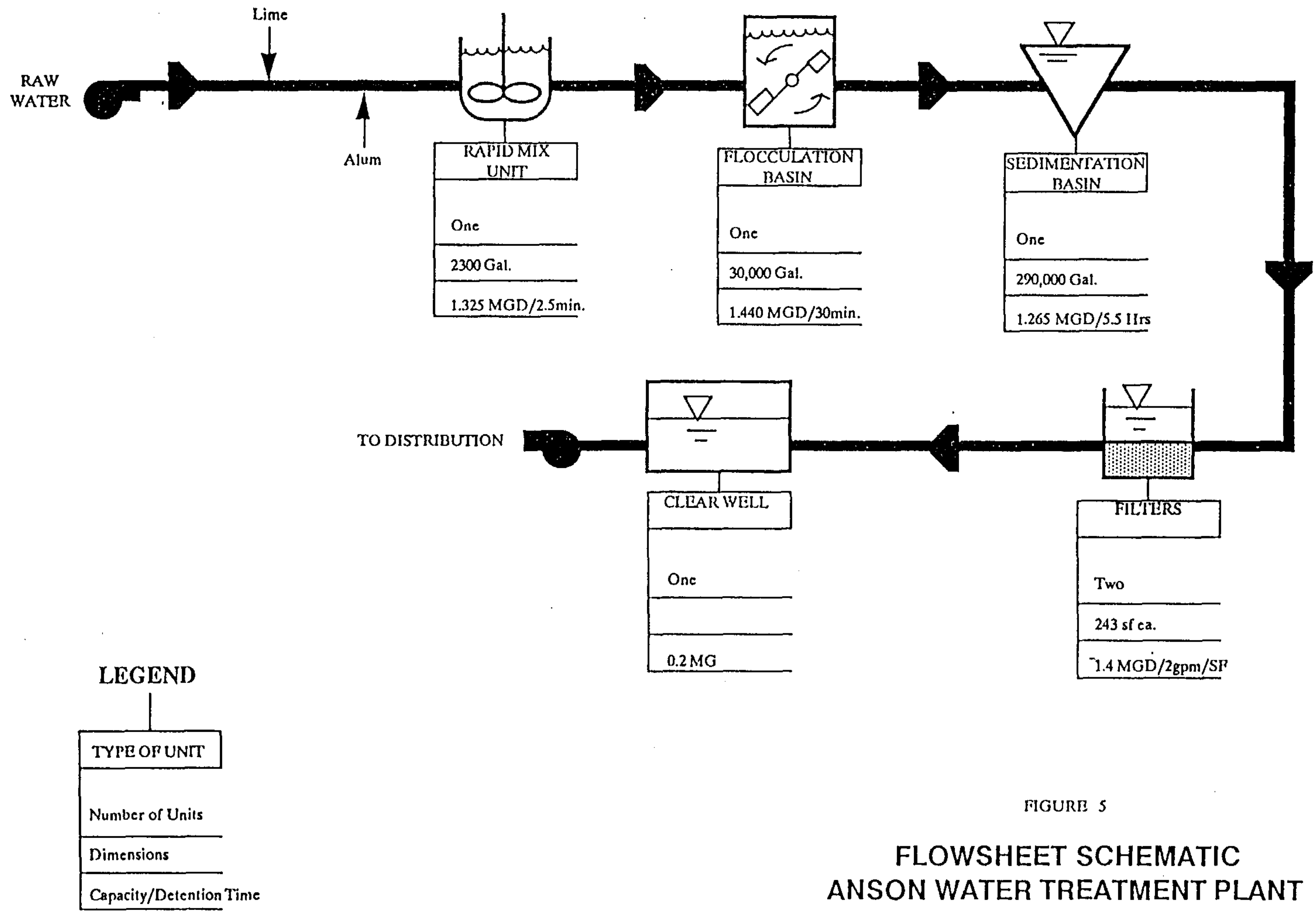


FIGURE 5

FLOWSHEET SCHEMATIC
ANSON WATER TREATMENT PLANT

FREESE AND NICHOLS, INC.

PCD HD 2

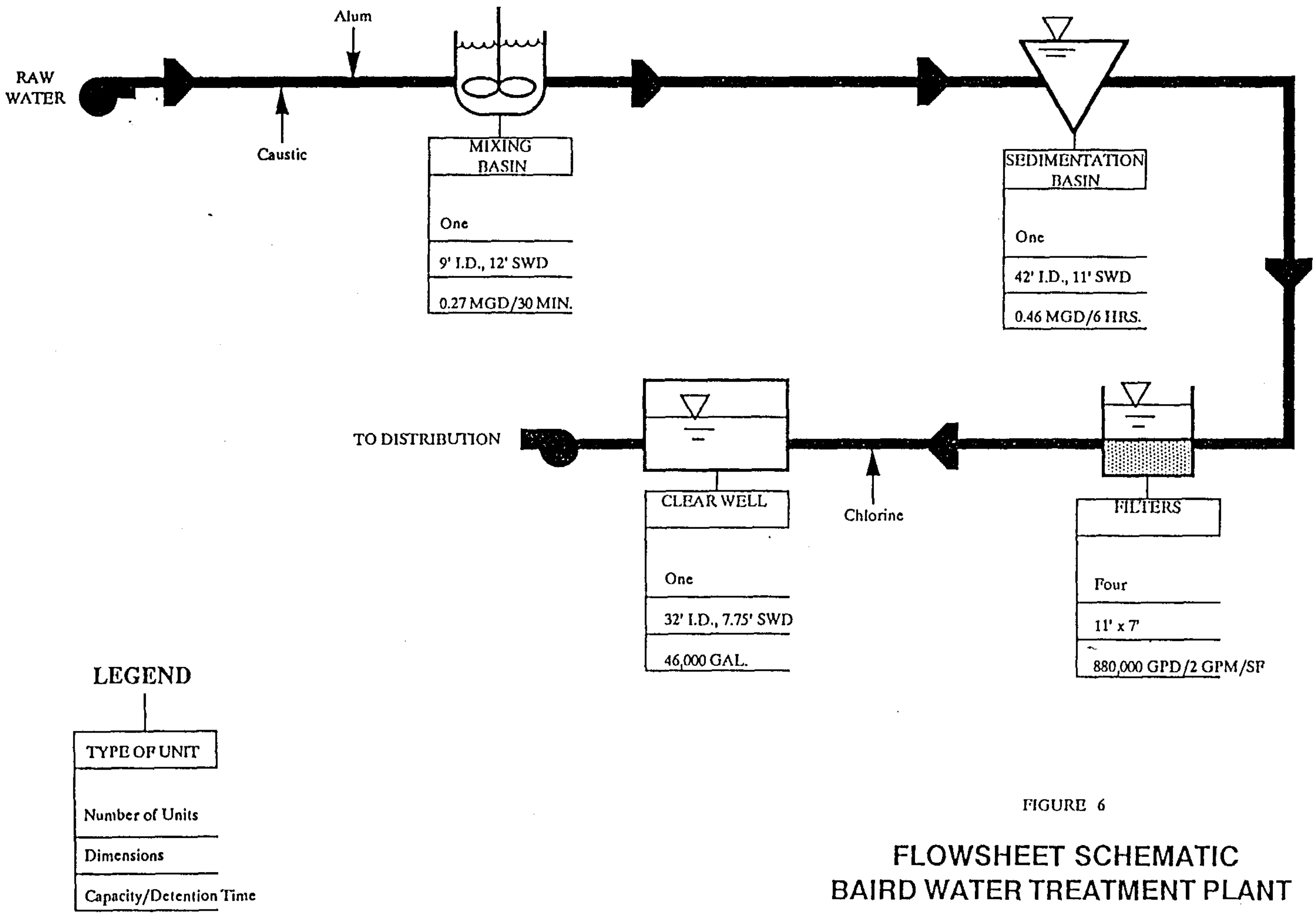


FIGURE 6

FLOWSHEET SCHEMATIC
BAIRD WATER TREATMENT PLANT

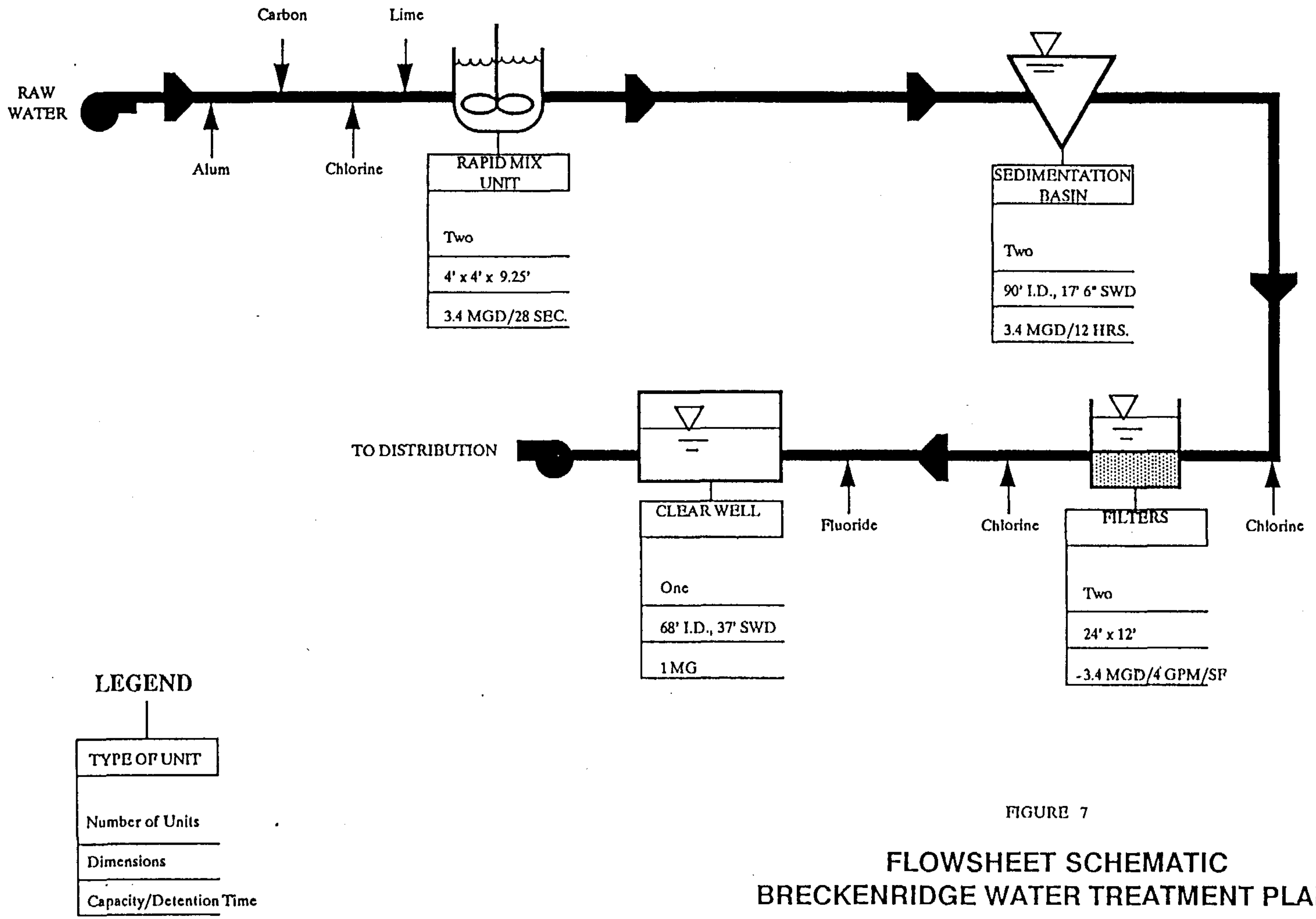


FIGURE 7

FLOWSHEET SCHEMATIC
BRECKENRIDGE WATER TREATMENT PLANT

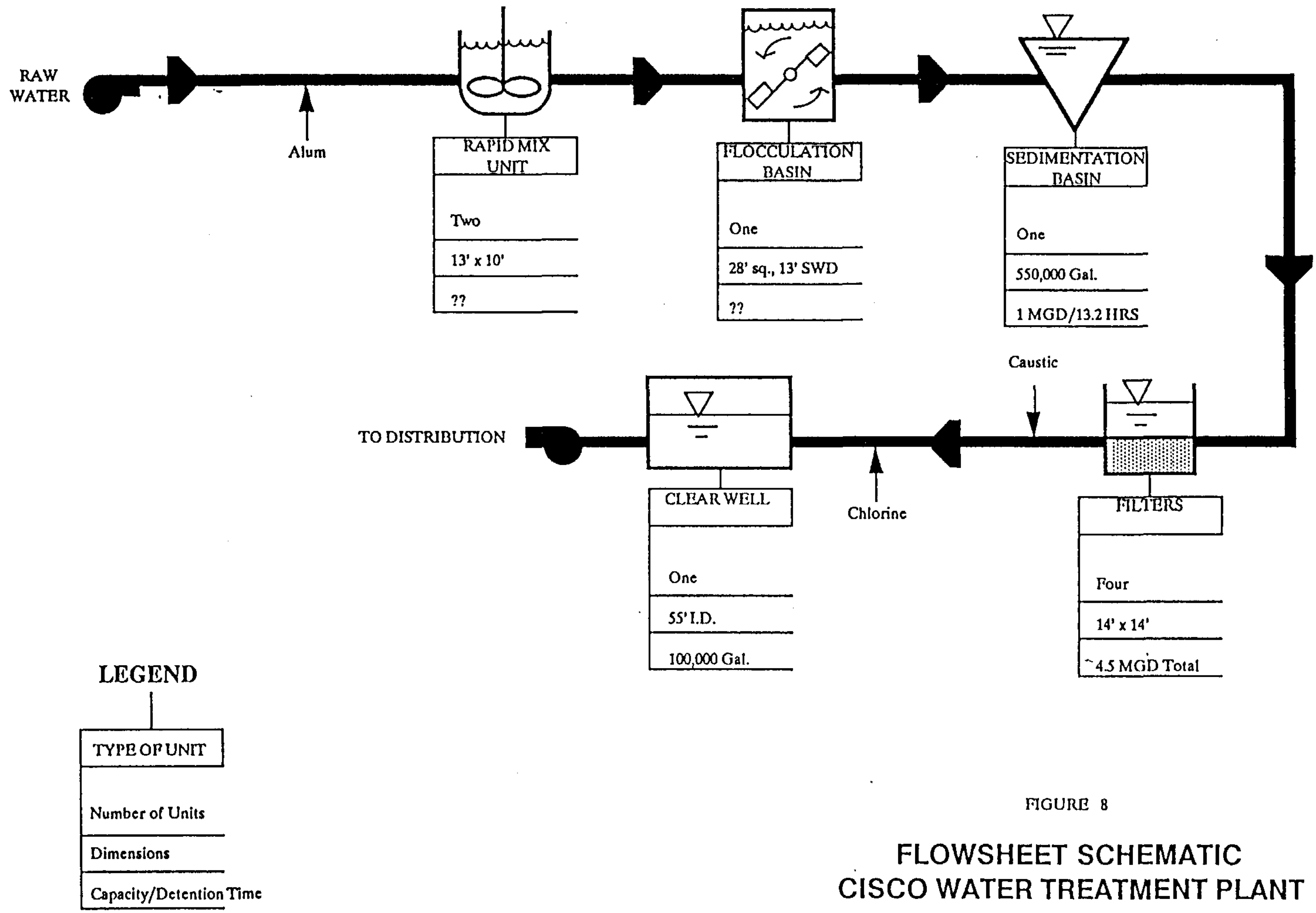


FIGURE 8

FLOWSHEET SCHEMATIC
CISCO WATER TREATMENT PLANT

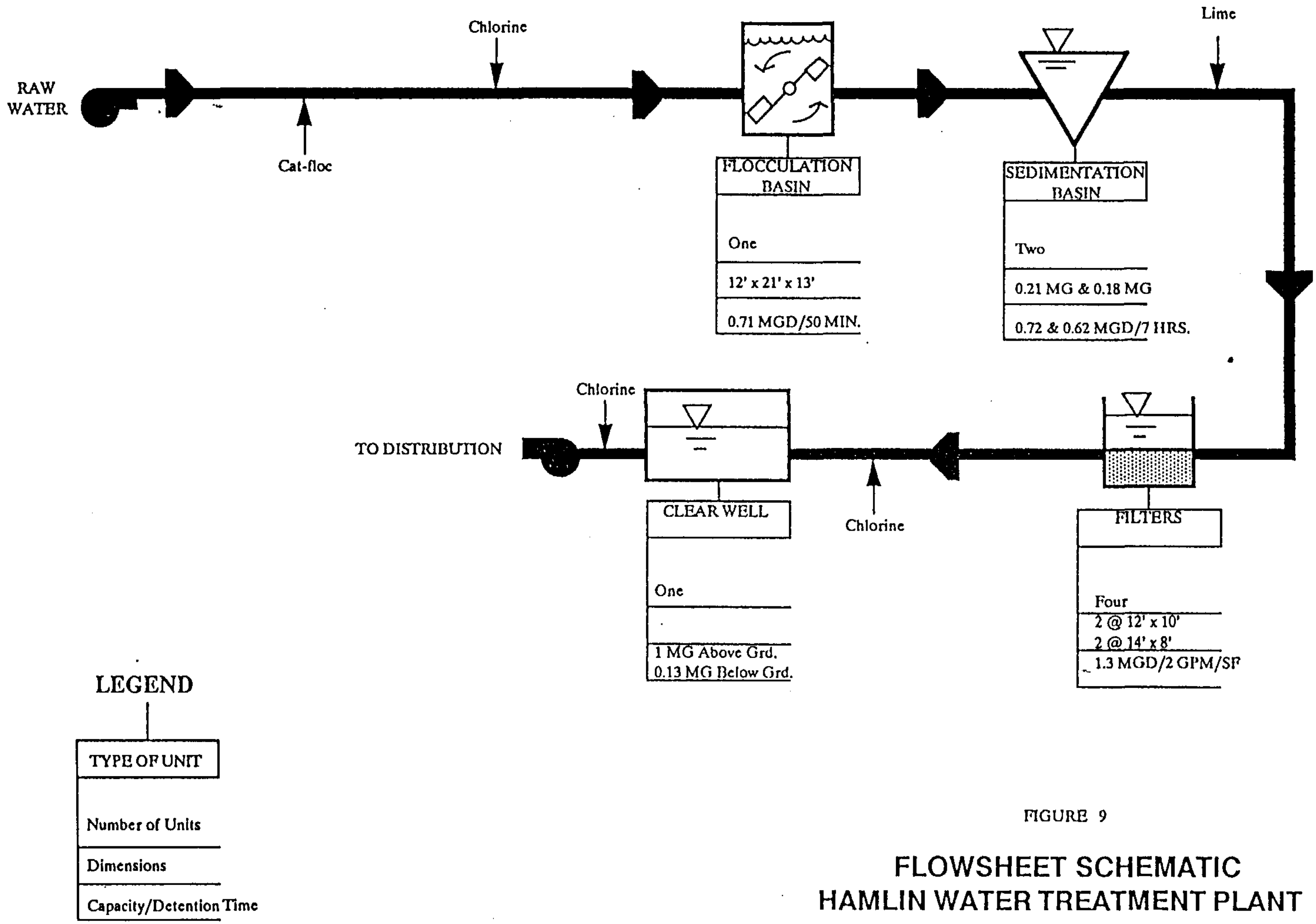


FIGURE 9

FLOWSHEET SCHEMATIC HAMLIN WATER TREATMENT PLANT

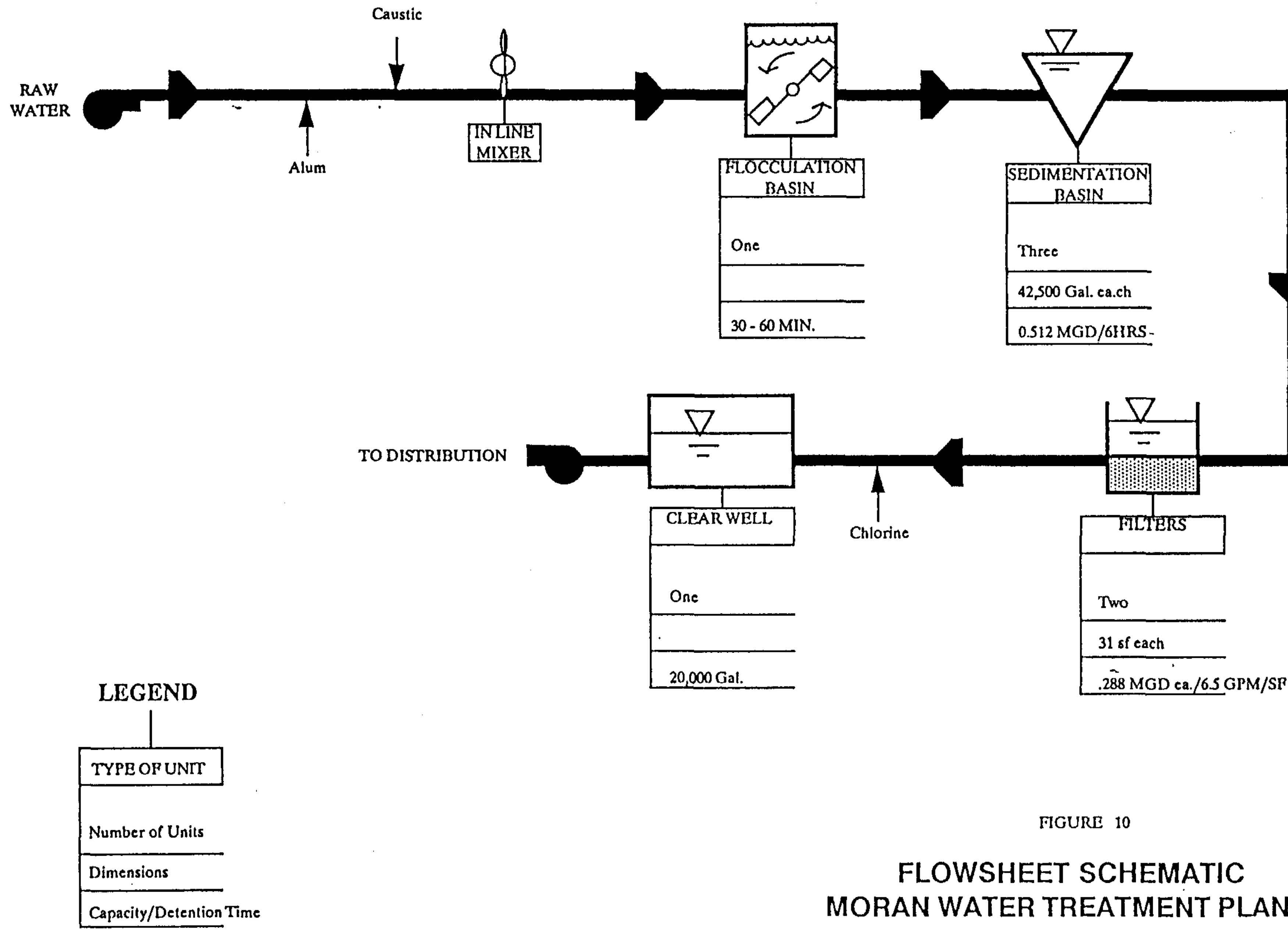


FIGURE 10

FLOWSHEET SCHEMATIC
MORAN WATER TREATMENT PLANT

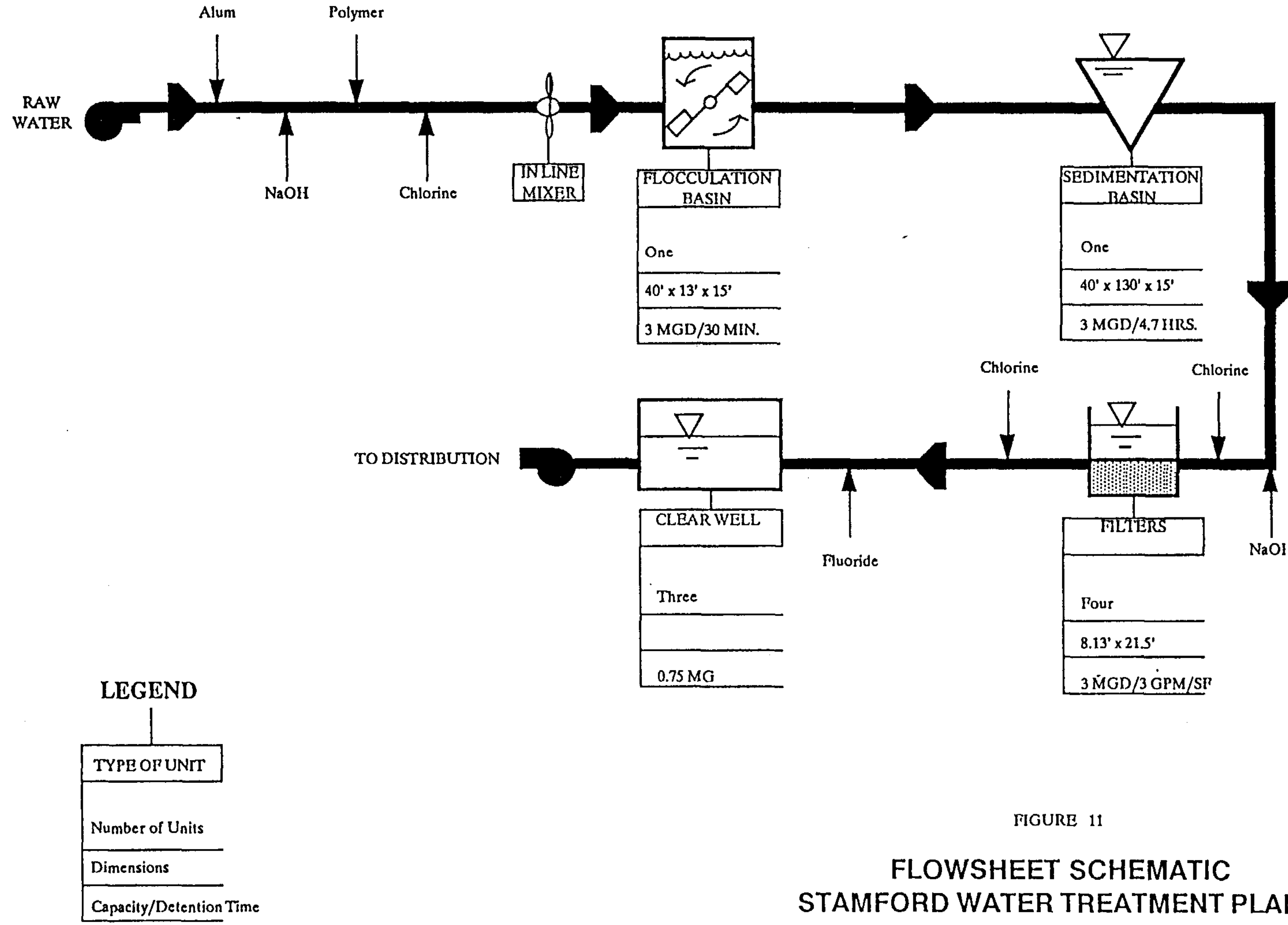


FIGURE 11

FLOWSHEET SCHEMATIC
STAMFORD WATER TREATMENT PLANT

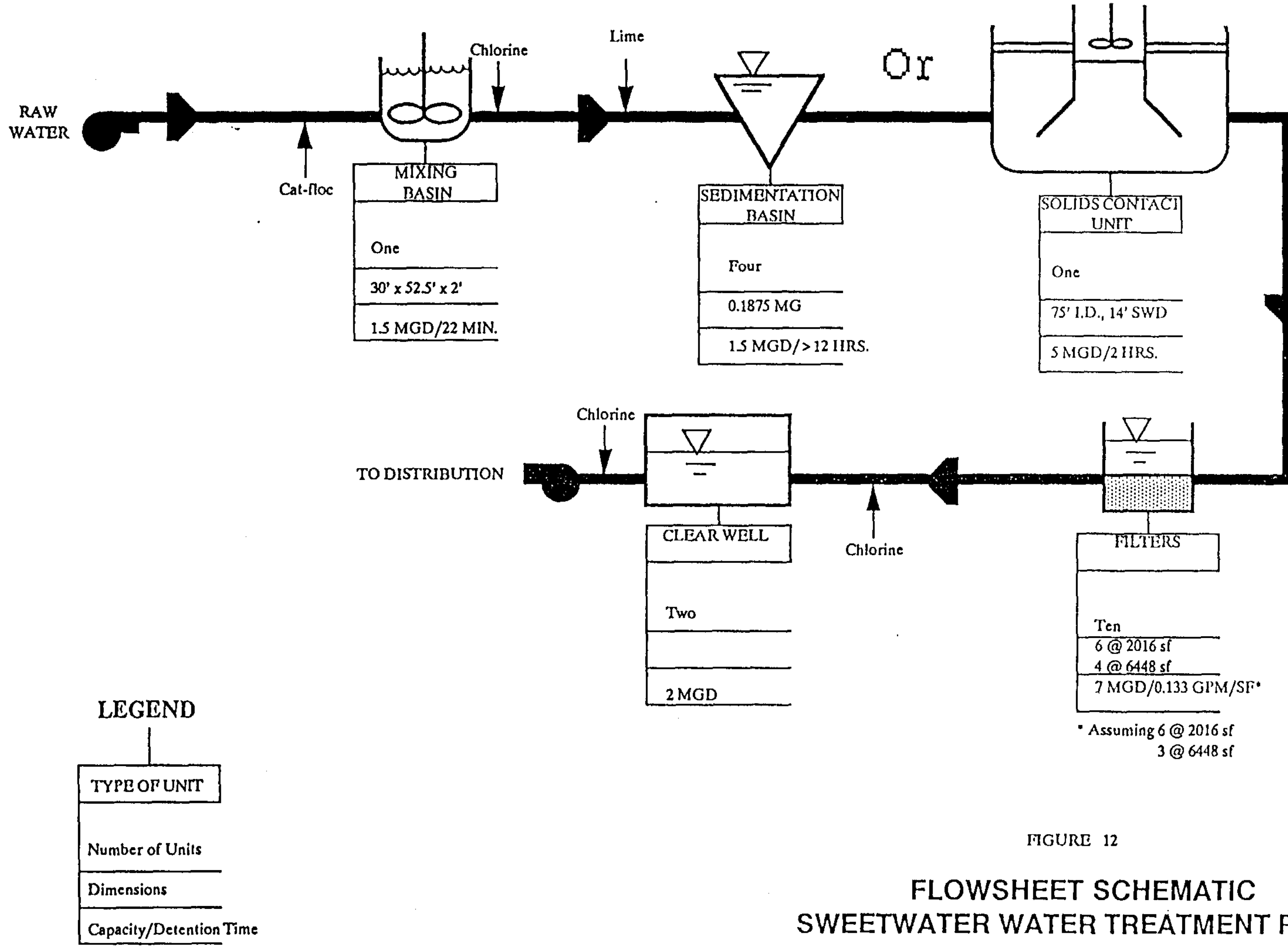


FIGURE 12

FLOWSHEET SCHEMATIC
SWEETWATER WATER TREATMENT PLANT

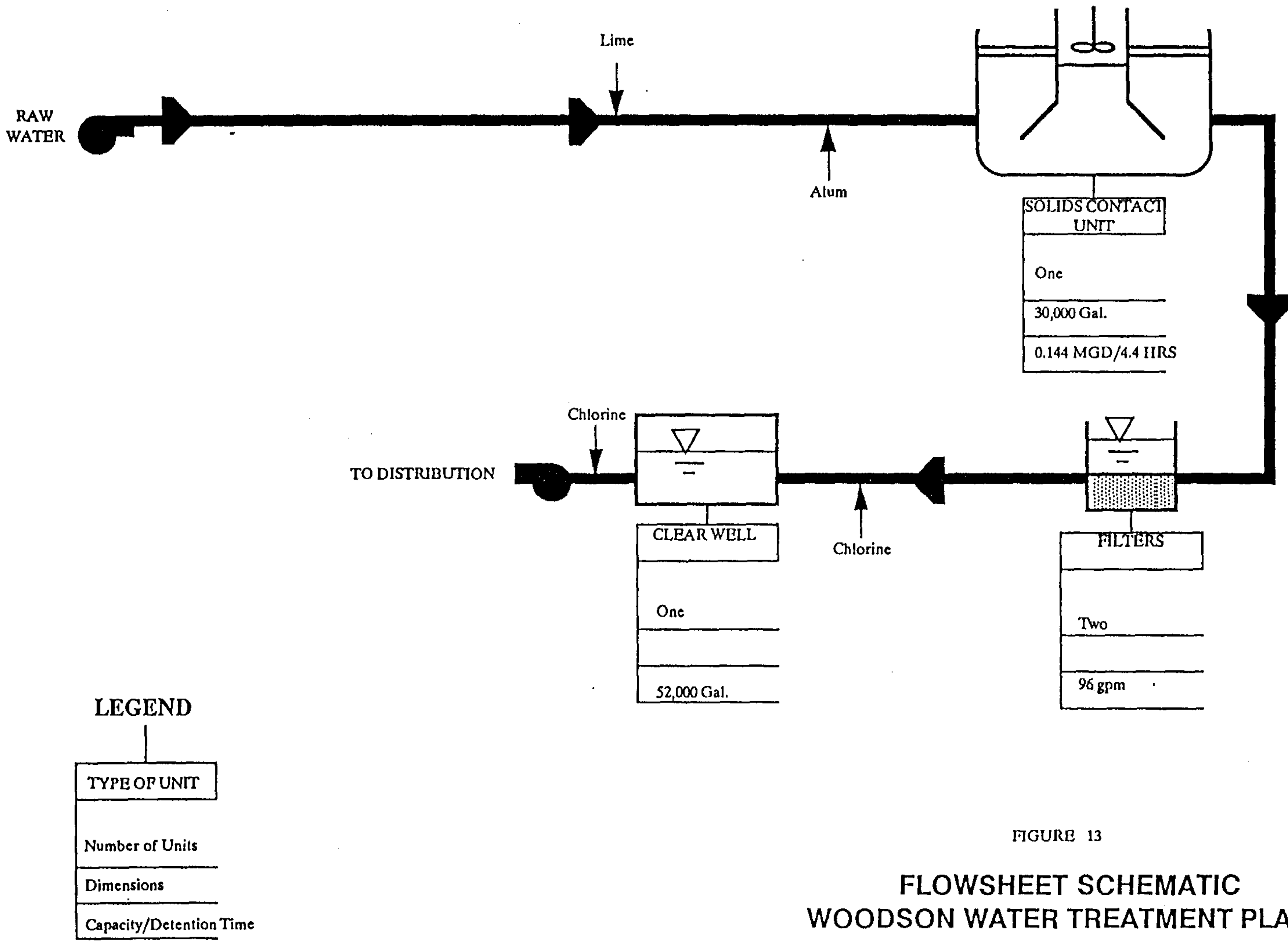
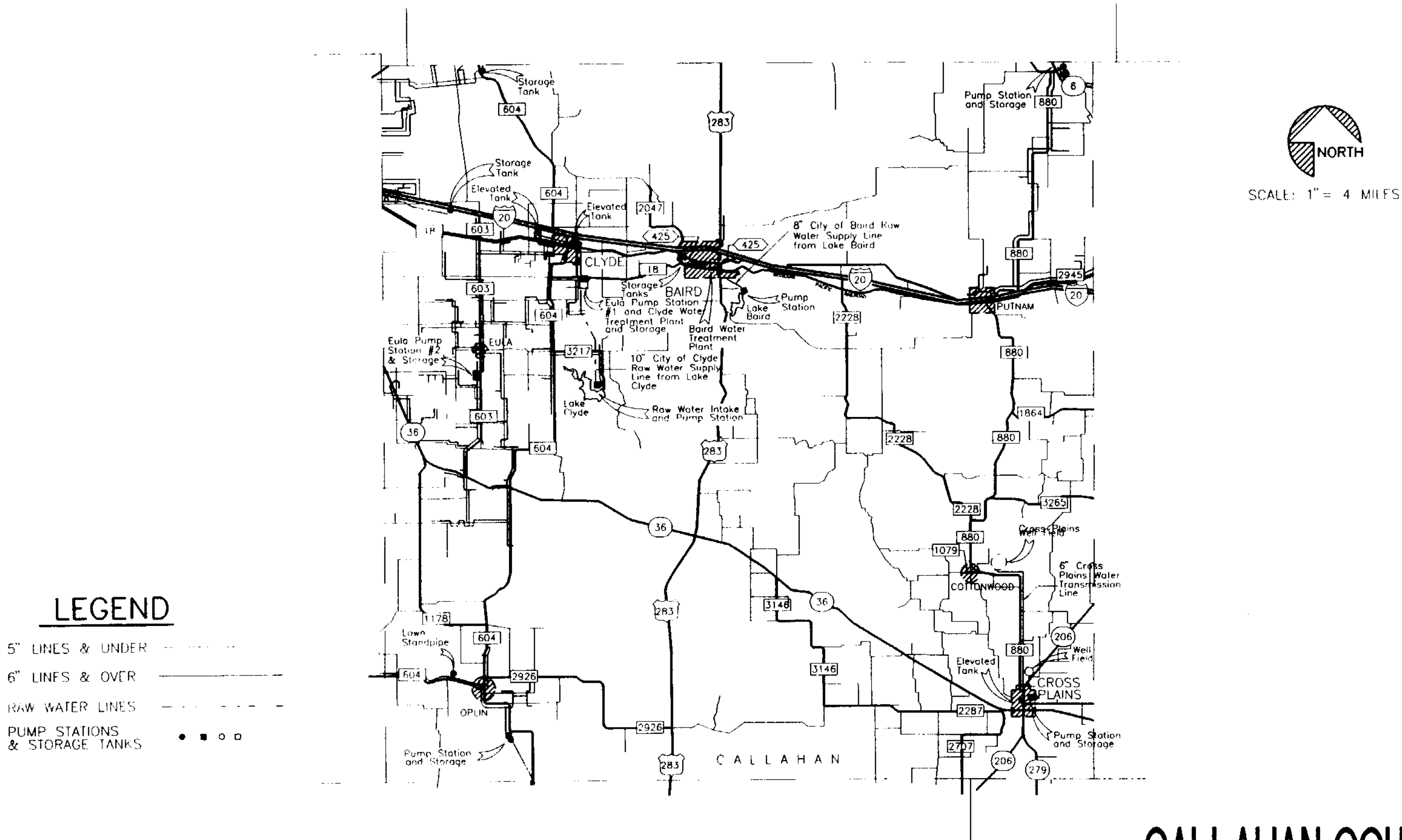


FIGURE 13

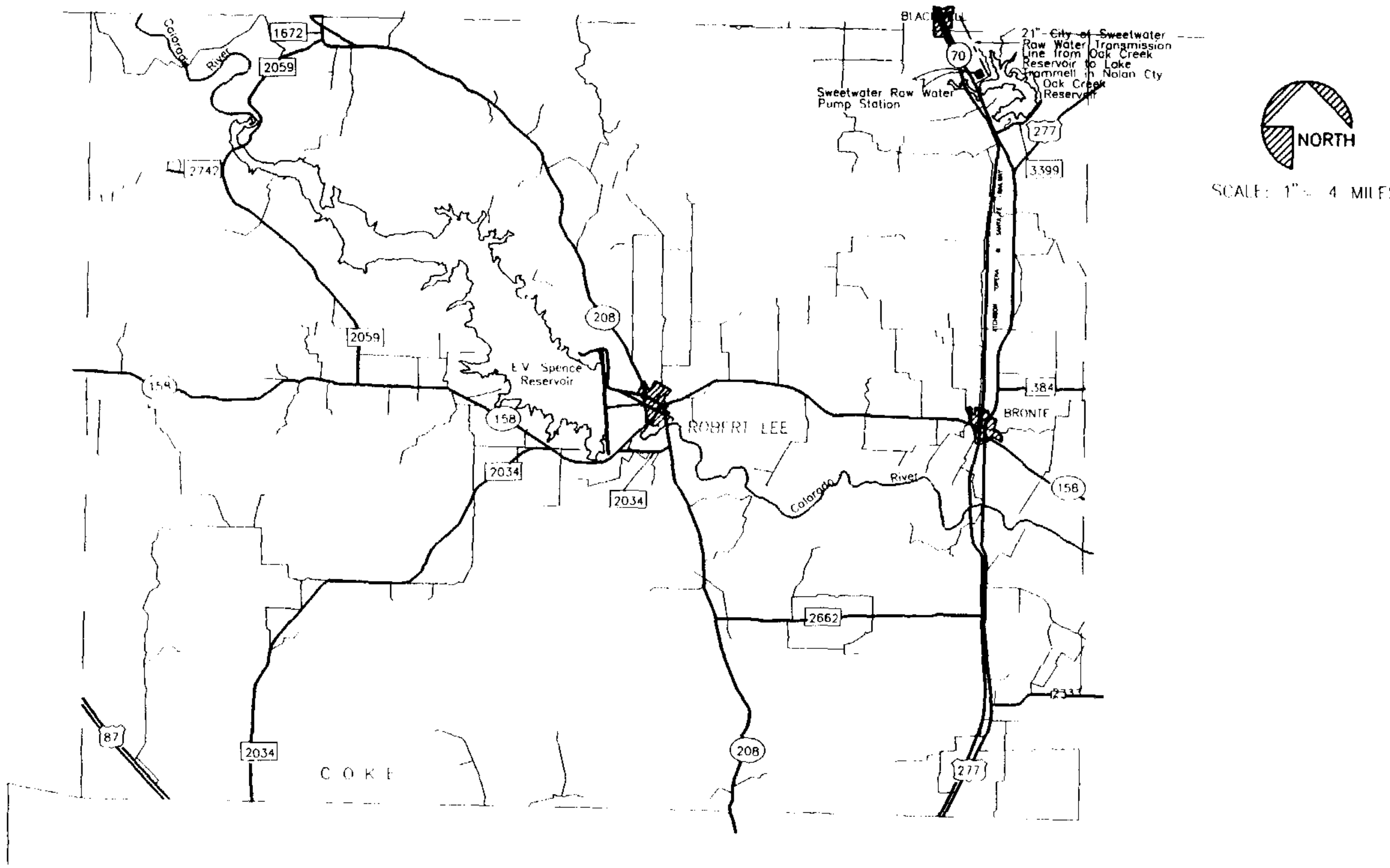
FLOWSHEET SCHEMATIC
WOODSON WATER TREATMENT PLANT

APPENDIX H

EXISTING WATERLINES BY COUNTY



CALLAHAN COUNTY



LEGEND

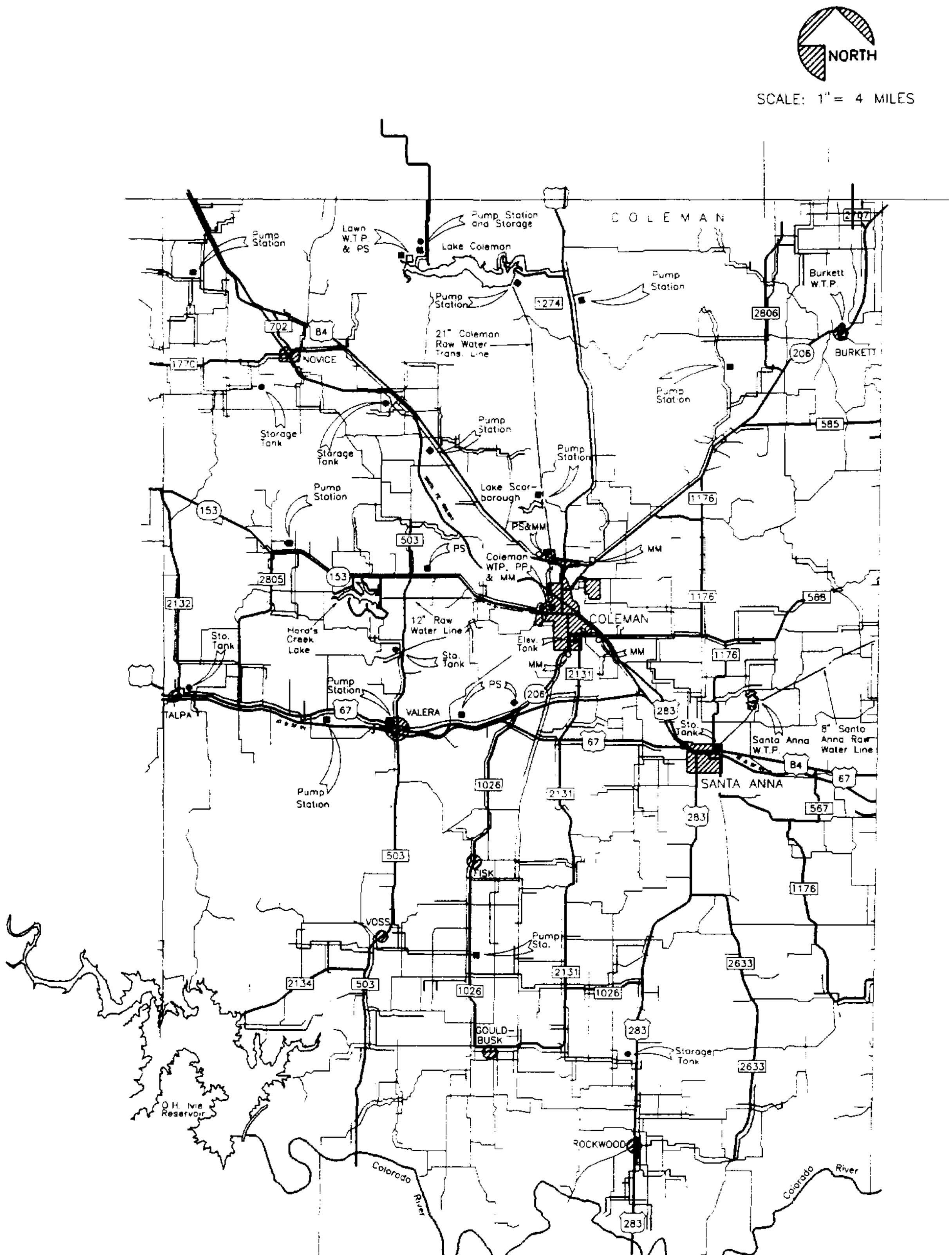
5" LINES & UNDER

6" LINES & OVER

RAW WATER LINES

PUMP STATIONS & STORAGE TANKS

COKE COUNTY



LEGEND

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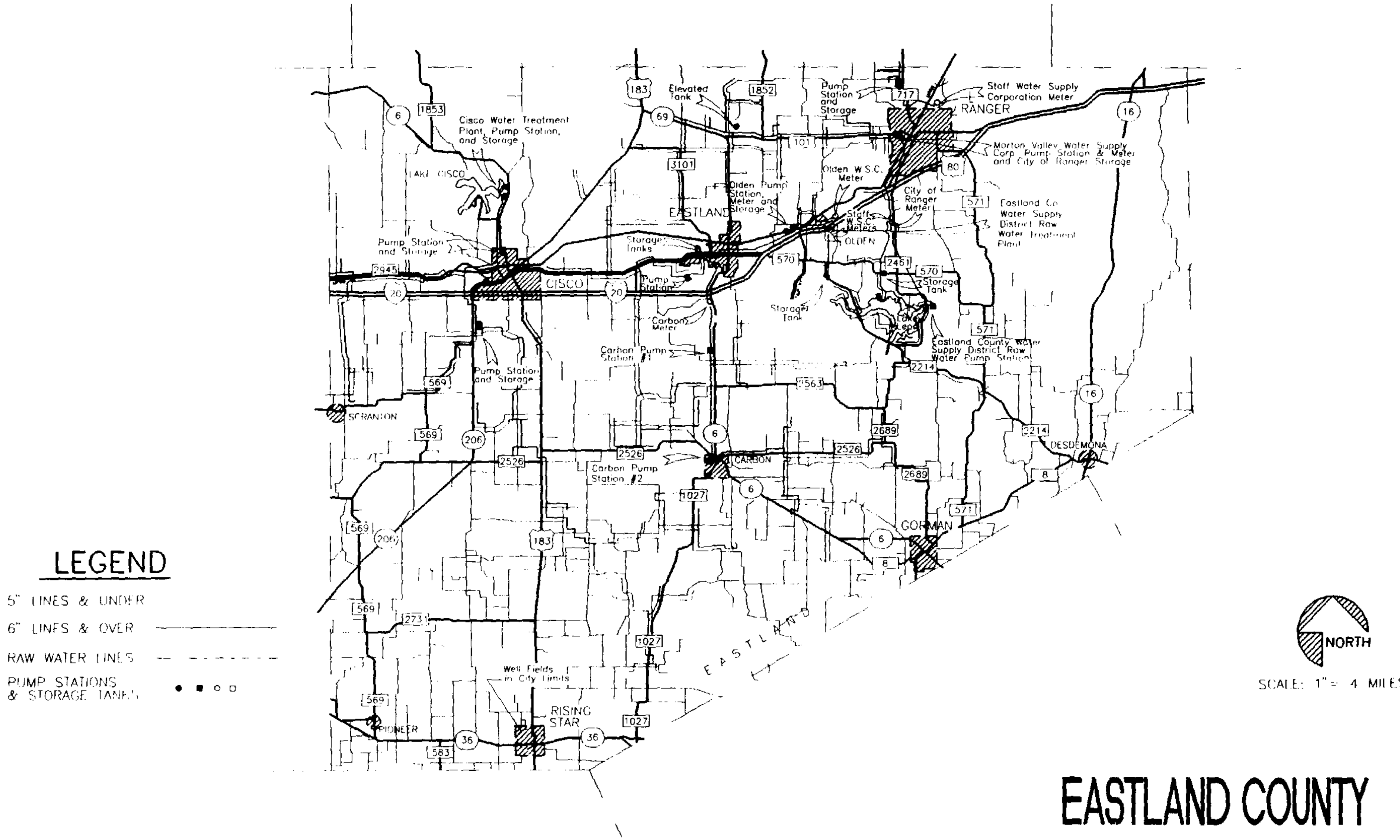
6" LINES & OVER

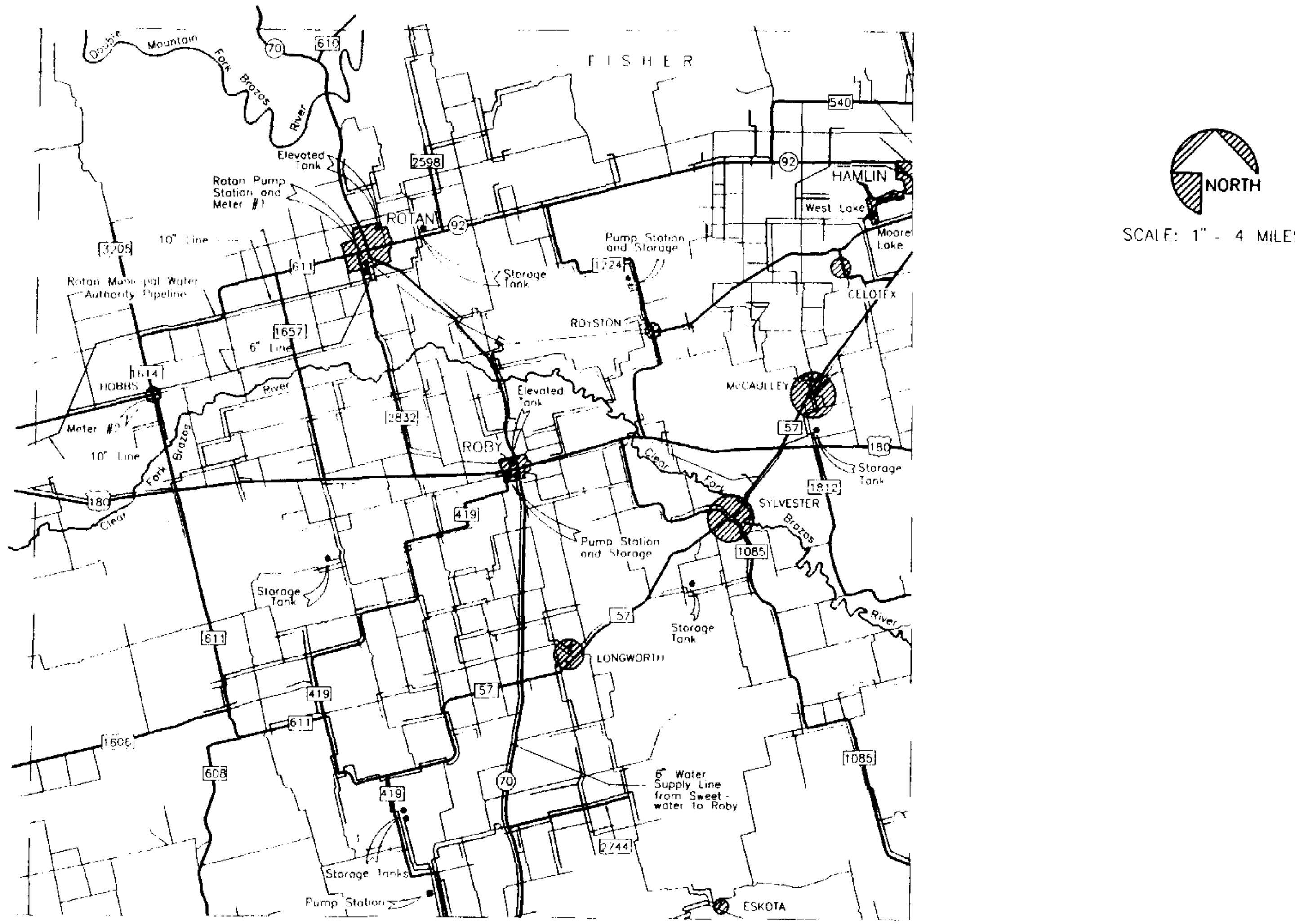
RAW WATER LINES

PUMP STATIONS & STORAGE TANKS

COLEMAN COUNTY



EASTLAND COUNTY



LEGEND

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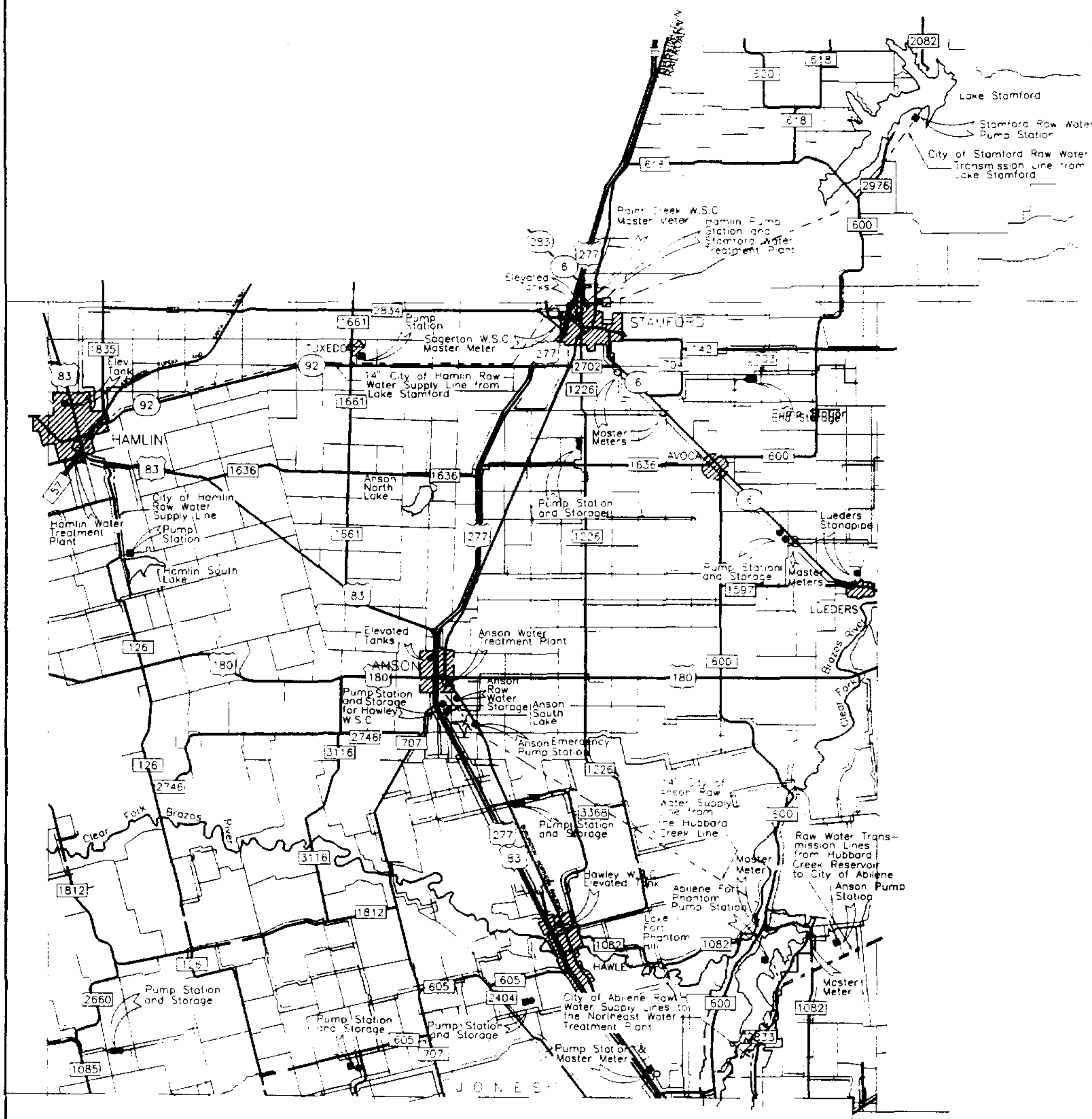
6" LINES & OVER

RAW WATER LINES

PUMP STATIONS & STORAGE TANKS

FISHER COUNTY



LEGEND

5" LINES & UNDER

6" LINES & OVER

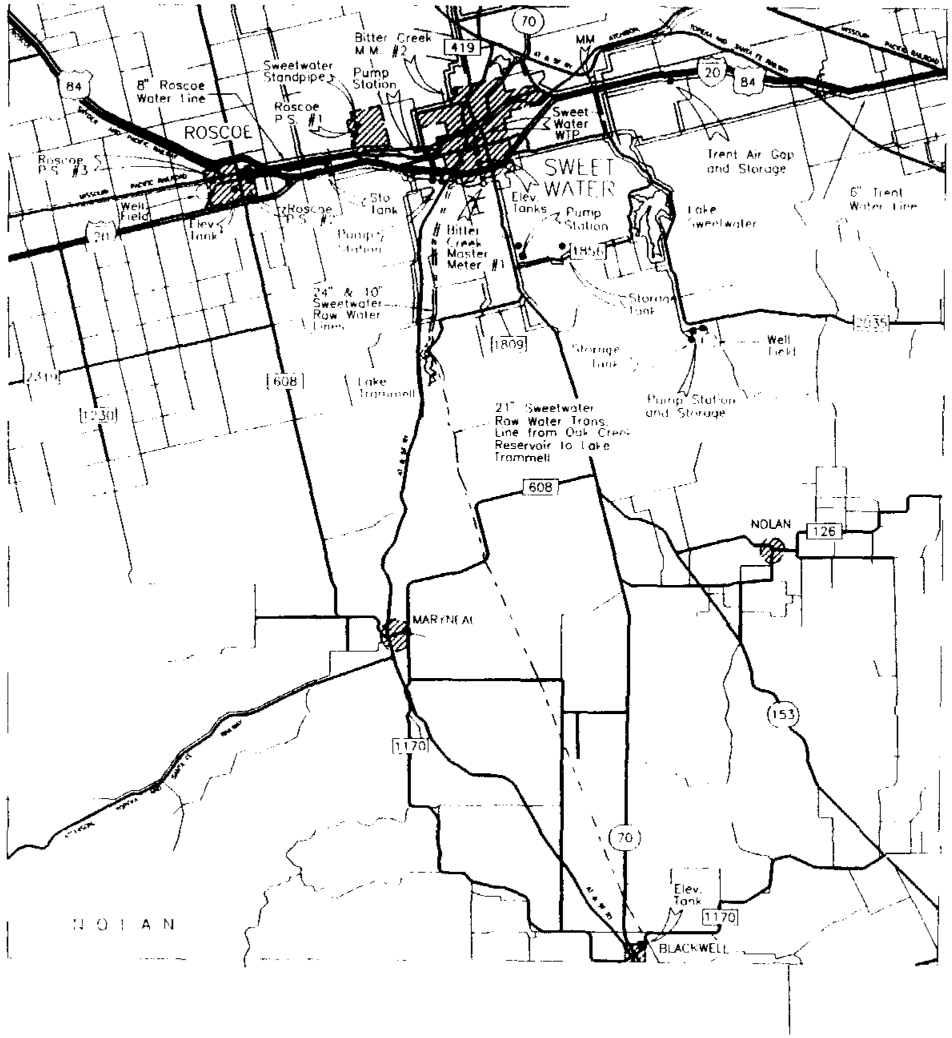
RAW WATER LINES

PUMP STATIONS & STORAGE TANKS

NORTH

SCALE: 1" = 4 MILES

JONES COUNTY



LEGEND

5" LINES & UNDER

6" LINES & OVER

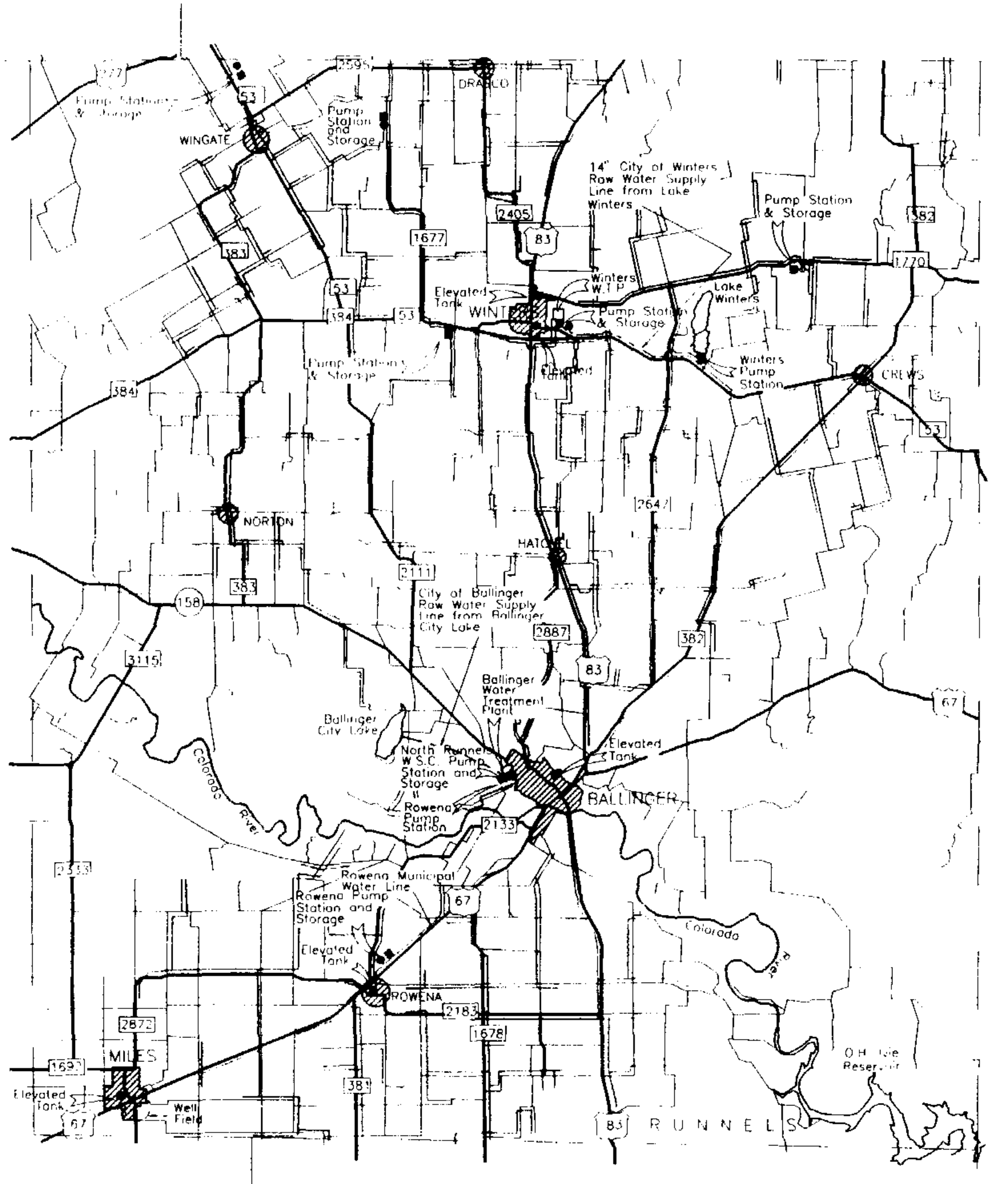
RAW WATER LINES

PUMP STATIONS & STORAGE TANKS

NORTH

SCALE: 1" = 4 MILES

NOLAN COUNTY



LEGEND

5" LINES & UNDER

6" LINES & OVER

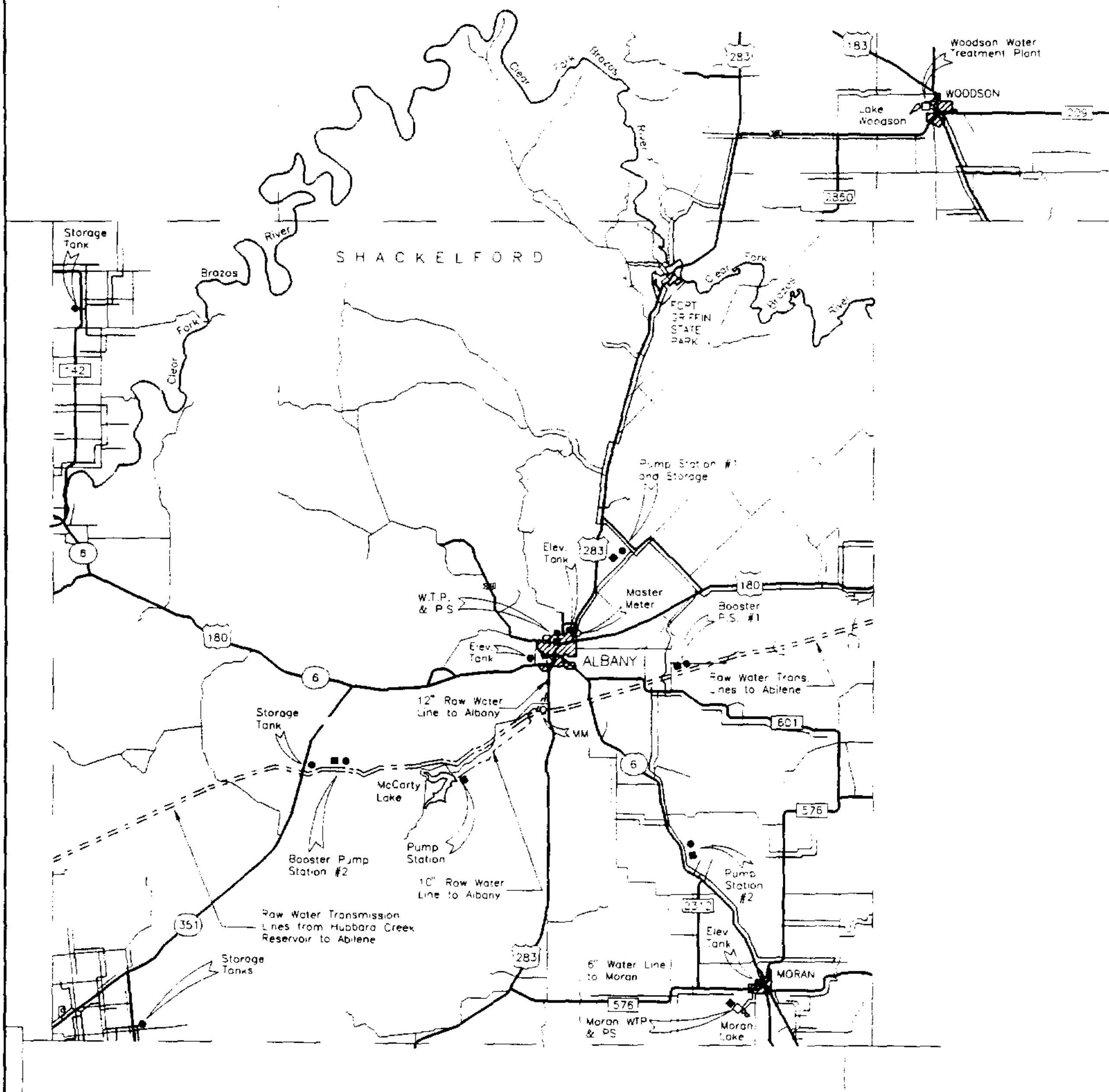
RAW WATER LINES

PUMP STATIONS & STORAGE TANKS

NORTH

SCALE: 1" = 4 MILES

RUNNELS COUNTY



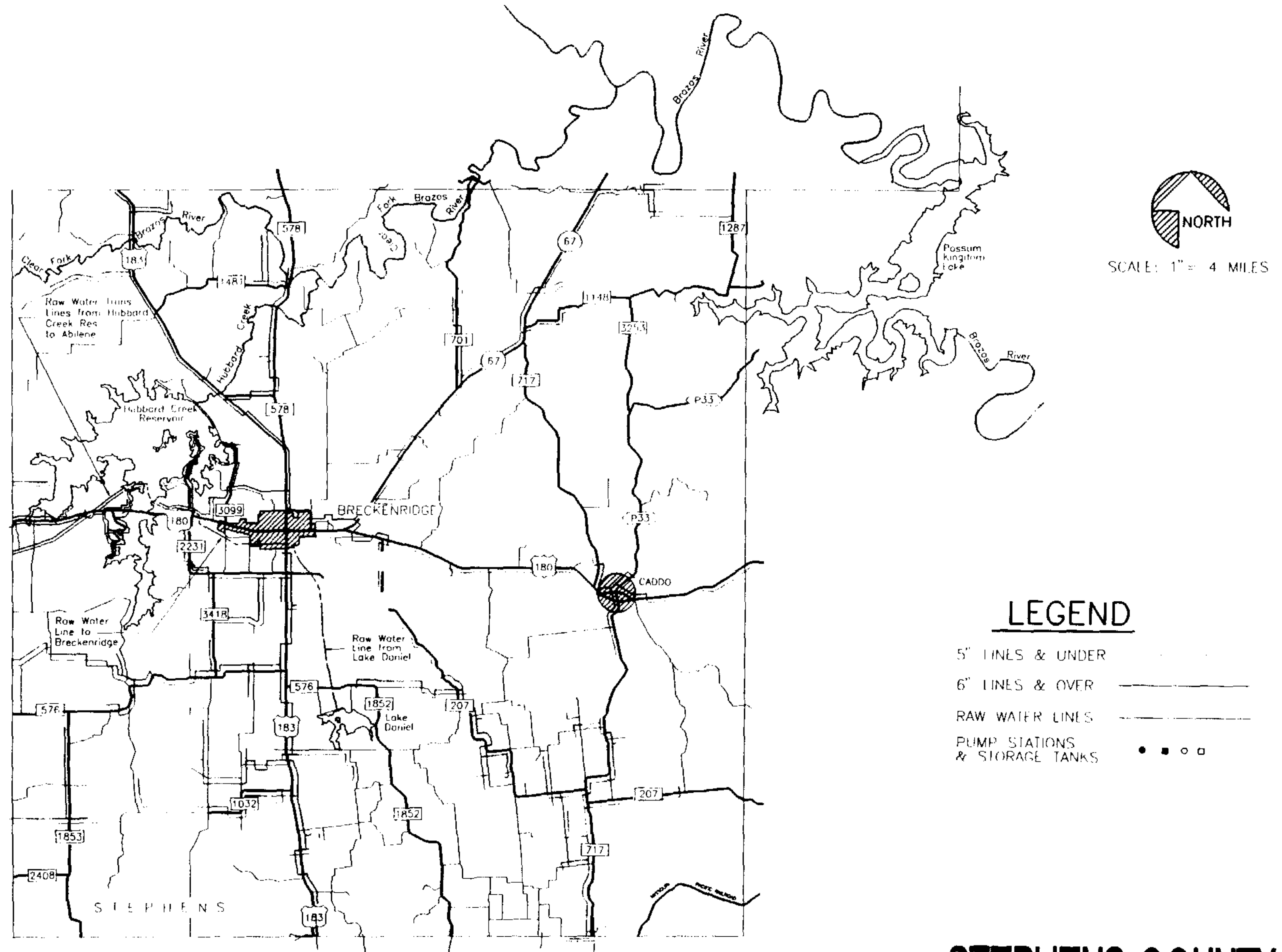
LEGEND

5" LINES & UNDER	———————
6" LINES & OVER	———————
RAW WATER LINES	— - — - — -
PUMP STATIONS & STORAGE TANKS	● ■ ○ □

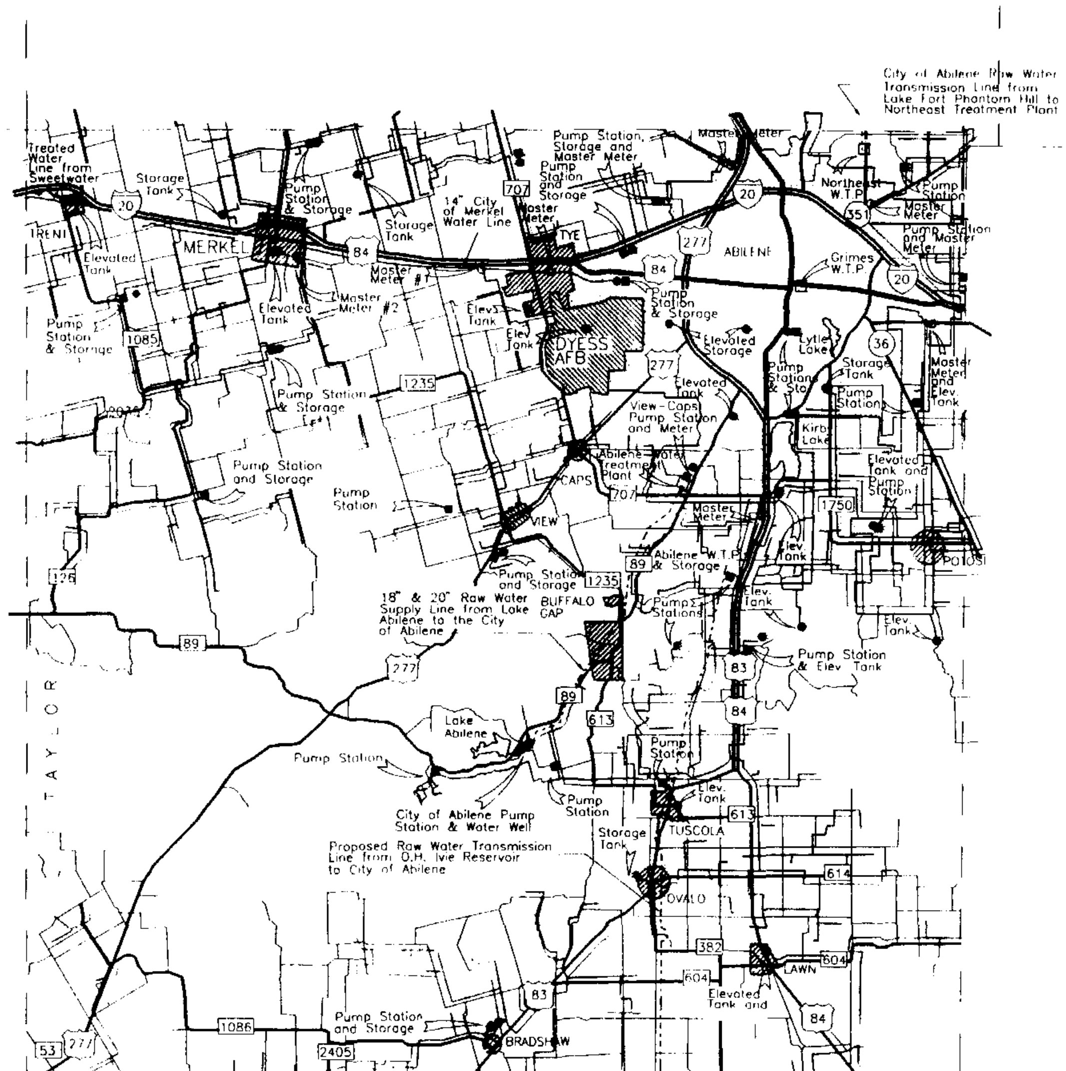
NORTH

SCALE: 1" = 4 MILES

SHACKELFORD COUNTY



STEPHENS COUNTY



SCALE: 1" = 4 MILES

LEGEND

5" LINES & UNDER

6" LINES & OVER

RAW WATER LINES

PUMP STATIONS & STORAGE TANKS

TAYLOR COUNTY

ABILENE, TEXAS, AND WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT

STUDY OF LONG-RANGE WATER SUPPLY

1980

ABILENE, TEXAS

AND

WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT

STUDY OF LONG-RANGE WATER SUPPLY

OCTOBER 1980

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ABILENE, TEXAS AND WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT

STUDY OF LONG-RANGE WATER SUPPLY

OCTOBER 1980

1. INTRODUCTION

In April of 1979, the City of Abilene and the West Central Texas Municipal Water District authorized Freese and Nichols, Inc., to prepare two engineering studies relating to surface water supplies available to the City and the District. A report on the first investigation, entitled "Study of Coordinated Operation of Existing Raw Water Supply Sources" (1), was delivered in January of 1980. This second study contains estimates of the long-range water requirements for Abilene and WCTMWD through the year 2030 and an evaluation of potential supplemental sources of supply. The scope of this investigation of the long-range water supply includes the following principal areas:

a. A review of historical trends in water use by the City of Abilene and WCTMWD.

b. A comparison of the total available supply from existing sources with the projected future requirements to estimate the date at which an additional source of supply will be necessary.

c. A general study to select the most promising potential alternative sources, with consideration of the amount of additional supply, pumping distance, static lift, water rights, approxi-

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(1) Numbers in parentheses match references listed in Appendix A.

mate cost, and water quality.

d. An evaluation of the feasible amounts of additional yield, the preliminary sizing and layout of the raw water facilities, and the estimated chemical quality of the water for the selected most promising alternatives.

e. Estimates of present-day capital costs and annual operating costs for the selected most promising alternatives.

Item "a" is discussed in Section 2 of this report, followed by the comparison of the available supply with projected demand (Item "b") in Section 3. The potential sources of supply (Item "c") are presented in Section 4. The evaluation of the most promising sources (Item "d") and the estimation of the associated costs (Item "e") are combined in Section 5. The conclusions and recommendations of the study are summarized in Section 6.

2. PROJECTED WATER REQUIREMENTS

General

The total water requirement of a region is the sum of various types of demands. Within the West Central Texas Municipal Water District service area, these demands result primarily from domestic households and commercial establishments and from manufacturing concerns supplied by the municipalities. Electric power plant cooling water, irrigation water, and oil field injection water represent additional uses which, although not as large as the needs of the municipalities, are nevertheless significant in terms of long-range planning to maintain a balance between supply and demand.

The West Central Texas Municipal Water District was formed in order to meet anticipated future demands within the Cities of Abilene, Albany, Anson, and Breckenridge. The four member cities each own at least one surface water reservoir which is capable of meeting a portion of the water needs. The District's primary purpose is to assure that each of its member cities will have available a dependable water supply to supplement the cities' sources.

The District completed Hubbard Creek Dam and Reservoir in 1962, in anticipation of water requirements in excess of the dependable supply afforded by the other existing reservoirs. In 1978 (the maximum year prior to 1980), the District supplied municipalities approximately 6,000 acre-feet of water from Hubbard Creek Reservoir. Over 5,000 acre-feet of surplus water were also sold for irrigation and mining purposes, and 640 acre-feet were required for maintenance of the dam and for the residential supplies of lakeshore homes (2). Some or all of these quantities will be exceeded in 1980.

Population

The historical growth recorded by the Bureau of the Census (3, 4), for the five-county area that includes the Abilene Standard Metropolitan Statistical Area and the District's other member cities is delineated in Table 2.1 and illustrated in Figure 2.1. Historically, the area as a whole has shown continued, although sometimes erratic, growth. From time to time, various economic stimuli have caused rapid spurts of development, followed by periods of stabilization. Between 1960 and 1970, there was a significant decline in population. However, the preliminary 1980 estimates by the Bureau of the Census indicate that there have been significant population increases in all five counties. Callahan County is not served by the WCTMWD but is part of the Abilene SMSA and is included here to show the over-all regional growth pattern.

The Texas Department of Water Resources (TDWR) has recently made population estimates for all counties and some cities within Texas (5, 6). These projections, for the five counties listed in Table 2.2, predict moderate growth rates of approximately 1.2 percent per year ("low series") and 1.7 percent per year ("high series"). As illustrated in Figure 2.1, the "low series" projection is basically consistent with the area's historical growth. The trend indicated by the "low series" values was used in this study as one of the guidelines for estimates of future populations of the District member cities and their service areas.

The WCTMWD service area contains certain economic factors that could dramatically alter the population characteristics of the region.

Table 2.1

Historical County Populations (2,3)

County	Year								
	1900	1910	1920	1930	1940	1950	1960	1970	1980*
Callahan	8,768	12,973	11,844	12,785	11,568	9,087	7,929	8,205	10,866
Jones	7,053	24,299	22,323	24,233	23,378	22,147	19,299	16,106	16,919
Shackelford	2,461	4,201	4,960	6,695	6,211	5,001	3,990	3,323	3,844
Stephens	6,466	7,980	15,403	16,560	12,356	10,597	8,885	8,414	9,722
Taylor	10,499	26,293	24,081	41,023	44,147	63,370	101,078	97,853	115,600
Total	35,247	75,746	78,611	101,296	97,660	110,202	141,181	133,901	156,951

*Note: The populations for 1980 are preliminary census count figures. Final figures will not be released by the Census Bureau until later this year.

HISTORICAL AND PROJECTED POPULATIONS FOR THE FIVE COUNTY AREA AND FOR THE W. C.T. M. W.D.

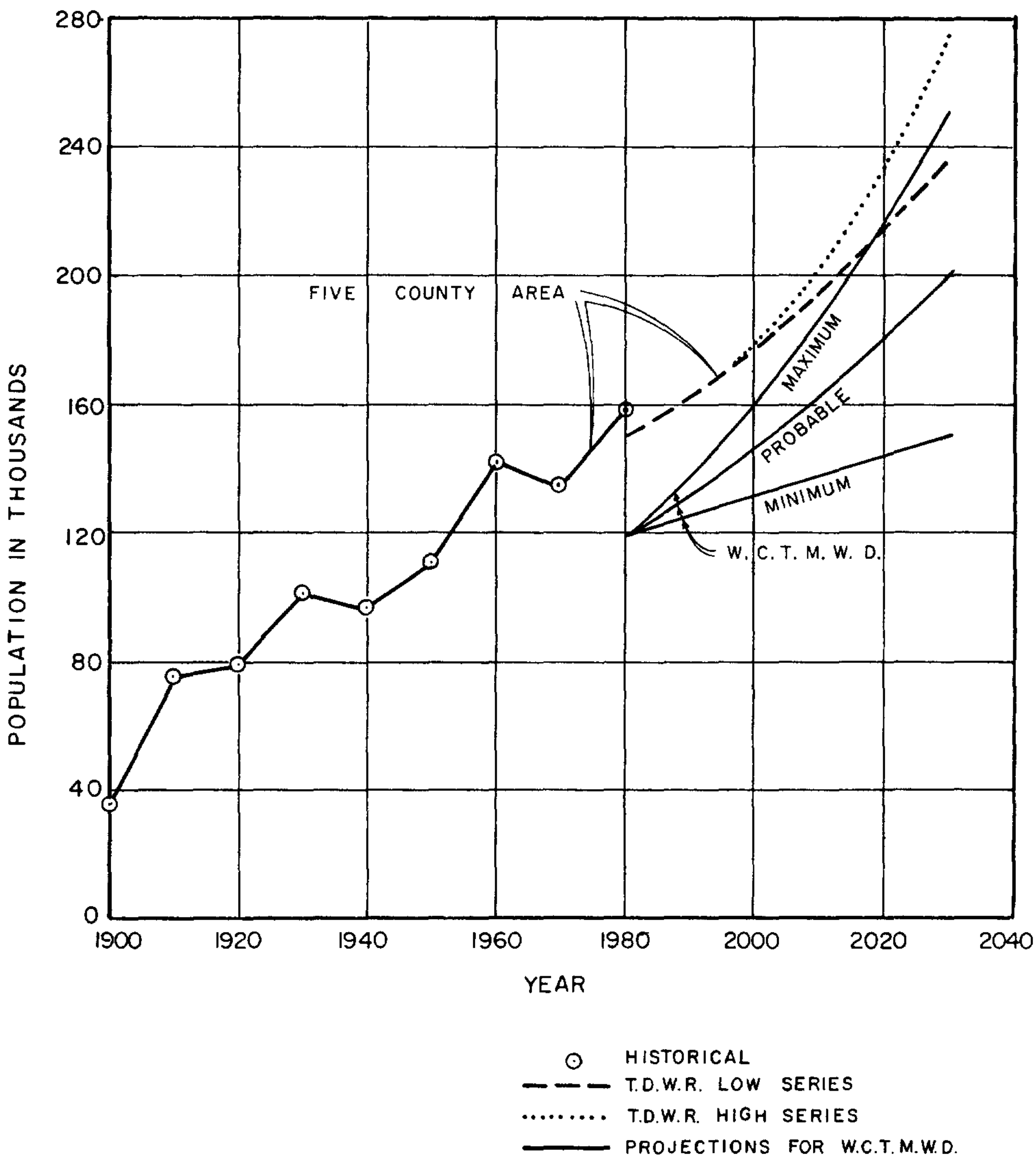

FIGURE 2.1

Table 2.2

Texas Department of Water Resources
Population Estimates (5)

County	Year 1980	1990	2000	2010	2020	2030
Low Series						
Callahan	10,300	11,700	13,600	15,100	16,300	17,300
Jones	16,200	16,400	16,600	17,600	18,600	19,700
Shackelford	3,200	3,000	2,800	2,800	2,800	3,000
Stephens	8,900	9,200	10,000	10,900	12,200	13,800
Taylor	110,300	121,700	134,800	149,400	165,700	182,300
Total	148,900	162,000	177,800	195,800	215,600	236,100
High Series						
Callahan	10,300	11,700	13,600	15,500	17,500	19,900
Jones	16,200	16,400	16,600	17,800	20,800	26,800
Shackelford	3,200	3,000	2,800	2,800	3,000	3,400
Stephens	8,900	9,200	10,000	11,200	13,100	15,900
Taylor	110,300	121,700	134,800	153,300	177,400	209,100
Total	148,900	162,000	177,800	200,600	231,800	275,100

Throughout the area are a number of oil fields that have recoverable secondary oil and gas reserves, and there are also significant areas that have retrievable quantities of bituminous coal (7). Expanded programs for recovery of those energy resources in the future could spur a greater growth in population than predicted in present projections. Such types of positive economic activity should be monitored closely by the District and the member cities so that dramatic increases in municipal or industrial needs can be detected and provided for if they occur.

Estimated future water use populations for the WCTMWD cities are presented in Table 2.3, covering the 50-year period from 1980 through 2030 by decades. There is obviously much uncertainty associated with such estimates if they extend more than a short time into the future, and the degree of uncertainty grows larger as the period of projection increases. In recognition of this factor, the information in Table 2.3 has been developed in the form of three separate trends, including a "probable" condition, a "minimum" condition and a "maximum" condition. In general, the minimum and maximum estimates are smaller or greater than the probable estimate by 5 percent in 1990, 10 percent in the year 2000, 15 percent in 2010, 20 percent in 2020 and 25 percent in 2030. All values have been rounded to the nearest 100 people, and it has been assumed that none of the cities will experience a decrease in population.

The probable projections are based primarily on the trends predicted by the "low series" of the Department of Water Resources (5), adjusted to begin in 1980 with populations consistent with the preliminary counts of the Census Bureau. In the case of Abilene, where many of the water customers are outside the corporate limits of Abilene itself, the estimates were developed from the populations of Taylor County and Jones County. It is estimated that approximately 90 percent of the residents in Taylor County and 10 percent of those in Jones County presently receive water from Abilene, plus approximately 500 additional people living in Jones County near Lake Fort Phantom Hill. These percentages are increasing, and larger fractions of the two counties are expected to be served by the City from year to year. By 2030, Abilene

Table 2.3

Projected Water Use Populations for Member Cities of the West Central Texas Municipal Water District

	1980	1990	2000	2010	2020	2030
Minimum						
Abilene	106,200	112,400	118,900	125,500	131,500	137,000
Albany	2,400	2,400	2,400	2,400	2,400	2,400
Anson	2,800	2,800	2,800	2,800	2,800	2,800
Breckenridge	6,800	6,900	7,200	7,600	8,200	8,900
Total	118,200	124,500	131,300	138,300	144,900	151,100
Probable						
Abilene	106,200	118,300	132,100	147,600	164,400	182,700
Albany	2,400	2,500	2,600	2,700	2,800	2,900
Anson	2,800	2,900	3,000	3,100	3,200	3,300
Breckenridge	6,800	7,200	8,000	8,900	10,200	11,900
Total	118,200	130,900	145,700	162,300	180,600	200,800
Maximum						
Abilene	106,200	124,200	145,300	169,700	197,300	228,400
Albany	2,400	2,600	2,900	3,100	3,400	3,600
Anson	2,800	3,000	3,300	3,600	3,800	4,100
Breckenridge	6,800	7,600	8,800	10,200	12,200	14,900
Total	118,200	137,400	160,300	186,600	216,700	251,000

Note: The population figures for Abilene include water users living outside the city limits.

is projected to supply water to 95 percent of Taylor County and 15 percent of Jones County, plus approximately 1,000 additional people living around Lake Fort Phantom Hill.

Albany, Anson and Breckenridge have all shown population increases since 1970 according to the preliminary Census Bureau results. The 1980 figures shown for these cities in Table 2.3 are approximately the same as the census counts, rounded to even hundreds. The future growth for

Anson and Breckenridge is patterned to be generally consistent with the trends predicted by the Department of Water Resources for Jones and Stephens Counties. The Department's projection for Shackelford County does not reflect the growth that has occurred since 1970, and the TDWR trend was not followed in the projection for Albany. Instead, Albany was assumed to continue to gain population at a moderate rate over the next 50 years.

Most of the future population increase is predicted to occur in the Abilene water service area. Through 2020, based on the probable projection, Abilene is expected to account for 94 percent of the growth, and the comparable figure through the year 2030 is 93 percent.

Municipal Water Use

The raw water requirements of the WCTMWD member cities for the seven-year period from 1972 through 1979, as reported to the District, are summarized in Table 2.4. Although the annual use varied somewhat with the occurrence of wet and dry years, the general trend was for fairly uniform use during the first five years. The years 1977 and 1978 were exceptionally dry, and the water requirements increased. Although complete figures for 1980 will not be available for several months, it is apparent that water use in 1980 will exceed that of 1978 in most cases.

To project the future municipal water requirements of the member cities, present levels of water use were first established from the records of recent years and available information for 1980. These amounts were then adjusted decade by decade to reflect the projected increases in population shown in Table 2.3 and Figure 2.1, together

Table 2.4

Member Cities Raw Water Use as Reported to WCTMWD (1)

- Values in Acre-Feet -

City	1972	1973	1974	1975	1976	1977	1978	1979
Abilene	16,005	15,883	19,813	17,084	18,670	21,142	22,050	21,672
Albany	361	278	371	301	331	469	534	637
Anson	445	*	625	462	408	503	519	495
Breckenridge	1,193	815	933	853	1,121	1,323	1,407	1,522
Total	18,004	-	21,742	18,700	20,530	23,437	24,510	24,326

*Not available from District records.

with projected percent increases in per capita consumption for the study area as recently published by the Texas Department of Water Resources (8), allowing in all cases for the high per capita consumption during drouth conditions. The TDWR publication contains data on per capita consumption rates for both urban and rural areas. The TDWR water use estimates for urban areas were established from historical data collected from cities within each county, with allowances for treatment and distribution losses.

In the county-wide TDWR data, the projected rates of increase in per capita water demand over the next decades are not as rapid as historical increases. Water use in recent decades has reflected changes in the prevailing standard of living, such as the widespread adoption of water-using appliances in households and increased ownership of private swimming pools. This trend has been noticed in the City of Abilene and in many major urban areas, but it probably will not be matched by comparable changes in years to come. The future percentage increases predicted by the TDWR for average per capita water use under normal weather conditions in urban areas of the counties within the WCTMWD seem reasonable, and they have been adopted in this study.

The average per capita demand is generally higher in dry years than in normal years, and the amount of the increase under critical drouth conditions can be expected to be about 15 gpcd (9). Consequently, the normal water demands predicted for the District have been increased by 15 gpcd to account for the higher over-all water consumption that occurs in drouth years. The total projected municipal water requirements for the District and each of the member cities under drouth conditions are presented in Table 2.5.

Steam Electric Cooling Water

In addition to the municipal requirements that will be placed on the existing supply in the future, West Texas Utilities has contracted with the City of Abilene for cooling water to supply the power plant at Lake Fort Phantom Hill. The actual demand for the existing 355 MW facility was 1,744 acre-feet in 1978, but the load factor was below normal that year (10). Water use will probably be higher in most years, and the increasing demand for electricity may require a higher level of operation at this facility in the future. The potential for plant expansion through addition of new generating units is not entirely clear at this time. Any such increase in plant capacity would lead to a corresponding increase in cooling water needs.

For planning purposes, the power plant cooling water requirement at Lake Fort Phantom Hill has been assumed to be 2,000 acre-feet per year in 1980, increasing to 4,000 acre-feet per year by 1990 and then remaining at that level through 2030.

Water Requirements at Hubbard Creek Reservoir

Summarized in Table 2.6 are the total water sales from Hubbard Creek Reservoir for the period from 1966 through 1979. The historical raw water use directly from Hubbard Creek Reservoir for summer and permanent homes on the shore of the lake, maintenance of the dam, and water released to downstream users is listed in the "other" column in the table. The projections for these water requirements should be added to the projections of the municipal and steam electric cooling water

Table 2.5

Projected Municipal Water Requirements for the WCTMWD Through the Year 2030

- Quantities in Acre-Feet -

		Minimum Projection	Probable Projection	Maximum Projection
Abilene	1980	24,000	24,000	24,000
	1990	27,900	29,300	30,800
	2000	30,100	33,500	36,800
	2010	32,400	38,100	43,900
	2020	34,500	43,100	51,800
	2030	36,500	48,600	60,800
Albany	1980	600	600	600
	1990	700	700	700
	2000	700	700	800
	2010	700	800	900
	2020	700	800	1,000
	2030	700	900	1,100
Anson	1980	600	600	600
	1990	700	700	700
	2000	700	700	800
	2010	700	800	900
	2020	700	800	1,000
	2030	700	900	1,100
Breckenridge	1980	1,500	1,500	1,500
	1990	1,700	1,800	1,900
	2000	1,800	2,000	2,200
	2010	1,900	2,200	2,600
	2020	2,100	2,500	3,400
	2030	2,400	3,000	4,500
Total	1980	26,700	26,700	26,700
	1990	31,000	32,500	34,100
	2000	33,300	36,900	40,600
	2010	35,700	41,900	48,300
	2020	38,000	47,200	57,200
	2030	40,300	53,400	67,500

Notes: The water use projections in this table assume per capita use rates as anticipated during a critical drouth period.
All quantities are rounded to the nearest hundred acre-feet.

Table 2.6

Total Water Supplied Historically From
Hubbard Creek Reservoir (1)

Year	Municipal (AF/Yr)	Irrigation (AF/Yr)	Mining (AF/Yr)	Other* (AF/Yr)	Total (AF/Yr)
1966	0	0	111	0	111
1967	0	0	366	132	498
1968	0	0	568	108	676
1969	0	344	1,235	60	1,639
1970	0	810	1,452	220	2,482
1971	164	1,753	1,497	247	3,661
1972	1,113	1,383	1,723	255	4,474
1973	264	726	3,278	378	4,646
1974	2,544	1,168	3,833	378	7,923
1975	530	977	3,833	370	5,710
1976	484	861	4,258	375	5,978
1977	930	1,090	3,858	495	6,373
1978	5,930	1,220	3,860	637	11,647
1979	3,258	1,087	3,725	644	8,714

*Note: The category labeled "Other" includes raw water for summer and permanent homes on the shores of the lake, maintenance of the dam, and water released to downstream users.

requirements to obtain the firm demand on the combined water supply facilities of the WCTMWD member cities. They are estimated to average 600 acre-feet per year as of 1980, increasing to 900 acre-feet per year in 1990 and 1,000 acre-feet per year thereafter.

Irrigation and Mining Water Requirements

The full capabilities of Hubbard Creek Reservoir have not been required to date. Since 1966, varying amounts of surplus water have been sold for irrigation and mining, as shown in Table 2.6. In 1979, the WCTMWD supplied 1,087 acre-feet of water for irrigation and 3,725 acre-feet for mining to customers outside the member cities of the District (2). These sales are covered by short-term contracts that are subject to termination or curtailment when the District must use its entire supply for municipal demands. Based on the historical water requirement records, the irrigation demand averaged slightly less than 1,200 acre-feet per year during the period from 1971 through 1979. For the purpose of long-range planning, a future potential use at this level has been adopted.

The mining use of Hubbard Creek Reservoir water has been for oil field water flooding operations. In recent years, the amount of water used for this purpose has been consistently less than the total covered by existing agreements between WCTMWD and the oil companies, and the actual use has never been more than 52.9 percent of the contracted amount. Mining use during the 1975-1979 period averaged slightly more than 3,900 acre-feet per year. For the purpose of long-range planning, the potential mining requirements are projected to increase to 4,800 acre-feet per year in 1980 and 5,000 acre-feet per year by 1990, remaining at that level through the year 2030.

Total Water Requirements

The projected total firm water requirements for the West Central Texas Municipal Water District under drouth conditions through the year 2030, exclusive of potential water supplied for irrigation or oil field operation, are summarized in Table 2.7. The projected probable amount required to meet District needs on that basis in the year 2030 is 58,400 acre-feet per year. The projected maximum amount is 72,500 acre-feet per year. To determine the potential total requirements, 1,200 acre-feet per year should be added for irrigation in the vicinity of Hubbard Creek Reservoir, and 5,000 acre-feet per year should be included for oil field use. These additions increase the probable total requirements to

Table 2.7

Projected Total Firm Water Requirements for WCTMWD Under Drouth Conditions Through the Year 2030 Exclusive of Water Supplied for Irrigation or Oil Field Use

Year	Municipal Water Requirements			Water For Steam Elec. Generation (Ac-Ft)	Water Use At Hubbard Creek Res. (Ac-Ft)	Total Water Requirements		
	Minimum Demand (Ac-Ft)	Probable Demand (Ac-Ft)	Maximum Demand (Ac-Ft)			Minimum Demand (Ac-Ft)	Probable Demand (Ac-Ft)	Maximum Demand (Ac-Ft)
1980	26,700	26,700	26,700	2,000	600	29,300	29,300	29,300
1990	31,000	32,500	34,100	4,000	900	35,900	37,400	39,000
2000	33,300	36,900	40,600	4,000	1,000	38,300	41,900	45,600
2010	35,700	41,900	48,300	4,000	1,000	40,700	46,900	53,300
2020	38,000	47,200	57,200	4,000	1,000	43,000	52,200	62,200
2030	40,300	53,400	67,500	4,000	1,000	45,300	58,400	72,500

Note: The above totals are exclusive of potential demands for irrigation and secondary oil recovery operations, which are estimated to be 1,200 acre-feet per year and 5,000 acre-feet per year, respectively, from 1990 through 2030.

64,600 acre-feet per year and the maximum total requirement to 78,700 acre-feet per year as of 2030.

3. REQUIREMENTS FOR ADDITIONAL SUPPLY SOURCE

Existing Water Supply

The 1980 report to Abilene and West Central Texas Municipal Water District on "Study of Coordinated Operation of Existing Raw Water Supply Sources" (1) sets forth the optimized system yield from an integrated system operation of Lake Fort Phantom Hill and Hubbard Creek Reservoir. Under the recommended operating guidelines, the total system yield (after allowing for projected runoff depletions) is estimated to be 51,320 acre-feet per year in 1980, decreasing at a uniform rate to 45,940 acre-feet per year in 2030.

Abilene, Albany and Breckenridge also have other existing reservoirs that should be included in the determination of the total available supply. A summary of the estimated yields of those other reservoirs is presented in Table 3.1, together with the combined yield of Hubbard Creek Reservoir and Lake Fort Phantom Hill. The total dependable yield from all present sources is estimated to be 53,540 acre-feet per year in 1980 and 46,760 acre-feet per year in 2030. For detailed discussion on the derivation of these estimates, reference should be made to the coordinated operations report (1).

Projected Dates For Development of Additional Water Supply

The projected dates for the development of an additional source of supply can be established by comparing the projected water requirements with the available yield. A graph of the dependable water supply during the period from 1980 to 2030 is illustrated in Figure 3.1. On the same graph are curves that define the estimated future demands for the minimum, probable, and maximum conditions with and without allowance for the

Table 3.1

Summary of Estimated Reservoir Yields
- Values in Acre-Feet -

Reservoir	1980 Dependable Yield	1980 Runoff Depletion	1980 Yield After Depletion	2030 Dependable Yield	2030 Runoff Depletion	2030 Yield After Depletion
Coordinated Hubbard Creek Res./ L. Ft. Phantom Hill	55,390	4,070	51,320	53,590	7,650	45,940
Lake Abilene	1,240	130	1,110	1,130	310	820
Lake McCarty	320	130	190	0	-	0
Lake Daniel	1,300	380	920	360	360	0
Combined Yield	58,250	4,710	53,540	55,080	8,320	46,760

Note: Lake Kirby, at Abilene, and the lakes at Anson are not presently used for municipal supply and are not counted as part of the available yield.

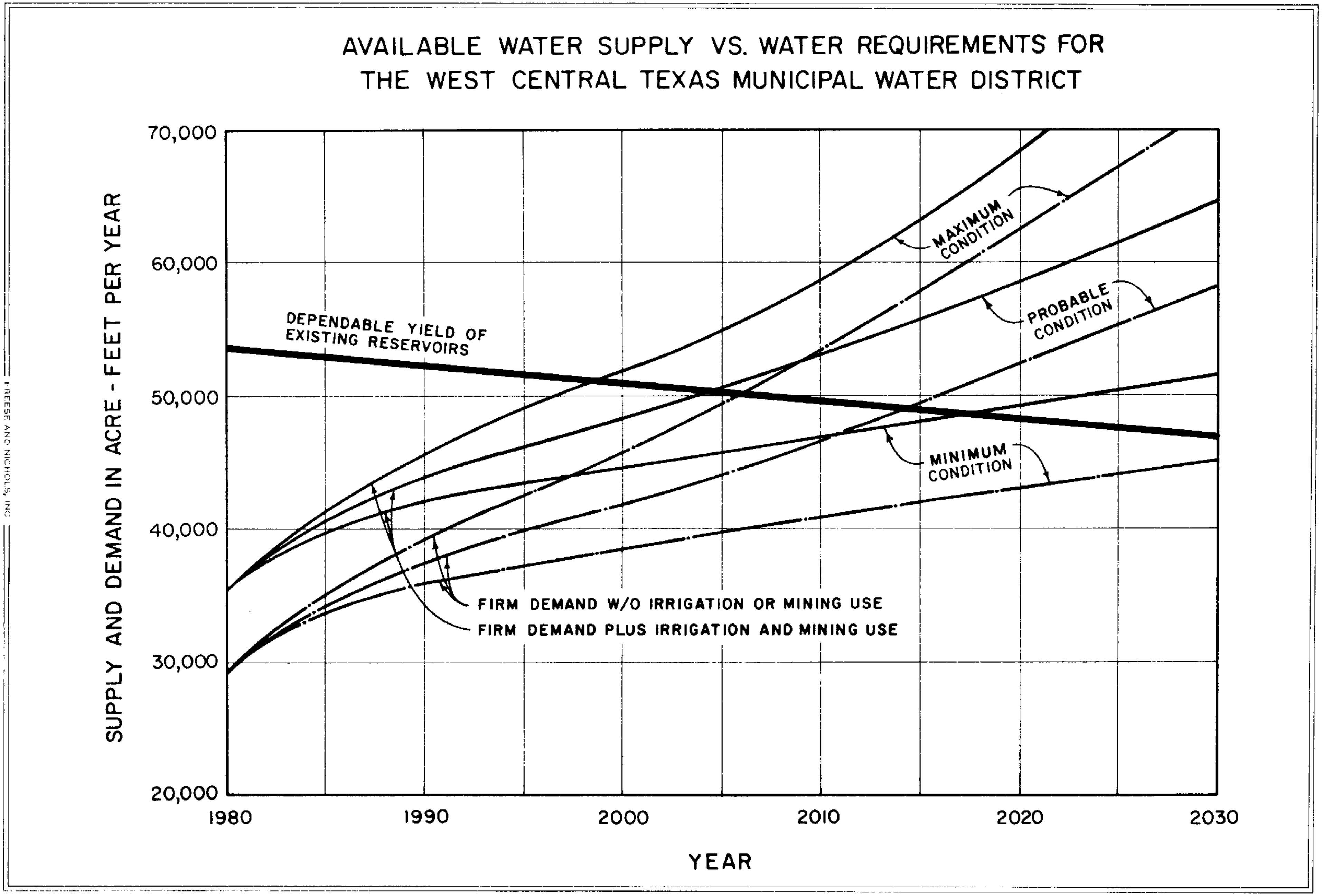

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FIGURE 3.1

irrigation and mining uses.

The estimated dates at which the next major source of water supply will be needed under various conditions of future development have been extracted from Figure 3.1 and are summarized in Table 3.2. If growth takes place at the maximum predicted rate and if the District continues to provide water for irrigation and mining, the new supply will be needed shortly before the year 2000. With the probable projection of future requirements plus the irrigation and mining use, the needs are shown to equal the supply by about the year 2005.

By discontinuing irrigation and mining use, the date when the next source is needed could be postponed significantly. For planning purposes, however, it is preferable to assume that the District will continue to make water available for those secondary uses as it has in the past. Even on that basis, there should be an excess of supply over demand for nearly 20 years, and it is apparent that there will be a comfortable margin of uncommitted supply for at least the next 10 or 15 years, allowing adequate time to select the best available alternative.

When considering potential new sources of supply, attention should be concentrated on projects capable of providing approximately 12,000 acre-feet per year of dependable yield or more. That will be enough added supply to allow the District and the member cities to meet the projected probable growth in firm demand, exclusive of use for irrigation or mining, through the year 2030. It would also be enough to satisfy the projected probable requirements, including irrigation and mining, until after the year 2020. The mining (secondary oil recovery) requirements can be expected to decrease and eventually cease as the oil

Table 3.2

Estimated Years When Additional Source of Water Supply Will Be Required For The West Central Texas Municipal Water District

	Minimum Requirements		Probable Requirements		Maximum Requirements	
	New Source Required	Acre-Feet Required in 2030	New Source Required	Acre-Feet Required in 2030	New Source Required	Acre-Feet Required in 2030
Total Firm Requirements: Municipal, Steam Electric and Local Hubbard Creek	After 2030	Existing Supply Adequate	2014	11,600	2006	25,700
Total Firm Requirements Plus Irrigation and Mining Requirements	2017	4,700	2004	17,800	1,998	31,900

fields are depleted, and the relatively minor amount of irrigation use could be discontinued whenever the water is needed for municipal purposes. Thus, a new supply capable of providing 12,000 acre-feet per year would be adequate to meet the District's probable needs until approximately the year 2030 as they are projected at this time.

Texas Water Development Board (12), the Clear Fork is considered to be a nutrient-rich stream. This condition apparently results from several factors, including treated municipal effluents and high nitrogen levels in springs and seeps issuing from alluvial deposits in the upper reaches of the watershed. Some of the water quality degradation is also due to agricultural runoff. Careful consideration of the quality of a potential supplemental source of supply, as well as the quantity, will be essential to any site selected within the immediate Brazos River Basin.

The rapidly increasing cost of electric energy makes the pumping distance a much more important economic factor than it has been in the past. Any supplemental source of supply must be within a reasonably accessible distance to keep the energy costs within affordable limits. The average price of electricity per kilowatt-hour for large industrial customers during the twenty-year period from 1958 to 1978, as reported by the United States Department of Energy, increased at a rate of approximately 5.2 percent per year, which is 1.1 percent above the general inflation rate. During the last five years of the period, electricity prices rose at 15.3 percent per year, 5.7 percent above general inflation. A continued increase of 10 to 15 percent per year for the forseeable future is frequently recommended for use in economic evaluations. These conditions have a significant impact on the cost of water, and in some cases a source of supply with higher initial cost may be justified if it will have a lower pumping head and therefore lower long-term operating costs.

The general limits of the area reviewed for potential sources of supply are illustrated on Figure 4.1. The boundaries are generally de-

POTENTIAL SOURCES OF WATER SUPPLY WITHIN ACCESSIBLE PUMPING DISTANCE OF ABILENE AND WEST CENTRAL TEXAS MUNICIPAL WATER DISTRICT

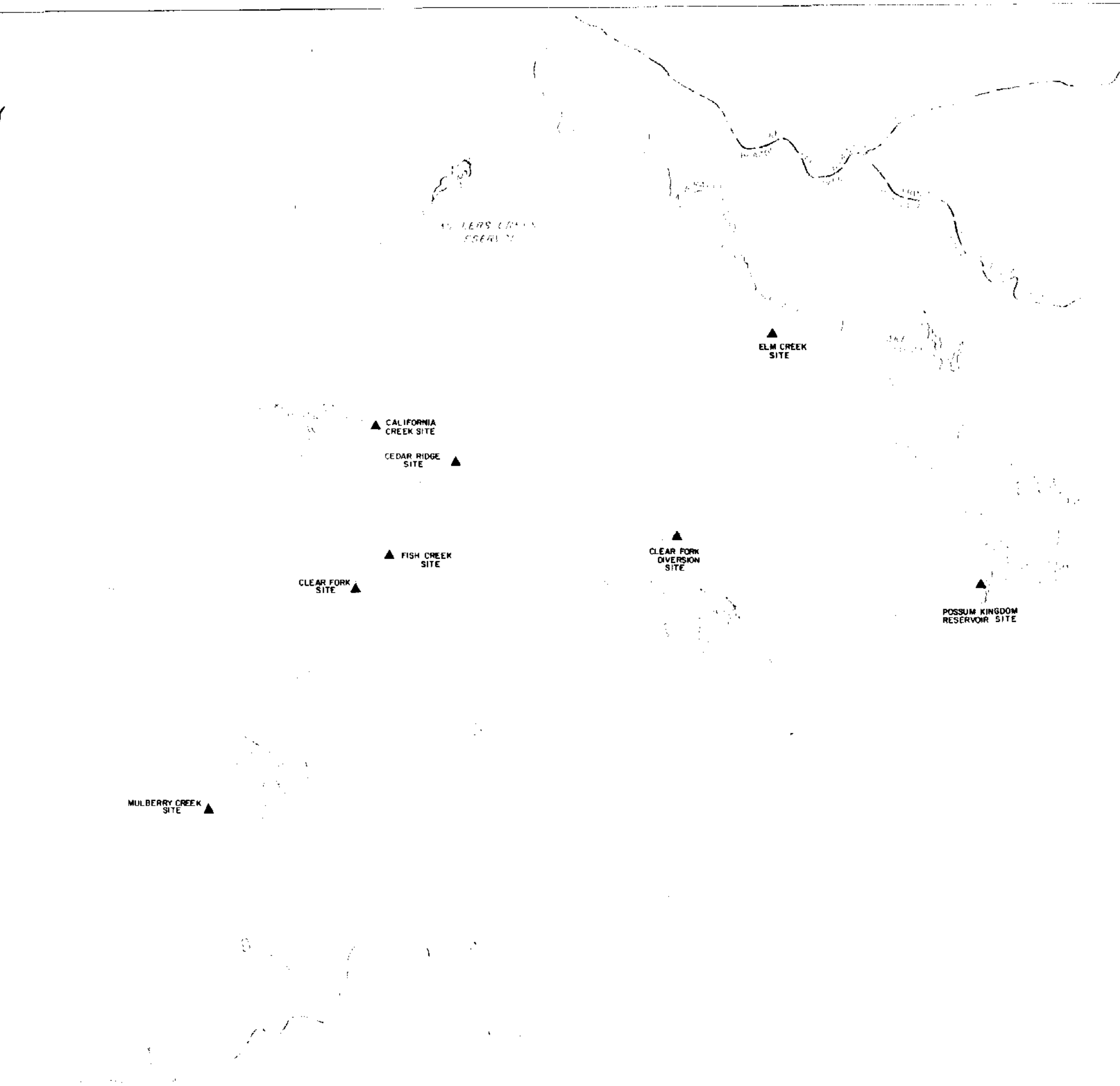


FIGURE 4.1

fined by the divide between the Red River Basin and the Brazos River Basin on the north, Possum Kingdom Reservoir on the east, the divide between the Colorado River Basin and the Brazos River Basin on the south, and the Jones-Fisher County line on the west. The area lies mostly within the watershed of the Clear Fork of the Brazos, but the northeastern section drains into the main stem of the Brazos River.

Potential sources in the Red River Basin were not considered because of pumping distance, inferior quality, and the extent of existing surface water development. Some parts of the Colorado River Basin are within feasible distance from the WCTMWD cities, but there, too, the potential supply is already committed to holders of water rights within the Colorado Basin. The Stacy Reservoir site, south of Abilene on the main stem of the Colorado, is presently being developed by the Colorado River Municipal Water District and probably represents the last significant project that will be built in the upper reaches of that basin. It is unlikely that any water from the Colorado could be obtained for use in the Abilene area. Based on these considerations, it is apparent that the District's next source of water supply will almost certainly have to be located within the Brazos River Basin.

Several potential sources of supply in the Brazos Basin within an accessible pumping distance of the WCTMWD service area have received consideration previously. The most attractive of these, along with some additional potential alternatives, were selected for initial consideration and screening. The alternatives considered and their general characteristics are summarized in Table 4.1. The general location of each site is indicated on Figure 4.1. The possible sources can be

Table 4.1

Potential Sources of Future Additional Supply
Within Accessible Pumping Distance

Source of Supply	Required Facilities Characteristics: Storage Reservoir Construction	Conservation Capacity (Ac-Ft)	Pump Sta.	Static Head (Ft)	Pipeline Length (miles)	Estimated Yields (a): Before Depletions (Ac-Ft/Yr)	After Depletions (Ac-Ft/Yr)	Estimated Quality
Possum Kingdom Reservoir	No	724,500	Yes	335	23.3(b)	-	228,100(e)	Poor
Cedar Ridge Reservoir Site	Yes	342,880	Yes	290	32.5(c)	28,800	20,600	Poor
Clear Fork Reservoir Site	Yes	94,000	Yes	100	18.0(c)	13,000	5,450	Poor
California Creek Reservoir Site	Yes	(d)	Yes	180	30.9(c)	6,480	5,080	Fair
Mulberry Creek Reservoir Site	Yes	26,000	Yes	20	8.2(c)	5,500	4,700	Good
Elm Creek Reservoir Site	Yes	72,500	Yes	180	22.7(b)	5,470	unknown	Good
Clear Fork Diversions to Fish Creek Reservoir Site	Yes	150,000	Yes	70	21.1(c)	8,450	8,365	Fair
Clear Fork Diversions to Hubbard Creek Reservoir	No	(d)	Yes	160	4.5(b)	16,000	14,500	Fair

(a) Initial yield
(b) To Hubbard Creek Reservoir
(c) To Fort Phantom Hill Reservoir
(d) Diversion works with minimum conservation capacity
(e) Includes sediment accumulation

separated into three categories.

(a) Obtaining water from an existing reservoir with available yield.

(b) Construction of a new reservoir.

(c) Pumping peak flows from the Clear Fork of the Brazos River into an existing or proposed reservoir.

Of the eight possibilities outlined in Table 4.1, one falls into the first of these categories, five are in the second category, and two are in the third. All will be discussed briefly in the following paragraphs of this section, and the more promising alternatives will be covered in detail in Section 5 of the report.

Possum Kingdom Reservoir

Only Possum Kingdom Reservoir was considered under the first type of potential source. The Texas Department of Water Resources estimates the yield of Possum Kingdom Reservoir to be 228,100 acre-feet per year as of the year 2030 (12). Under certain circumstances, it is possible that part of the yield could be purchased from the Brazos River Authority, which owns and operates Possum Kingdom Dam. Historically, the concentrations of dissolved solids in the Possum Kingdom water have equaled or exceeded 1,300 mg/l about half the time. Thus, the use of this water for municipal and many manufacturing purposes is somewhat limited because of its salinity. The Corps of Engineers, through a proposed Brazos River natural salt control project (13), is attempting to establish the feasibility of improving the quality. The potential of Possum Kingdom Reservoir as a supplemental source of supply for the

District may depend to a large extent upon construction of the natural salt control facilities.

Cedar Ridge Reservoir Site

Five potential new reservoir sites were considered. The Cedar Ridge and the Clear Fork sites are on the main stem of the Clear Fork of the Brazos; the California Creek and Mulberry Creek Reservoir sites are on tributaries of the Clear Fork; and the Elm Creek Reservoir site is on a tributary of the Brazos River.

The Cedar Ridge Reservoir site is an adaptation of the Breckenridge Reservoir site, which has previously been included in reports by the Texas Water Development Board. The Breckenridge site is located approximately six miles downstream from the confluence of Paint Creek with the Clear Fork of the Brazos. The Cedar Ridge site is located above this confluence, with the intent to eliminate some of the poorer quality water that is associated with low flows from Paint Creek. As indicated in Table 4.1, the site is capable of producing a significant amount of new yield and would represent a substantial increase in the District's total supply. The conservation capacity and associated yield indicated in Table 4.1 are representative of the potential that can be developed at the site. A more complete discussion is included in Section 5. The most recent quality data on the Clear Fork of the Brazos near the proposed site indicate poorer quality than had been reflected in earlier quality observations. Elimination of the flows from Paint Creek would help to some extent, but the quality of water from the Cedar Ridge Reservoir site would be marginal at best.

Clear Fork Reservoir Site

The Clear Fork Reservoir Site was included in an earlier long-range water supply study for Abilene (14). At that time, a conservation storage capacity of 94,000 acre-feet was determined to yield approximately 30,500 acre-feet per year. The computations of the runoff for those reservoir operation studies were made prior to establishing the present Abilene Clear Fork diversion facilities, and they did not include an allowance for runoff depletions. Also, the earlier reservoir studies were based on emptying the conservation storage, which probably is not altogether realistic from an operational standpoint. The year-2030 dependable yield of this site is estimated to be approximately 5,450 acre-feet per year. The proposed reservoir would cover a portion of the community of Lueders at the normal water surface elevation, and the inundation would increase significantly during flooding. The reservoir would also necessitate relocation or raising of U.S. Highway 380. The water quality would be comparable to that anticipated in Cedar Ridge Reservoir site.

Mulberry Creek Reservoir Site

Several reservoir sites have been previously considered on Mulberry Creek, on the west side of Abilene (14). The quality of the water should be good, but the maximum anticipated yield for the most logical site is less than half the desired amount.

California Creek Reservoir Site

Previous studies on capturing the high flows of California Creek and diverting them to another reservoir have indicated a practical average diversion rate of approximately 6,480 acre-feet per year during the critical period (15). Additional amounts could be diverted during other periods, but this approach would require a larger diversion dam and a larger pumping and pipeline facility. The quality of the water in times of high flow is usable if mixed with better quality water, but the available quantity is inadequate.

Elm Creek Reservoir Site

The Elm Creek Reservoir site is located on a tributary of the main stem of the Brazos River, approximately 23 miles north of Hubbard Creek Reservoir. Preliminary indications based on limited quality data are that the site should produce water of good quality. Previous reservoir operation studies (16) for 72,500 acre-feet of storage capacity only indicate a yield of 5,470 acre-feet per year, which is less than half the desired amount.

Clear Fork Diversions to Fish Creek Reservoir Site

Diversion of the peak flows from the Clear Fork of the Brazos River into an existing or proposed storage reservoir would provide for impoundment of the better quality water while allowing the poorer quality lower flow to pass. This concept is similar to Abilene's present diversion operation which transfers Clear Fork water into Lake Fort Phantom Hill. Several potential off-channel storage reservoirs were considered along the Clear Fork of the Brazos between Lueders and U.S. Highway 183. The most acceptable of the potential sites was on Fish Creek, approximately 21 miles northeast of Abilene. For 149,600 acre-feet of conservation storage in the Fish Creek Reservoir site, a dependable yield of 8,450 acre-feet per year was determined. The yield is based on runoff computed from daily flows at the U.S. Geological Survey stream gaging station on the Clear Fork of the Brazos River near Nugent. The runoff values were corrected for diversions to Lake Fort Phantom Hill, and diversions were only considered possible when the flow in the Clear Fork exceeded 200 cfs. This source would require construction of a diversion structure and a 1,000 cfs pump station on the Clear Fork, as well as the dam on Fish Creek. Water impounded in the Fish Creek Reservoir site should be of fair quality.

Clear Fork Diversions to Hubbard Creek Reservoir

A similar operation was also considered at a point on the Clear Fork near Hubbard Creek Reservoir. With a 1,000 cfs diversion pump station at that location, the dependable yield of Hubbard Creek could be increased by 16,200 acre-feet per year. The runoff values were determined from daily observations recorded at the USGS stream gaging station on the Clear Fork of the Brazos River at Fort Griffin. Only flows in excess of 300 cfs were considered available for diversion. Water of fair quality should be available for mixing with Hubbard Creek water.

Selected Sites

Of the above potential sources for future additional supply, three were selected for more detailed evaluation: Possum Kingdom Reservoir, the Cedar Ridge Reservoir site, and diversion of water from the Clear Fork into Hubbard Creek Reservoir. Each is discussed at greater length in the following section of the report.

5. EVALUATION OF PROMISING SOURCES

Evaluation Procedures

The detailed evaluations of the feasible amounts of additional yield, of the chemical quality of the water, of the preliminary design for the necessary facilities and of the estimated capital and operating costs are described in the subsequent paragraphs. Each of these principal areas is discussed for the selected promising sources.

The yields were calculated by means of computer simulations of reservoir performance, based on assumed operation at various rates of withdrawal during the period of recorded historical hydrologic data. Annual water supply demands were varied from run to run over a range from zero up to rates which would have emptied the reservoirs at the low point of the critical drouth. For each proposed reservoir, a selected range of conservation storage capacities were also considered. The definitive yield estimates were determined from the rates of withdrawal which would have left remaining volumes of storage equal to one year's demand in the reservoirs at the end of the drouth. This criterion provides a safety factor to allow for the possible occurrence of future drouth conditions more severe than any recorded in the past. It also recognizes the difficulty of removing the last few acre-feet from the bottom of a lake and protects against the possible deterioration of water quality that tends to occur if the reservoir content approaches zero. The key inputs to the computer simulations are runoff amounts, evaporation data, demand patterns and the reservoir area and capacity characteristics. Allowances were also made for potential future reductions in watershed runoff characteristics.

The question of water quality in the potential sources of supply is at least as important as the question of quantity. Observed quality conditions have been recorded at selected streams and reservoirs by the U.S. Geological Survey (17), and these data have been used to estimate the quality of water available from the various sources. Chemical quality predictions were calculated by means of computer simulations of reservoir performance, considering the probable initial concentrations in the reservoirs and the estimated concentrations in the natural runoff and in diversions from nearby streams.

To establish the design flow requirements for the proposed facilities, consideration was given to the critical year in the coordinated Lake Fort Phantom Hill-Hubbard Creek Reservoir operation study analysis (1). Since most of the yield will be used at Abilene, the critical year occurs when the minimum amount is available from Lake Fort Phantom Hill and the maximum amount is used from Hubbard Creek Reservoir. Under the critical conditions around the year 2020, approximately 12,400 acre-feet per year would be available from Lake Fort Phantom Hill and 34,800 acre-feet per year from Hubbard Creek Reservoir, for a total of 47,200 acre-feet per year. This amount is the coordinated system yield as of 2020 after deducting the estimated future runoff depletions. Schematic diagrams illustrating the utilization of this supply have been included with the discussion of each potential supplemental source.

Estimates of the construction costs for each required facility were prepared in terms of 1980 dollars. The unit costs for pipeline construction were established from representative projects in Texas and from discussion with pipe manufacturers. The construction costs for pump stations were based on data developed by the U.S. Bureau of Reclamation for pumping plant cost estimation procedures (18) and were adjusted to 1980 by applying the Engineering News-Record construction cost indices (19). The unit costs for the major dams and diversion works were based on recent experience with similar projects. Allowances for engineering, administration and contingencies have been included in the estimates.

In the design of the proposed facilities, full utilization of the existing facilities was assumed where practical. Debt service and costs of operation and maintenance on the existing facilities would be the same for each alternate site. Those amounts have not been included in the cost estimates presented in this report, and the costs shown herein refer only to the construction and operation of new facilities. This procedure permits a clear comparison of the incremental cost associated with the various alternative sources of additional supply.

The operating cost for a raw water supply system is the sum of the energy costs, maintenance costs, replacement costs and administrative costs. For the purpose of comparing alternatives, a representative present-day cost of $0.03 per kilowatt-hour (KWH) has been assumed. For purposes of comparison, pumping rates and energy costs have been based on the projected probable demands as of the year 2020, assuming continued mining and irrigation use as of that date. Procedures for estimating the maintenance, replacement and administrative costs associated with pipelines and pump stations have been established by the U.S. Bureau of Reclamation (18). The annual operation and maintenance costs of the major dams and diversion works have been estimated as a percentage of the construction costs.

Possum Kingdom Reservoir

Possum Kingdom Reservoir is located on the Brazos River below the mouth of the Clear Fork, in Palo Pinto, Young and Stephens Counties. The reservoir is owned by the Brazos River Authority, which has a permit to impound 750,000 acre-feet of water and to use 1,500,000 acre-feet annually for municipal and industrial requirements, mining, irrigation, recreation and power generation. The dam was completed in March of 1941.

The Texas Water Development Board (12) estimates that the yield of Possum Kingdom Reservoir as of 2030 will be 228,100 acre-feet per year. The use of a portion of this yield by Abilene and WCTMWD would have to be through contractual agreement with the Brazos River Authority. The terms of such a contract have not been established at this time, but it is reasonable to assume that agreement might be satisfactorily established based on the cooperative relationship that has existed between the Brazos River Authority and the West Central Texas Municipal Water District in the past.

At the present time, the yield of Possum Kingdom Reservoir is basically committed to meet existing obligations of the Brazos River Authority. However, the Authority's over-all water supply system consists of a number of separate dams and reservoirs, and in many cases there is considerable flexibility to meet the demands from more than one source. For example, water requirements for rice irrigation near the Gulf Coast make up a major part of the total demand from the Brazos Basin, and the irrigators can use water that has been released from various reservoirs in the system, including Possum Kingdom. Thus, although the Authority presently considers the water in Possum Kingdom Reservoir to be committed to the fulfillment of various outstanding obligations, the construction of a new reservoir elsewhere in the basin could have the effect of releasing some of the yield at Possum Kingdom for other purposes. By participating in the cost of providing new reservoir storage farther downstream, the West Central Texas Municipal Water District could presumably obtain in exchange the right to use a portion of the water from Possum Kingdom.

A primary objective of the Brazos River Authority for many years has been the construction of the Millican Reservoir, on the Navasota River southeast of Bryan. This project is under consideration by the Corps of Engineers as a multiple-purpose structure for flood control, water supply and other uses. When built, it will have a large conservation capacity and a yield possibly in excess of 200,000 acre-feet per year. The project is presently being studied by the Corps, and the resulting report is expected to be released next year. Millican Reservoir or some equivalent combination of other alternatives on the Navasota River probably will be the last major increment of water supply to be constructed in the Brazos Basin. In that sense, the feasibility of the Millican project could be important to Abilene and the District, since participation in that development could be the key to obtaining water from Possum Kingdom Reservoir.

The most likely place to divert water from Possum Kingdom Reservoir to the District's raw water supply system is through the existing pump station on the Caddo Creek arm and through the 36-inch portion of the pipeline that serves Texas Pacific Oil Company, Inc. (Figure 4.1). This pipeline extends approximately 48,000 feet in a westerly direction from the lake. The capacity of the 36-inch section exceeds the oil company's requirements, and the excess should be available to the District. By the time the District needs supplemental water, the oil field requirements may be less than they are now, and additional capacity could also be available.

Assuming that enough yield might be obtained, the other obvious concern with Possum Kingdom Reservoir is the chemical quality of the water. The Corps of Engineers' in-depth report on pollution control (13) reached the following conclusions:

a. Natural salt pollution in the Brazos River is not a local or confined condition. It degrades all flows of the main stem as well as a large portion of the tributary flows. The salinity content of these flows usually exceeds acceptable levels and, therefore, limits municipal, industrial and agricultural use of the water.

b. Salt pollution in the Brazos River is due almost entirely to natural causes originating upstream from Possum Kingdom Reservoir.

c. The high dissolved solids content of the Brazos River is derived principally from large amounts of sodium chloride and lesser amounts of calcium and magnesium sulfate. High chloride concentrations are the greatest chemical limitation to efficient utilization of the main stem of the river.

d. By controlling the isolated sources of pollution, the water in

Possum Kingdom Reservoir could be improved enough to be generally acceptable for municipal, industrial, and irrigation uses.

The Corps of Engineers' recommended plan for pollution abatement includes construction of three salinity control reservoirs - Croton, Dove, and Kiowa Peak Lakes - on tributaries of the Salt Fork of the Brazos. The estimated first cost for the recommended structures was $50,347,000, with annual charges of $3,485,000, based on July 1972 price levels and a 5.5 percent rate of interest for a 100-year economic life. Although these estimates are now out of date, they have been included to show the an order of magnitude of the project.

The Corps of Engineers utilized a mathematical simulation model to estimate the effect of the proposed improvements on the quality in the Brazos River. The model was initially designed to duplicate, as closely as possible, flow and quality conditions observed during the period from 1941 through 1962. The model was then modified to include water supply reservoirs and salinity control structures proposed for construction prior to the year 2020. The results from these model simulations are summarized in Table 5.1. The values in the table represent chemical quality conditions in the Brazos River near Palo Pinto, twenty miles downstream from Possum Kingdom Dam. The numbers shown for improved conditions do not reflect improvements that will accrue from reduction of pollution from oil production. The table illustrates the percent of the time that a given quality concentration in parts per million would be exceeded. The maximum total dissolved solids concentration is indicated to be reduced from 2,020 ppm to 1,230 ppm with the proposed

Table 5.1

Estimated Water Quality in Possum Kingdom Lake in 2020
With and Without Natural Salt Pollution Control Program

Percent of Time Exceeded	Chloride Concentrations		Sulfate Concentrations		Total Dissolved Solids Concentrations	
	Natural (PPM)	Improved (PPM)	Natural (PPM)	Improved (PPM)	Natural (PPM)	Improved (PPM)
0	775	365	470	395	2,020	1,230
10	710	320	435	350	1,840	1,065
20	670	300	415	335	1,750	1,020
30	630	295	395	320	1,655	985
40	590	275	280	310	1,560	940
50	550	250	360	295	1,470	885
60	510	240	340	285	1,375	830
70	470	225	320	270	1,280	780
80	415	205	290	245	1,175	730
90	340	170	245	195	960	640
100	190	115	160	150	640	420

Note: Extracted from Table I-32, Volume 2 Brazos River Basin, Texas Natural Salt Pollution Control Study, U.S. Army Engineer District, Fort Worth, Texas, 1 June 1976.

improvements. The maximum chloride concentration is reduced from 775 ppm to 365 ppm. With the pollution control plan, the Corps of Engineers estimates that the water quality in Possum Kingdom Reservoir will satisfy the Public Health Service drinking water standards for chlorides fifty percent of the time and will meet the standard for total dissolved solids three percent of the time.

The proposed water delivery system from Possum Kingdom Reservoir to Hubbard Creek Reservoir and Abilene is illustrated in Figure 5.1. A schematic of the supplies and demands under year-2020 critical conditions is presented in Figure 5.2. The facilities have been assumed to delivery water at a constant annual rate from Possum Kingdom Reservoir to Hubbard Creek Reservoir. The facilities between Hubbard Creek Reservoir and Abilene have also been assumed to deliver water at a constant annual rate, with sufficient excess capacity to provide the peak-day requirements of Albany and Anson.

The proposed 36-inch pipeline from the terminus of the 36-inch Texas Pacific Oil Company pipeline is larger than required to deliver the average annual flow in 2020. This larger size has been included in the proposed plan in anticipation that the full capacity of the existing pipeline would be available to the District in later years, as the oil operation requirement declines in the area.

The estimated capital costs for the proposed water system improvements are presented in Table 5.2. The total estimated capital cost is $26,043,500. Details of the cost estimates can be found in Appendix F. This total includes an amount for a 9.2-MGD pump station at Possum Kingdom Reservoir and for a 36-inch pipeline from the pump station to

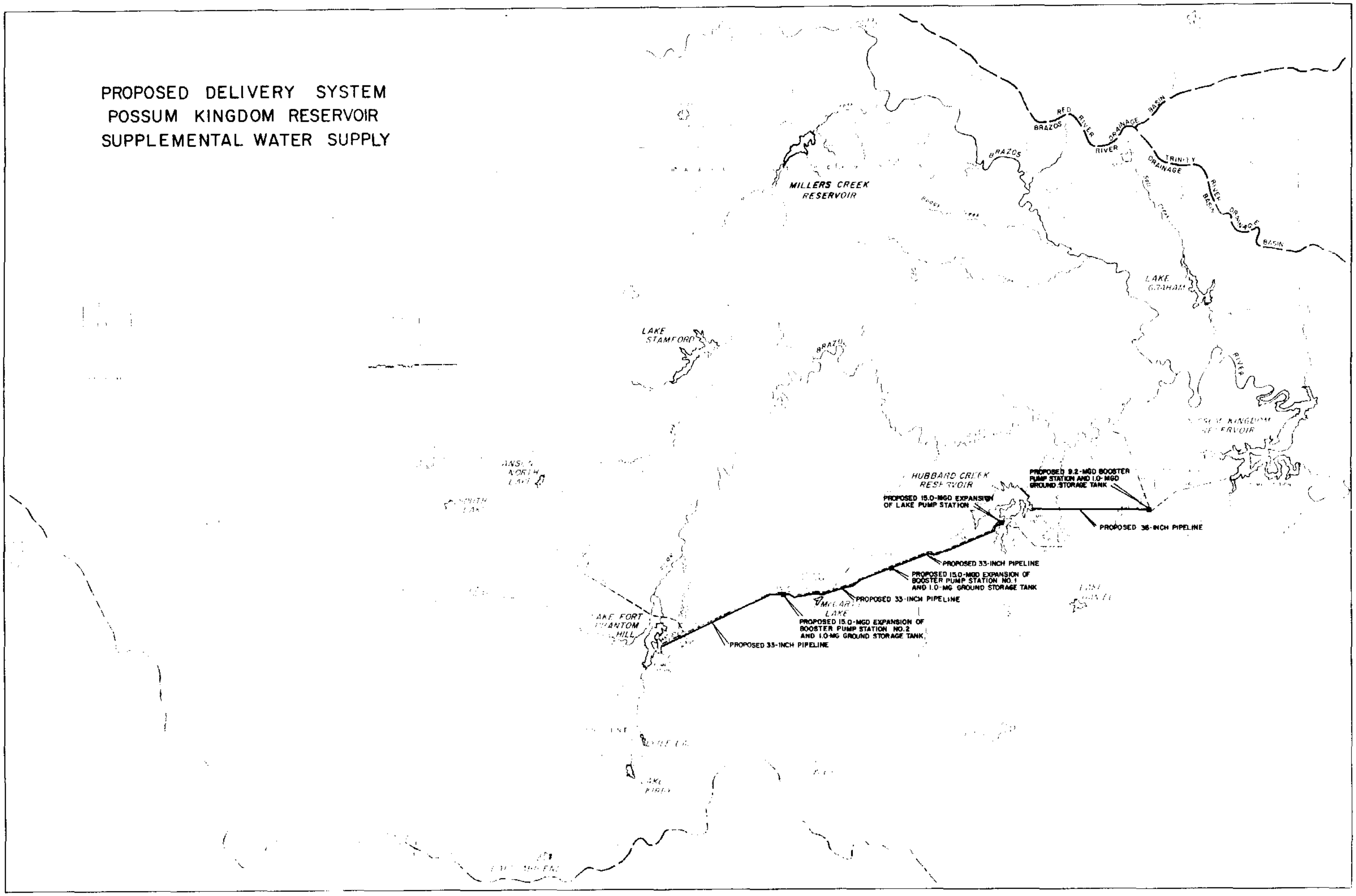
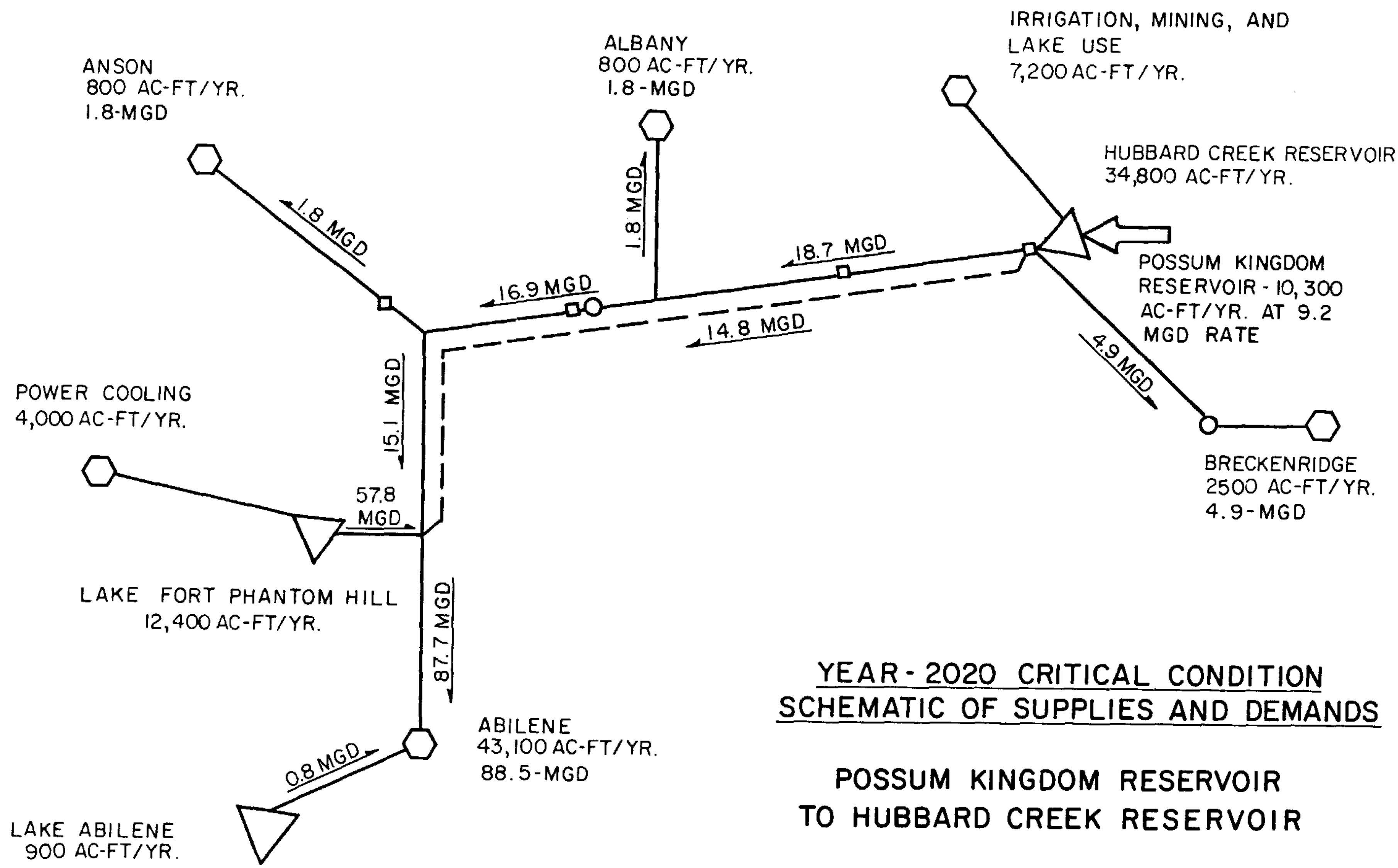

PROPOSED DELIVERY SYSTEM
POSSUM KINGDOM RESERVOIR
SUPPLEMENTAL WATER SUPPLY
MILLERS CREEK RESERVOIR
BRAZOS
RED RIVER DRAINAGE BASIN
BRAZOS RIVER
TRINITY RIVER BASIN
DRAINAGE
BASIN
LAKE GRAHAM
LAKE STAMFORD
RIVER
HUBBARD CREEK RESERVOIR
PROPOSED 9.2-MGD BOOSTER PUMP STATION AND 1.0-MGD GROUND STORAGE TANK
PROPOSED 15.0-MGD EXPANSION OF LAKE PUMP STATION
PROPOSED 36-INCH PIPELINE
PROPOSED 33-INCH PIPELINE
PROPOSED 15.0-MGD EXPANSION OF BOOSTER PUMP STATION NO.1 AND 1.0-MG GROUND STORAGE TANK
PROPOSED 33-INCH PIPELINE
LAKE
PROPOSED 15.0-MGD EXPANSION OF BOOSTER PUMP STATION NO.2 AND 1.0-MG GROUND STORAGE TANK
PROPOSED 33-INCH PIPELINE

FIGURE 5



YEAR - 2020 CRITICAL CONDITION SCHEMATIC OF SUPPLIES AND DEMANDS

POSSUM KINGDOM RESERVOIR TO HUBBARD CREEK RESERVOIR

Note: Annual supplies and demands expressed in acre-feet per year. Peak day design flows expressed in MGD.

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FIGURE 5.2

its present terminus, both in 1980 dollars. These items are included to account for the probable requirement to reimburse the present owners for all or part of the original cost. The exact amounts for these items would have to be established through negotiations. The estimated capital costs do not include an allowance for West Central Texas Municipal Water District participation in a quality improvement program for the Brazos River.

The estimated annual cost for the proposed facilities is also included in Table 5.2. The estimated amount of $3,192,300 per year does not include the debt service and operating expenses on the existing facilities of the District. Charges for the purchase of water from Possum Kingdom Reservoir would also have to be added to the estimated annual cost. The cost per 1,000 gallons for the 10,300 acre-feet per year of supplemental water needed in 2020 is shown to be approximately $0.95. That amount, however, does not include the basic cost of the water at the reservoir, which is a significant (but presently unknown) quantity. Nor does it include any allowance to cover participation in costs of Federal quality improvement programs. It should be assumed that the cost of the water at Possum Kingdom would be at least $0.30 per 1,000 gallons.

Cedar Ridge Reservoir Site

Cedar Ridge Reservoir site is located on the Clear Fork of the Brazos River approximately 8.3 river miles above the mouth of Paint Creek. Located in a narrow canyon area, the site is approximately 32 miles northeast of Lake Fort Phantom Hill and approximately 24 miles east of Stamford.

Table 5.2

Possum Kingdom Reservoir Supply System
Summary of Capital and Year-2020 Annual Costs

Capital Costs

Items	Estimated Costs
9.2-MGD pump station at Possum Kingdom Reservoir	$ 825,800
36-inch pipeline from Possum Kingdom Reservoir to booster pump station	3,743,000
9.2-MGD booster pump station	645,600
36-inch pipeline from booster pump station to Hubbard Creek Reservoir	5,369,000
15.0-MGD expansion of WCTMWD lake pump station	680,500
15.0-MGD expansion of WCTMWD booster pump station No. 1	887,100
15.0-MGD expansion of WCTMWD booster pump station No. 2	700,600
33-inch pipeline from Hubbard Creek Reservoir to Lake Fort Phantom Hill	13,191,900
	$26,043,500

Annual Costs for Proposed Facilities

Items	Estimated Costs
Principal and interest payment, 30-years at 7.5%	$ 2,205,900
Possum Kingdom transmission system operation and maintenance	9,800
Possum Kingdom pump station and booster pump station power cost	189,700
Hubbard Creek Reservoir transmission system operation and maintenance	26,600
Hubbard Creek Reservoir lake pump station and booster pump station's power costs	760,300
	$ 3,192,300

Note: These estimates are based on 1980 price levels.

Other reservoir sites in the general area, but below the confluence of Paint Creek, have been considered previously. The Breckenridge Reservoir site, located six miles downstream of the confluence, has been included in reports by the Texas Water Development Board (12). The contributing watershed above these sites is large enough to support a major project with a substantial yield. However, water quality studies indicated essentially unfavorable prospects for municipal use (20). The concentrations of total dissolved solids in these proposed reservoirs frequently exceeded 1,000 milligrams per liter and ranged upward to a maximum of nearly 3,900 milligrams per liter. The intent in selecting an alternative site above Paint Creek, although the yield would be reduced, was to determine if the quality could be improved.

Detailed hydrologic investigations were undertaken to determine the quantity of water that would be available from the Cedar Ridge Reservoir site on a dependable basis. The development of runoff, evaporation rates, and area-capacity data used in the reservoir operation simulations is described in Appendix B. The total drainage area above the site is approximately 2,691 square miles. This area is partially controlled by several existing reservoirs. The principal ones are Lake Fort Phantom Hill, Kirby Lake, Lake Abilene and Lake Sweetwater.

The results of a series of reservoir simulation studies indicated that a reservoir with an initial capacity of 342,880 acre-feet would yield 28,200 acre-feet per year, allowing for a long-term loss of approximately 50,000 acre-feet of capacity due to sedimentation. A summary of the Cedar Ridge Reservoir site operation study has been included in Appendix C. The normal water surface for the 342,880 acre-feet of capacity would be elevation 1,432, and the surface area at that level is estimated to be 6,066 acres.

The 28,200 acre-feet per year yield is before deducting an estimated 8,200 acre-feet per year runoff depletion allowance for the year 2030. The runoff depletion estimate is based on an investigation made by the U.S. Bureau of Reclamation as part of the work of the U.S. Study Commission for Texas in the 1960's (21). This amount of additional yield would provide for the projected probable growth in water requirements beyond the year 2030. The allowed sediment storage (50,000 acre-feet) is based on the size of the contributing drainage area and the typical rate of silt production of the Rolling Plains land resource area which is above the site (22).

The pertinent U.S. Geological Survey quality records for the Clear Fork of the Brazos are tabulated in Table 5.3. Two characteristics reflected in the table are important to the evaluations of the Cedar Ridge Reservoir site. The average tonnage of total dissolved solids per acre-foot declines in the downstream direction. The poorer quality water originates in the upper reaches of the watershed. The quality gaging station on the Clear Fork of the Brazos at Nugent is a short distance upstream from the Cedar Ridge Reservoir site, and it provides the best indication of the quality of the runoff. Quality measurements have been made during two distinct periods. During the 1948-1952 period, flow-weighted monthly quality levels were determined. Since 1968, individual measurements, commonly referred to as "grab samples", have been obtained at the Nugent gage. The available data for both of these periods are summarized in Appendix D. The more recent individual

Table 5.3

Pertinent Clear Fork of the Brazos River Water Quality Data

Location	Drainage Area (Sq.mi.)	Period of Record	Average Flow Period of Record (cfs)	Concentration (Tons per day) TDS	Chloride	Sulfate	Avg. TDS Tons Per Ac-Ft
Clear Fork Brazos River at Hawley	1,416	1967-78	46.9	234			2.52
Clear Fork Brazos River at Nugent	2,199	1948-52	47.6	82	13(b)	23(b)	0.87
Clear Fork Brazos River at Nugent (a)	2,199	1968-78	68.6	410	94(b)	155(b)	3.01
Clear Fork Brazos River at Fort Griffin	3,988	1968-76	161.6	533	144(b)	157(b)	1.66
Clear Fork Brazos River at Eliasville (c)	5,697	1957-66	450	480	165	60	0.54
Clear Fork Brazos River at Eliasville	5,697	1966-78	276.0	670			1.23
Clear Fork Brazos River at Mouth (d)				320	75	50	

(a) Based on 51 grab samples
(b) Estimated, based on average of historical data
(c) Sources of Saline Water in the Upper Brazos River Basin, Texas, USGS Progress Report, June 1967
(d) Natural Sources of Salinity in the Brazos River, Texas, USGS Paper 1669-CC

measurements do not provide as complete an indication of the quality. These samples were obtained almost exclusively during low flow periods. However, a significant number of samples have been analyzed, and they indicate that a noticeable deterioration of the quality has occurred since the earlier period. This agrees with earlier findings of the USGS, which concluded that the increase in load could only be the result of oil field activities (23).

To obtain an understanding of the effect on the potential quality in the Cedar Ridge Reservoir site, two water quality simulation studies were carried out, one based on the 1948-52 data and the other with the more recent 1968-78 data. (Details of the determinations of representative relationships between inflow and quality are described in Appendix D.) The results of the two studies are compared in Table 5.4. Summaries of the analyses are included in Appendix E. The simulation using the 1968-78 data is representative of the presently available quality. The simulation with the 1948-52 data provides an indication of potential conditions if some of the recent increase in pollution can be removed.

The water quality based on the most recent data would not be acceptable for municipal use. If the stream can be restored to a condition comparable to the earlier quality data, the Cedar Ridge supply would be basically acceptable. The mineral concentrations would at times be relatively high, but not beyond tolerable levels for West Texas. Before the Cedar Ridge Reservoir site can be considered a viable alternative for municipal water, however, it would be essential to identify the

Table 5.4

Estimated Water Quality in the Cedar Ridge Reservoir Site In The Year 2030

Percent of Time Concentration Less Than Indicated Values	Total Dissolved Solids Concentrations (mg/l) 1948-1952 Nugent Data	Total Dissolved Solids Concentrations (mg/l) 1968-1978 Nugent Data
0%	275	2,000
10%	412	2,350
20%	462	2,620
30%	530	2,840
40%	593	3,070
50%	625	3,200
60%	658	3,320
70%	692	3,420
80%	755	3,590
90%	894	3,950
100%	1,070	4,551

sources of man-made pollution within the watershed and determine whether they can be brought under control.

The proposed water delivery system from Cedar Ridge Reservoir to Lake Fort Phantom Hill and from Hubbard Creek Reservoir to Abilene is illustrated on Figure 5.3. A schematic of the supplies and demands under year-2020 critical conditions is presented in Figure 5.4. The facilities have been assumed to deliver water at constant annual rates from the Cedar Ridge site to Lake Fort Phantom Hill and Hubbard Creek Reservoir to Abilene. An allowance has been made to provide the

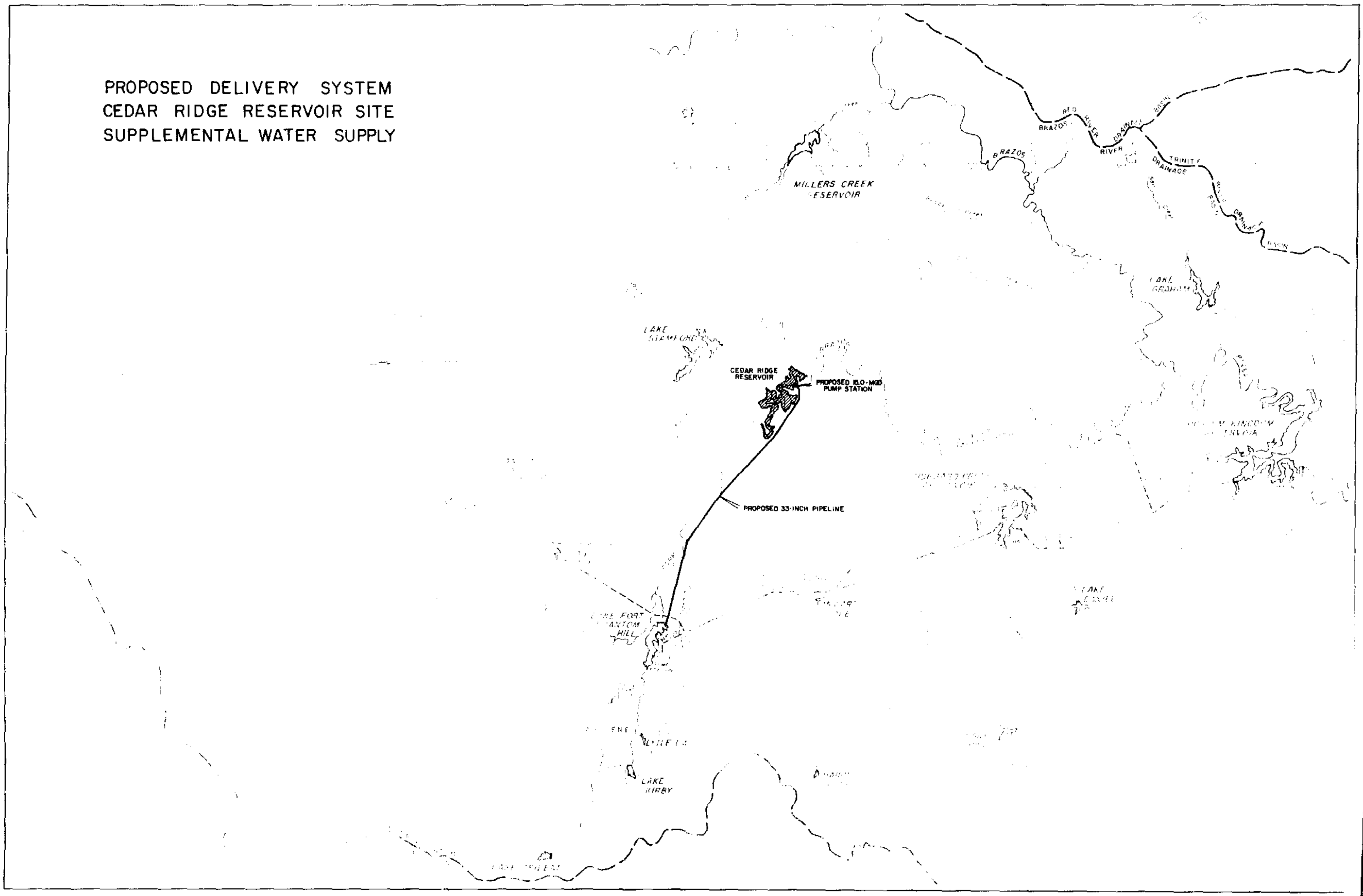

PROPOSED DELIVERY SYSTEM
CEDAR RIDGE RESERVOIR SITE
SUPPLEMENTAL WATER SUPPLY
MILLERS CREEK RESERVOIR
BRAZOS
RED RIVER DRAINAGE BASIN
BRAZOS RIVER
TRINITY DRAINAGE BASIN
LAKE GRAHAM
LAKE STAMFORD
CEDAR RIDGE RESERVOIR
PROPOSED 15.0-MGD PUMP STATION
PROPOSED 33-INCH PIPELINE
LAKE FORT PHANTOM HILL
LAKE KIRBY

FIGURE 5

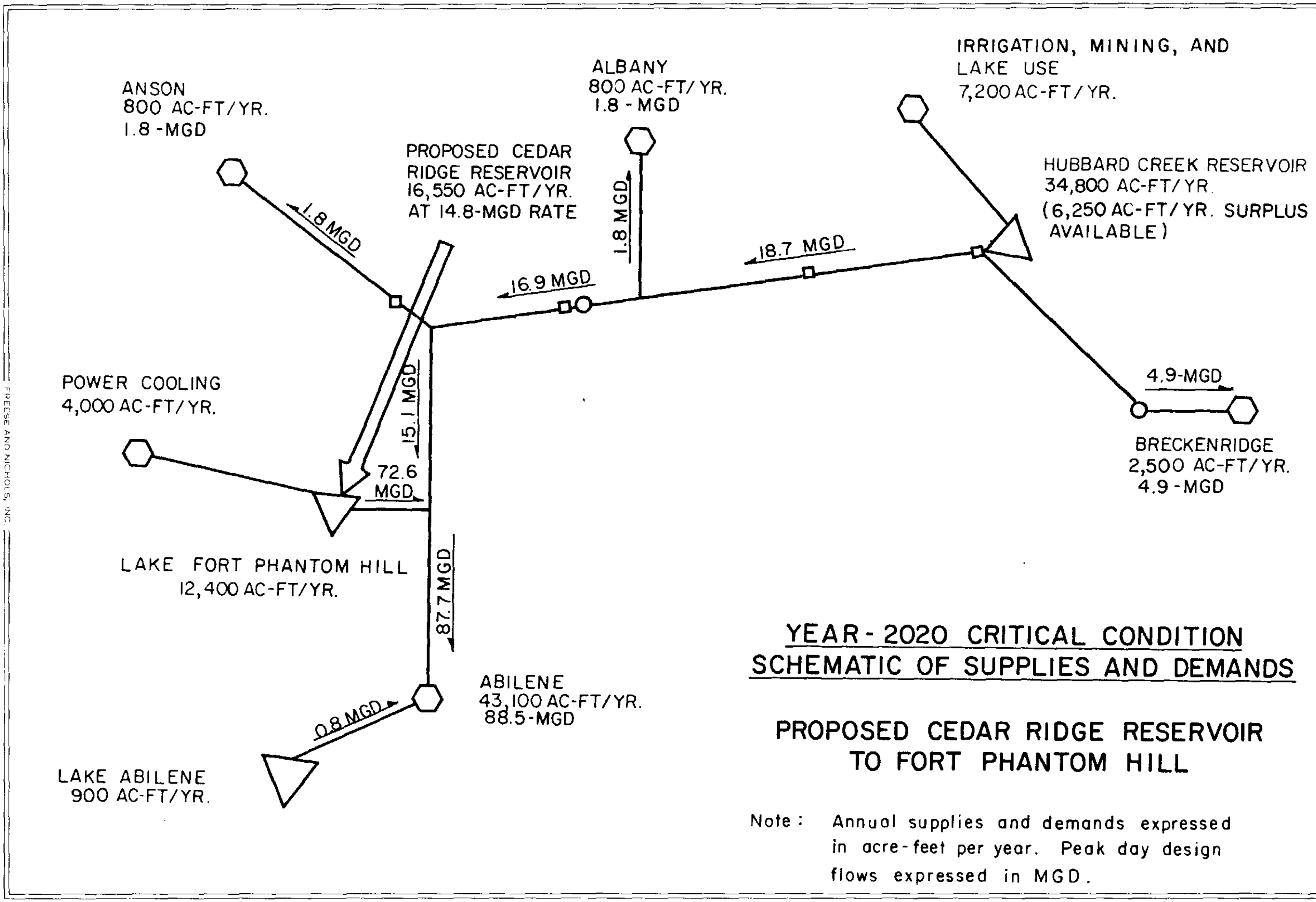

ANSON
800 AC-FT/YR.
1.8 -MGD
1.8 MGD
PROPOSED CEDAR RIDGE RESERVOIR
16,550 AC-FT/YR.
AT 14.8-MGD RATE
ALBANY
800 AC-FT/YR.
1.8 - MGD
1.8 MGD
16.9 MGD
18.7 MGD
IRRIGATION, MINING, AND LAKE USE
7,200 AC-FT/YR.
HUBBARD CREEK RESERVOIR
34,800 AC-FT/YR.
(6,250 AC-FT/YR. SURPLUS AVAILABLE)
15.1 MGD
POWER COOLING
4,000 AC-FT/YR.
72.6 MGD
4.9-MGD
BRECKENRIDGE
2,500 AC-FT/YR.
4.9 - MGD
LAKE FORT PHANTOM HILL
12,400 AC-FT/YR.
87.7 MGD
ABILENE
43,100 AC-FT/YR.
88.5-MGD
0.8 MGD
LAKE ABILENE
900 AC-FT/YR.
YEAR - 2020 CRITICAL CONDITION
SCHEMATIC OF SUPPLIES AND DEMANDS
PROPOSED CEDAR RIDGE RESERVOIR
TO FORT PHANTOM HILL
Note: Annual supplies and demands expressed in acre-feet per year. Peak day design flows expressed in MGD.
FREESE AND NICHOLS, INC.

FIGURE 5.4

peak-day requirements of Albany and Anson from the Hubbard Creek Reservoir pipeline. Under this procedure, Abilene would satisfy peaking water requirements from Lake Fort Phantom Hill. The proposed delivery procedure would leave 6,250 acre-feet per year of the Hubbard Creek Reservoir yield still unused as of 2020, taking 16,550 acre-feet per year from the Cedar Ridge Reservoir rather than the actual net additional supply requirement of 10,300 acre-feet per year. This approach would minimize the necessary capital investment and annual pumping costs.

The estimated capital costs for the proposed water system improvements are presented in Table 5.5. The total estimated capital cost is $82,163,700. Details of the cost estimates are included in Appendix F. Approximately 81 percent of the total is for the construction of Cedar Ridge Dam and Reservoir.

Included in the total estimate is provision for added pumping and pipeline capacity to allow transfer of more water from Lake Fort Phantom Hill to Abilene, over and above the amounts that would be needed for the other two alternatives. Although the pump station and pipeline facilities for bringing raw water from Lake Fort Phantom Hill will need to be increased for each of the systems under consideration, the Cedar Ridge source would need more capacity at that location because the new supply of water would be routed through Fort Phantom Hill Reservoir. Costs for improvements to the Fort Phantom Hill transmission facilities which would be common to all three alternatives have not been included in the comparative estimates, and only the net amount of additional cost associated with the Cedar Ridge source has been specifically indicated.

The estimated annual cost for the proposed facilities is also shown

Table 5.5

Cedar Ridge Reservoir Site
Summary of Capital and Year-2020 Annual Costs

Capital Costs

Items	Estimated Costs
Cedar Ridge Dam and Reservoir	$66,789,900
33-inch pipeline to Lake Fort Phantom Hill	12,149,300
15.0-MGD pump station on Cedar Ridge Reservoir	2,503,900
15.0-MGD added pumping and transmission capacity at Lake Phantom Hill	720,600
	$82,163,700

Annual Costs for Proposed Facilities

Items	Estimated Costs
Principal and interest payment, 30-years at 7.5%	$ 6,959,300
Reservoir operation and maintenance	100,000
Cedar Ridge Reservoir pump station power costs	339,900
Lake Fort Phantom Hill additional power costs	18,000
Transmission pipeline operation and maintenance	9,500
Lake Fort Phamtom Hill additional pumping facility operation and maintenance	5,000
	$ 7,431,700

Note: These estimates are based on 1980 price levels.

Hubbard Creek Reservoir in 2030 would yield a dependable supply of 44,000 acre-feet per year with a minimum content of 43,590 acre-feet at the end of the critical period. This yield is 16,000 acre-feet per year greater than that determined for Hubbard Creek Reservoir with historical runoff and independent operation without the Clear Fork diversions (1). A summary of the Hubbard Creek Reservoir operation study with the combined inflow has been included in Appendix C. It is estimated that runoff depletions through the year 2030 will reduce the diversion benefits by approximately 1,500 acre-feet per year based on the average diversions during the critical period. This reduction leaves a balance of 14,500 acre-feet per year of supplemental supply resulting from the diversion facility.

As has been indicated in Table 5.3, the U.S. Geological Survey has maintained a station for monitoring water quality on the Clear Fork of the Brazos at Fort Griffin since November 1967. These records were used to estimate the quality of the diversions on a daily basis. A description of the computational procedure has been included in Appendix D, along with a summary of the available quality data.

The results of the analysis of the quality in Hubbard Creek Reservoir with historical inflow and Clear Fork diversions are listed in Table 5.6. A summary of the computer simulation of the reservoir quality is presented in Appendix E. It appears that the quality in Hubbard Creek Reservoir would be affected only to a small degree by the diverted water. A previous estimate (1) concluded that the concentration of total dissolved solids in Hubbard Creek Reservoir would be under 900 milligrams per liter 90 percent of the time with full use of

Table 5.6

Estimated Water Quality in Hubbard Creek Reservoir With Clear Fork Diversions in the Year 2030

Percent of Time Concentration Less Than Indicated Values	Total Dissolved Solids Concentrations (mg/l)
0%	343
10%	455
20%	580
30%	648
40%	686
50%	720
60%	760
70%	805
80%	870
90%	968
100%	1,298

the yield and natural runoff conditions. The 90 percentile level of 968 milligrams per liter with Clear Fork diversions is only slightly higher than the former estimate.

The proposed water delivery system from the Clear Fork of the Brazos to Hubbard Creek Reservoir and from Hubbard Creek to Abilene and the other member cities is illustrated in Figure 5.5. A schematic of the supplies and demands under year-2020 critical conditions is presented in Figure 5.6. The facilities to deliver water from Hubbard Creek to Abilene are identical to those required if the supplemental

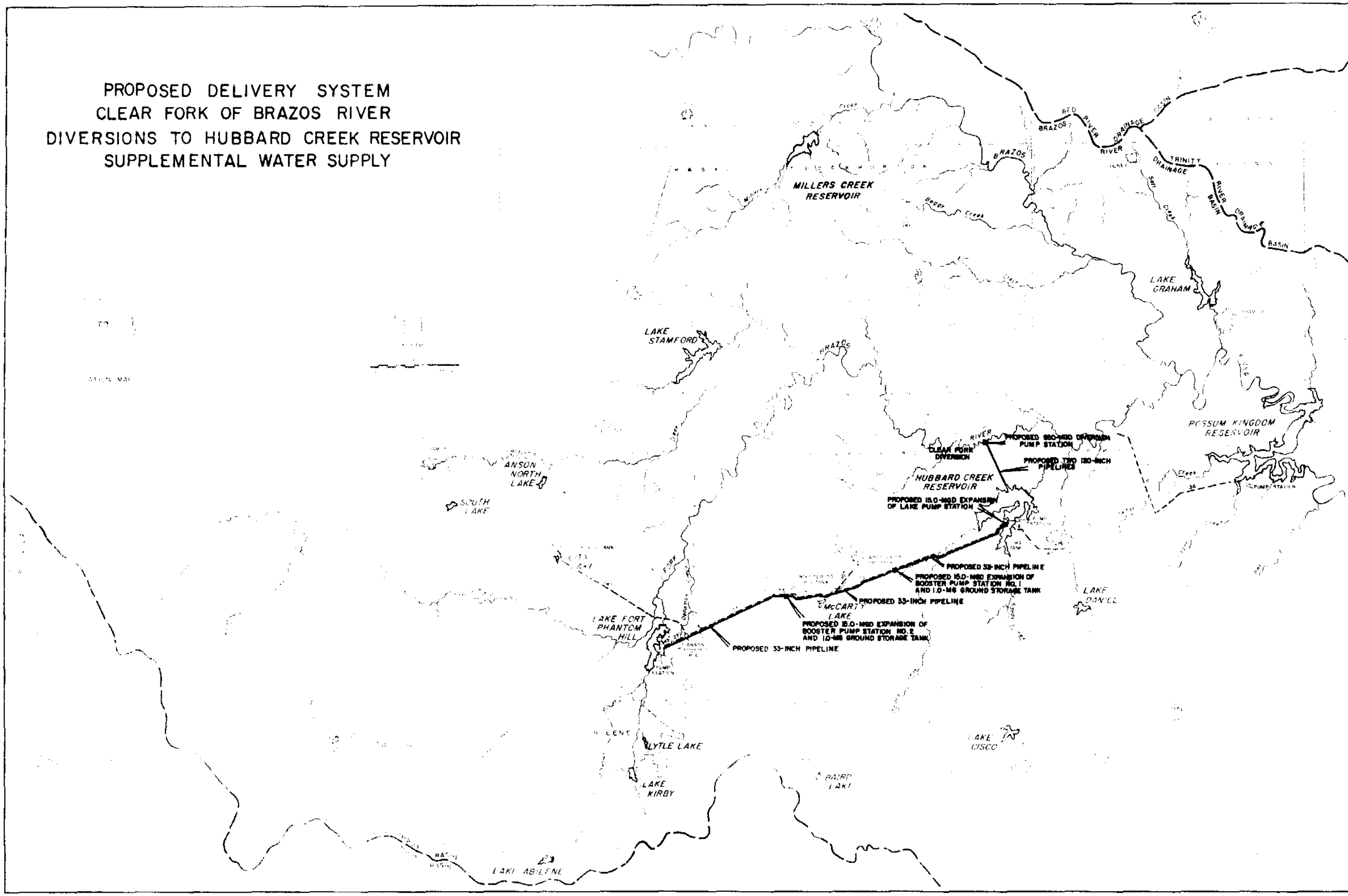
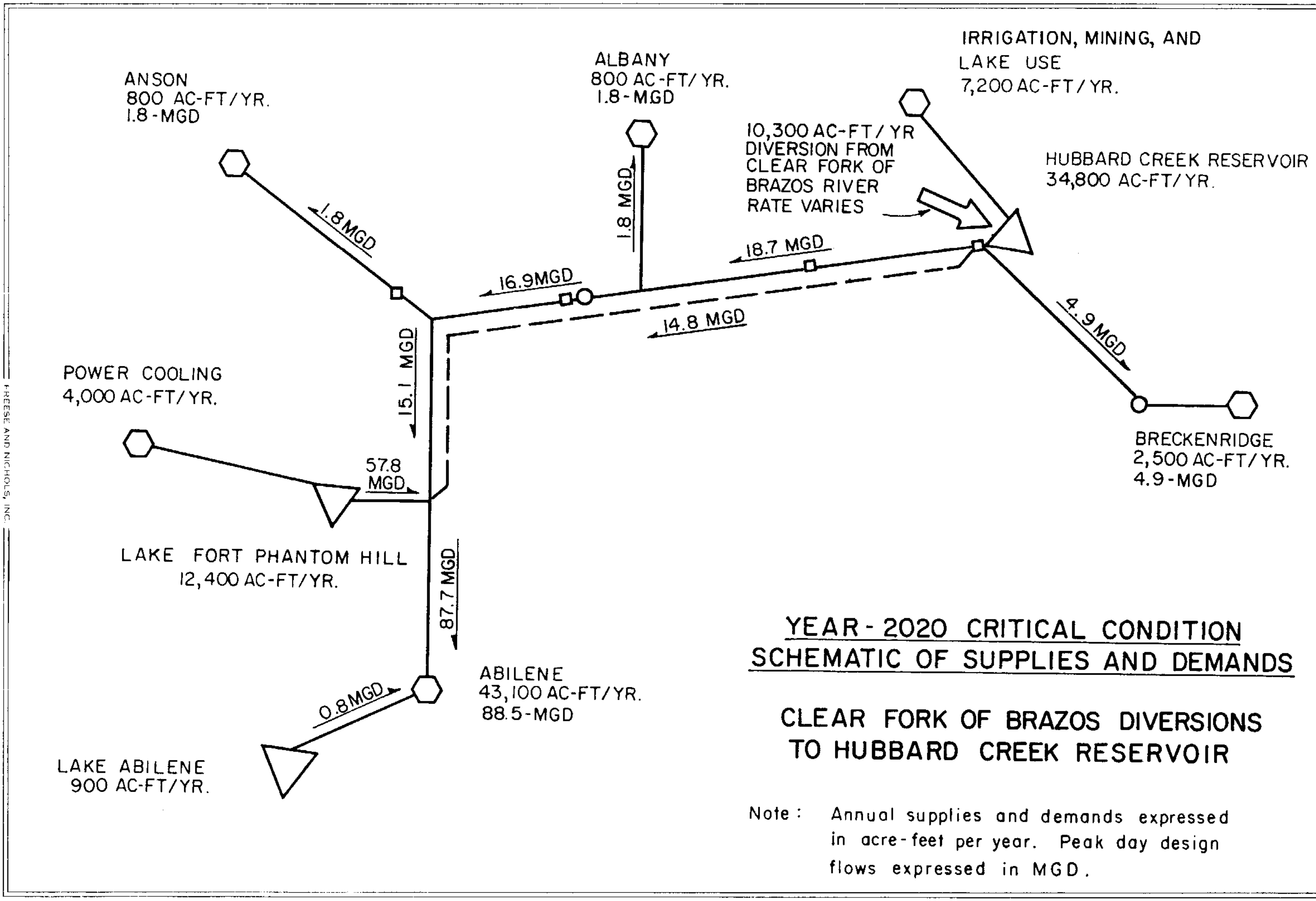

PROPOSED DELIVERY SYSTEM
CLEAR FORK OF BRAZOS RIVER
DIVERSIONS TO HUBBARD CREEK RESERVOIR
SUPPLEMENTAL WATER SUPPLY
MILLERS CREEK RESERVOIR
BRAZOS
RED RIVER DRAINAGE BASIN
BRAZOS RIVER
TRINITY RIVER DRAINAGE BASIN
LAKE GRAHAM
LAKE STAMFORD
BRAZOS
POSSUM KINGDOM RESERVOIR
RIVER
PUMP STATION
CLEAR FORK DIVERSION
PROPOSED TWO 120-INCH PIPELINES
HUBBARD CREEK RESERVOIR
PROPOSED 15.0-MGD EXPANSION OF LAKE PUMP STATION
PROPOSED 33-INCH PIPELINE
PROPOSED 15.0-MGD EXPANSION OF BOOSTER PUMP STATION NO. 1 AND 1.0-MG GROUND STORAGE TANK
PROPOSED 33-INCH PIPELINE
McCARTY LAKE
PROPOSED 15.0-MGD EXPANSION OF BOOSTER PUMP STATION NO. 2 AND 1.0-MG GROUND STORAGE TANK
PROPOSED 33-INCH PIPELINE
LAKE DANIEL
ANSON NORTH LAKE
SOUTH LAKE
LAKE FORT PHANTOM HILL
LYTLE LAKE
LAKE KIRBY
LAKE CISCO
LAKE ABILENE

FIGURE 5.5



YEAR-2020 CRITICAL CONDITION
SCHEMATIC OF SUPPLIES AND DEMANDS

CLEAR FORK OF BRAZOS DIVERSIONS
TO HUBBARD CREEK RESERVOIR

Note: Annual supplies and demands expressed in acre-feet per year. Peak day design flows expressed in MGD.

FIGURE 5.6

supply is obtained from Possum Kingdom Reservoir. A 650-MGD (1,000 cfs) pump station at the river would deliver water to Hubbard Creek Reservoir through two 120-inch pipelines. The facilities between Hubbard Creek Reservoir and Abilene have been assumed to operate at a constant annual delivery rate. An allowance has been made to provide the peak-day requirements of Albany and Anson. Abilene would obtain peaking water requirements from Lake Fort Phantom Hill.

The estimated capital and annual costs for the proposed water system improvements, based on 1980 price levels, are presented in Table 5.7. The capital cost is estimated to be $68,435,200. Over 77 percent of the total cost is required for the diversion pump station and pipelines. Details of the cost estimates are presented in Appendix F.

The estimated annual cost for the proposed facilities is $7,072,900, in addition to any debt service and operating expenses on the existing facilities. The energy cost for the Clear Fork pump station is based on the average yearly diversion conditions. Actual years would vary significantly above and below the indicated average amount. The cost per 1,000 gallons for the supplemental water estimated to be used as of 2020 is approximately $2.11.

Table 5.7

Clear Fork of Brazos River Diversions to Hubbard Creek Reservoir
Summary of Capital and Year-2020 Annual Costs

Capital Costs

Items	Estimated Costs
650-MGD pump station on Clear Fork of Brazos	$24,173,500
Two 120-inch pipelines from Clear Fork of Brazos to Hubbard Creek Reservoir	28,801,600
15.0-MGD expansion of WCTMWD lake pump station	680,500
15.0-MGD expansion of WCTMWD booster pump station No. 1	887,100
15.0-MGD expansion of WCTMWD booster pump station No. 2	700,600
33-inch pipeline from Hubbard Creek Reservoir to Lake Fort Phantom Hill	13,191,900
	$68,435,200

Annual Costs for Proposed Facilities

Items	Estimated Costs
Principal and interest payment, 30 years at 7.5%	$ 5,796,500
Clear Fork of Brazos diversion and transmission system operation and maintenance	246,100
Clear Fork of Brazos diversion pump station power costs (average year flow conditions)	241,000
Hubbard Creek Reservoir pump station and booster pump stations power costs	760,300
Hubbard Creek Reservoir transmission system operation and maintenance	29,000
	$ 7,072,900

Note: These estimates are based on 1980 price levels.

6. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

a. The probable firm water supply requirements of the West Central Texas Municipal Water District and its member cities under drouth conditions are projected to increase from approximately 29,300 acre-feet per year as of 1980 to 41,900 acre-feet per year in 2000, 52,200 acre-feet per year in 2020 and 58,400 acre-feet per year in 2030. The projected demands for the next ten years should be reasonably close, but beyond that time an increasing allowance should be made for unpredictable factors that may lead to greater or less water use. Recommended minimum, probable and maximum projections are shown in Table 2.7, on Page 2.14.

b. In addition to the firm requirements for municipal use and minor needs at Hubbard Creek Reservoir, the District is presently selling water for irrigation and mining (secondary oil recovery) operations. These uses accounted for approximately 4,800 acre-feet last year. They can be curtailed when the water is needed to meet the needs of the District member cities, but as long as there is enough water to satisfy all demands it will be desirable to continue the secondary sales, which provide added income for the District and are beneficial to the economy of the area. Irrigation is expected to remain at the present average level of approximately 1,200 acre-feet per year. There will probably be an increase in water requirements for oil field use, and it is concluded that the District can count on being able to sell approximately 5,000 acre-feet per year for that purpose during the next several decades.

Depending on economic trends in the petroleum industry, the demand could be appreciably more. As oil reserves are recovered over the years, water use for that purpose will gradually cease.

c. Counting the secondary requirements, the total water demand within the District under drouth conditions is now approximately 34,100 acre-feet per year, projected to increase to probable total requirements of 48,100 acre-feet per year by 2000 and 58,400 acre-feet per year by 2020. It is doubtful whether the water use for oil field operations will continue past 2020. Without that requirement, the probable total demand within the District under drouth conditions as of the year 2030 is estimated to be 59,600 acre-feet per year.

d. The total dependable yield from the existing reservoirs of the West Central Texas Municipal Water District and its member cities is estimated to be 53,540 acre-feet per year in 1980, decreasing uniformly with time to 46,760 acre-feet per year by 2030.

e. Based on the projected probable future requirements, including irrigation and secondary oil recovery, the District will need 10,300 acre-feet per year of additional dependable supply by 2020. Assuming oil field use no longer to be a factor by 2030, the additional amount of supply needed to meet the projected probable demand as of that date is 12,840 acre-feet per year. Without the irrigation use, the probable additional requirement as of 2030 is estimated to be 11,640 acre-feet per year.

f. Based on the projected probable needs, the next new source of supply should be capable of providing at least 12,000 acre-feet per year on a dependable basis in times of drouth through the year 2030.

g. To meet the estimated probable growth in requirements and to continue to provide water for irrigation and oil field use, a new supply will be needed by about the year 2004. Under the potential maximum projection of future requirements, the new supply could be needed as early as 1998.

h. Three alternative sources of potential additional supply have been identified which would be capable of providing 12,000 acre-feet per year or more through the year 2030. These are (a) Possum Kingdom Reservoir, (b) the Cedar Ridge Reservoir site on the Clear Fork of the Brazos River, and (c) supplemental diversions of water from the Clear Fork into Hubbard Creek Reservoir. Table 6.1 reflects in summary form the principal facts regarding yield, water quality and cost for these sources.

i. All three alternatives could provide sufficient yield to satisfy the probable firm requirements within the West Central Texas Municipal Water District through 2030.

j. The yield of Possum Kingdom is presently committed to existing obligations of the Brazos River Authority. Water from Possum Kingdom probably could only become available to the District when the Authority develops a new source of supply elsewhere in the Brazos Basin (for example, the proposed Millican Reservoir project), thereby freeing part of the Possum Kingdom yield for other uses.

k. Only the diversions from the Clear Fork of the Brazos River into Hubbard Creek Reservoir would provide water of acceptable quality under present watershed conditions.

l. If a program for tighter control of man-made pollution on the Clear Fork watershed could bring dissolved chemical concentrations back to the levels observed in the late 1940's and early 1950's, the Cedar Ridge project would be acceptable from the standpoint of quality. Such a program would also improve the quality of the Clear Fork flows that might be diverted into Hubbard Creek Reservoir.

m. A study published by the U.S. Army Corps of Engineers in 1973 (13) predicts that the quality of water in Possum Kingdom Reservoir could be improved to basically acceptable levels through control of natural pollution sources on the Salt Fork of the Brazos River.

n. All of the alternatives would be costly. The least expensive option would apparently be to obtain water from Possum Kingdom Reservoir, if that becomes possible through development of other projects by the Brazos River Authority and if the Federal pollution control project on the Salt Fork watershed becomes a reality. The price of raw water at Possum Kingdom Reservoir and local sponsorship costs of participation in the Federal pollution control project are not known at this time.

o. The unit costs of water obtained from Cedar Ridge Reservoir or from diversions of Clear Fork flows into Hubbard Creek Reservoir would be approximately the same. The capital cost of the Clear Fork diversion project would be significantly less than that of the Cedar Ridge project.

p. The Cedar Ridge project would produce more new yield than the Clear Fork diversions into Hubbard Creek and would therefore satisfy the

Table 6.1

Comparison of Alternative Sources of Additional Water Supply

	Possum Kingdom Reservoir	Cedar Ridge Reservoir Site	Diversion of Water from the Clear Fork of the Brazos to Hubbard Creek Reservoir
Available additional supply	12,000 Ac-Ft/Yr or more	20,000 Ac-Ft/Yr	14,500 Ac-Ft/Yr
Water quality under present conditions	Poor (a)	Poor (b)	Acceptable (b)
Estimated capital cost	$26,043,500	$82,163,700	$68,435,200
Estimated annual cost to meet 2020 demands	$ 3,192,300 (c)	$ 7,431,700 (d)	$ 7,072,900 (d)
Estimated cost per 1,000 gallons as of 2020	$0.95 (c)	$2.21 (d)	$2.11 (d)

<u>Notes</u>

(a) Water quality at Possum Kingdom Reservoir may be improved by proposed Federal pollution control improvements farther upstream.

(b) Water quality at the Cedar Ridge site and the Clear Fork diversion site may be subject to improvement through control of man-made pollution on the watershed.

(c) The annual cost and unit cost shown for Possum Kingdom water do not include the cost of purchasing the water at the reservoir or of participation in the proposed Federal pollution control project. These costs are not known at this time.

(d) The annual costs and unit costs shown for the Cedar Ridge Reservoir and Clear Fork Diversion projects do not include costs of monitoring oil field brine disposal operations on the Clear Fork watershed.

District's needs for a longer time beyond 2030.

q. If water requirements grow as projected, it will not be necessary to reach a definite decision regarding the next source of supply until about 1985.

<u>Recommendations</u>

a. It is recommended that the West Central Texas Municipal Water District proceed at this time to evaluate the prospects for more effective control of man-made pollution on the watershed of the Clear Fork of the Brazos River.

b. It is recommended that the District enter into discussions with the Brazos River Authority and the U.S. Army Corps of Engineers to determine (a) whether part of the yield of Possum Kingdom Reservoir might become available to the District in the foreseeable future and (b) whether the proposed Federal pollution control project which would improve the quality of the Possum Kingdom water is likely to be carried out in time to make that a viable alternative.

c. It is recommended that the District and its member cities reach a definite decision regarding the next source of supply by 1985, in order that detailed planning, project design and development can begin by that date.

APPENDIX A

LIST OF REFERENCES

APPENDIX A

LIST OF REFERENCES

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APPENDIX B

HYDROLOGIC AND AREA-CAPACITY DATA

Cedar Ridge Reservoir Site Inflow Data

Estimates of the inflow to the Cedar Ridge Reservoir Site were prepared for the 37-year period, 1941 through 1977. The U. S. Geological Survey maintained stream gaging stations on the Clear Fork of the Brazos at Nugent and on the Clear Fork at Fort Griffin during the study period. The data from these two gages which are located on either side of the Cedar Ridge Reservoir Site were used to determine the estimated runoff.

Adjusted Fort Griffin gage flows were determined by subtracting the Lake Stamford inflow (or Lake Stamford historical spills after construction), by subtracting historical Lake Fort Phantom Hill spills, by adding historical Clear Fork diversion to Lake Fort Phantom Hill, and by adding historical Deadman Creek diversions.

The historical runoff from the drainage area between the Cedar Ridge Reservoir Site and the Nugent Gage was determined by multiplying the difference between the Adjusted Fort Griffin Gage flow and the sum of Nugent Gage flows and the historical diversions from the Clear Fork to Lake Fort Phantom Hill by 0.346. This factor is the ratio of the drainage area below the Nugent Gage and above the Cedar Ridge Reservoir Site to the drainage area below the Nugent Gage and Lake Stamford and above the Fort Griffin Gage. The historical runoff values were adjusted for year 2030 conditions by subtracting future Deadman Creek Diversions and by adding future Lake Fort Phantom Hill spills.

The runoff from the drainage area above the Nugent Gage was determined by adding the historical Clear Fork Diversions to Lake Fort Phantom Hill and subtracting the estimated 2030 conditions Diversions to

Lake Fort Phantom Hill.

The adjusted Fort Griffin Gage flows are listed in Table B-1. The predicted year 2030 diversions from the Clear Fork to Lake Fort Phantom Hill are summarized in Table B-2. These predicted diversions are based on a combined reservoir operation study using a maximum annual diversion from the Clear Fork of 30,000 acre-feet per year and a demand of 30,690 acre-feet per year on Lake Fort Phantom Hill. The estimated 2030 conditions monthly inflows into the Cedar Ridge Reservoir Site are tabulated in Table B-3. An allowance for future depletions has not been deducted from the 2030 inflow values.

Table B-1

Adjusted Clear Fork of Brazos at Fort Griffin Flows
- Values in Acre-Feet -

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1941	121	3,340	5,040	51,210	208,300	95,700	18,490	15,160	8,410	151,770	21,430	11,640	590,611
1942	3,230	4,740	1,610	14,990	14,690	19,540	775	1,660	13,050	38,820	2,820	3,190	119,115
1943	1,690	1,690	4,380	3,240	9,650	17,160	730	3	0	0	0	0	38,543
1944	0	1,820	3,390	365	19,310	7,630	9,990	534	2,440	16,010	1,110	1,050	63,649
1945	593	751	15,830	31,090	5,200	18,370	52,030	4,520	70	14,100	1,240	1,160	144,954
1946	1,080	996	883	1,080	2,950	2,170	452	5,780	25,360	22,350	3,590	15,830	82,521
1947	910	421	802	406	88,800	12,120	1,430	55	3,060	14,720	3,690	4,950	131,364
1948	655	996	3,350	196	7,096	19,060	16,210	1,660	317	11,080	285	1	60,906
1949	655	920	291	3,710	31,170	15,040	11	469	8,190	6,290	213	0	66,959
1950	0	0	0	10,520	29,710	3,030	11,740	5,300	16,930	119	0	0	77,349
1951	0	2	580	59	14,930	33,360	5,070	437	43	0	0	0	54,481
1952	0	0	0	0	2,985	2,881	0	0	350	19	669	121	7,025
1953	13	0	19	0	5,813	8,530	88,479	10,006	59	15,235	447	0	128,601
1954	0	0	0	1,596	59,644	3,407	0	204	0	186	524	5	65,566
1955	3,050	503	39	123	28,627	24,093	4,432	292	94,770	22,750	27	6	178,712
1956	5	0	0	3	8,650	258	0	0	7	318	378	399	10,018
1957	21	69,987	3,858	183,355	411,100	130,745	7,720	3,750	3,180	6,320	3,690	774	824,500
1958	845	718	1,290	1,670	10,460	7,020	12,930	1,470	32,180	2,070	533	228	71,414
1959	351	319	202	18	22,338	33,219	11,750	1,350	253	27,520	293	1,190	98,803
1960	2,670	3,530	929	474	301	1,670	48,386	342	83	12,508	268	746	71,907
1961	1,960	3,386	1,587	424	3,226	73,009	83,030	5,718	27,930	3,308	7,720	3,136	214,434
1962	2,160	1,716	3,060	2,766	1,166	110,962	11,119	1,958	115,762	7,320	3,480	2,410	263,873
1963	1,680	1,410	1,190	4,290	26,012	30,648	711	0	471	7	120	398	66,937
1964	489	3,420	1,080	1,030	657	1,470	28	1,138	880	209	560	395	11,356
1965	551	496	423	4,884	87,241	3,120	43	0	7,334	22,600	2,240	990	129,922

Table B-1, Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1966	990	1,120	1,643	38,634	36,820	1,420	157	3,300	24,607	291	839	928	110,749
1967	752	525	567	467	2,178	8,607	4,007	27	7,991	1,590	971	1,390	29,072
1968	31,454	5,520	21,500	20,560	10,150	3,620	2,640	538	15	4	49	1,180	97,230
1969	829	1,440	1,960	2,590	90,658	1,902	263	247	40,320	5,080	3,700	4,130	153,119
1970	4,380	3,130	5,980	8,610	7,080	6,790	72	298	1,100	504	111	501	38,556
1971	600	615	382	628	14,011	12,540	714	117,495	46,447	11,050	4,270	4,362	213,114
1972	3,969	4,070	3,270	2,350	4,700	875	2,570	10,808	13,290	10,640	32,901	2,710	91,343
1973	9,400	13,345	28,859	118,218	4,823	7,780	1,440	1,720	7,450	2,940	1,420	1,310	98,705
1974	1,070	1,100	1,420	916	656	5	0	5,499	69,253	57,760	60,120	9,880	207,679
1975	10,970	19,990	6,340	4,990	18,200	4,240	25,930	6,380	2,580	1,190	4,180	2,370	107,360
1976	2,190	1,370	1,670	3,990	2,450	618	3,970	5,218	12,750	25,402	9,250	3,020	71,898
1977	3,570	2,310	6,820	14,610	13,600	2,160	1,000	310	3,530	1,700	1,330	1,420	52,360

Table B-2

Predicted 2030 Diversions From Clear Fork of the Brazos Into Fort Phantom Hill Reservoir
- Values in Acre-Feet -

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1941	0	0	1,280	0	0	0	3,540	0	3,330	0	3,210	1,290	12,650
1942	0	2,130	0	3,880	5,000	5,000	30	350	7,080	2,290	1,230	120	27,110
1943	110	0	5,330	4,870	430	140	0	0	0	0	0	0	10,880
1944	0	1,060	450	0	10,710	4,380	7,440	2,190	1,190	2,580	0	0	30,000
1945	0	0	2,160	4,000	3,000	6,000	14,840	0	0	0	0	0	30,000
1946	0	0	0	200	0	0	440	20	4,200	5,870	1,420	5,160	17,310
1947	260	0	0	0	16,000	4,500	230	0	0	6,750	1,000	1,260	30,000
1948	0	130	560	0	0	1,880	6,700	1,420	8	8,230	70	0	18,998
1949	0	0	0	330	10,330	3,870	0	0	5,080	3,230	0	0	22,840
1950	0	0	0	1,200	10,350	1,570	2,390	1,320	6,780	0	0	0	23,610
1951	0	0	490	0	8,170	8,660	2,170	30	0	0	0	160	19,680
1952	0	0	0	0	1,060	30	0	0	200	0	50	0	1,340
1953	0	0	0	0	580	0	2,320	1,790	0	630	0	0	5,320
1954	0	0	0	0	9,830	540	0	0	0	0	10	0	10,380
1955	0	0	0	0	12,360	9,880	1,550	0	3,837	0	0	0	27,627
1956	0	0	0	0	7,290	790	0	0	0	260	0	0	8,340
1957	0	11,050	1,120	0	0	5,580	1,390	140	230	1,740	0	0	21,250
1958	0	0	0	0	140	570	2,110	464	1,757	0	0	0	5,041
1959	0	0	0	0	7,290	8,000	7,300	350	0	6,920	140	0	30,000
1960	0	130	0	0	0	1,310	5,050	90	0	3,330	0	0	9,910

Table B-2, Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1961	0	0	0	0	1,530	7,700	6,250	770	9,339	320	50	0	25,959
1962	0	0	0	0	0	8,800	3,120	1,310	3,860	1,360	0	0	18,450
1963	0	0	0	30	4,820	5,090	30	0	0	0	0	0	9,970
1964	0	0	0	0	0	0	0	1,240	0	0	0	0	1,240
1965	0	0	0	2,828	16,450	2,020	0	0	5,215	2,937	550	0	30,000
1966	0	0	393	7,332	0	710	0	650	9,789	0	0	0	18,874
1967	0	0	0	0	1,138	5,927	2,097	0	3,141	190	0	0	12,493
1968	3,164	0	2,470	0	2,330	450	0	10	0	0	0	0	8,424
1969	0	0	0	0	8,650	1,350	0	140	12,980	1,930	200	0	25,250
1970	0	0	0	260	38	3,540	0	0	0	0	0	0	3,838
1971	0	0	0	0	7,071	4,900	380	15,000	0	2,000	649	0	30,000
1972	0	0	0	0	0	0	710	8,138	3,160	1,090	4,781	0	17,879
1973	0	0	5,330	3,180	24	340	0	0	2,630	0	0	0	11,504
1974	0	0	0	0	0	0	349	8,903	0	0	2,050	2,190	13,492
1975	0	0	0	0	0	0	0	0	260	0	860	0	1,120
1976	0	0	0	190	0	0	660	1,638	4,180	3,950	600	0	11,218
1977	0	0	1,900	4,260	4,490	110	0	110	0	0	0	0	10,870

Table B-3

Cedar Ridge Reservoir Site Inflows Under Year 2030 Conditions
- Values in 10 Acre-Feet -

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1941	20	175	274	3,126	11,504	6,896	913	1,890	183	9,564	1,089	500	36,134
1942	197	268	128	580	725	684	49	144	364	2,818	70	239	6,266
1943	130	129	0	0	456	1,102	110	48	15	26	19	30	2,065
1944	26	109	135	59	493	106	237	0	25	862	77	78	2,207
1945	39	55	609	1,103	199	615	3,188	516	44	1,241	131	111	7,851
1946	105	85	84	138	185	140	72	227	901	771	105	486	3,299
1947	45	40	65	39	2,984	432	91	6	115	959	172	191	5,139
1948	57	127	206	23	336	709	474	20	20	368	12	6	2,358
1949	52	53	23	255	824	410	6	23	217	189	10	9	2,071
1950	8	7	3	424	1,169	39	481	119	543	15	21	20	2,849
1951	18	15	74	29	269	1,057	214	49	3	15	7	78	1,828
1952	9	6	5	39	155	122	0	0	88	1	78	12	515
1953	1	1	9	0	167	308	2,884	326	1	589	15	2	4,303
1954	0	0	0	82	1,811	99	0	13	0	5	70	1	2,081
1955	106	38	1	4	664	395	203	37	4,517	1,070	8	2	7,045
1956	6	9	0	0	121	5	39	0	0	44	22	38	284
1957	0	3,193	131	11,500	39,228	9,354	377	243	214	243	222	67	64,772
1958	71	54	93	113	487	322	451	112	1,150	140	36	29	3,058
1959	31	23	24	8	1,081	1,230	429	72	16	914	27	98	3,953
1960	148	201	56	5	16	63	1,584	34	34	340	14	45	2,540
1961	110	146	73	24	191	3,374	3,625	204	1,781	149	534	192	10,403
1962	144	106	183	150	68	4,980	603	9	5,072	391	200	162	12,068
1963	128	99	86	237	1,013	1,079	33	0	28	1	17	34	2,755
1964	37	127	49	81	29	85	0	24	47	13	50	16	558
1965	20	21	113	320	4,323	64	0	0	171	1,349	102	69	6,552

Table B-3, Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1966	69	65	100	1,635	2,803	51	39	242	685	47	67	72	5,875
1967	32	24	36	41	129	188	157	9	293	106	44	66	1,125
1968	1,027	271	864	1,752	456	200	144	62	3	7	41	42	4,869
1969	43	75	102	110	4,043	94	5	27	2,417	201	265	285	7,667
1970	273	202	302	426	361	212	15	26	73	42	24	44	2,018
1971	49	46	26	55	434	245	56	5,483	3,474	920	316	343	11,447
1972	286	261	200	145	241	71	118	229	398	482	1,007	202	3,640
1973	480	626	991	588	279	391	118	118	260	184	115	96	4,246
1974	84	87	98	75	64	12	0	0	4,133	4,996	3,883	505	13,937
1975	1,692	1,852	1,113	304	1,096	229	3,436	383	182	117	262	188	10,854
1976	181	131	136	309	177	52	286	213	414	858	408	210	3,375
1977	254	176	271	461	360	151	112	98	174	47	74	87	2,265

Cedar Ridge Reservoir Site Evaporation Data

Monthly depths of evaporation losses from the reservoir surface area from 1941 through 1977 were derived from Texas Water Development Board Report 64, which is a compilation of net evaporation rates throughout the State. Although the original Water Development Board study covered only the period from 1940 through 1965, data for the next thirteen years (1966-1978) have subsequently been prepared as supplemental material and are available from the Board in the form of computer printouts.

The monthly rates at Cedar Ridge Reservoir Site were calculated from Quadrangles D-8 and E-8, as illustrated on Plate 2 of Report 64. The weighing factors developed for use with the data of each quadrangle were 0.49 for D-8 and 0.51 for E-8. A tabulation of the resulting calculated net evaporation rates are presented in Table B-4.

Cedar Ridge Reservoir Area and Capacity Data

The Cedar Ridge Reservoir area and capacity versus elevaton data were developed using U.S.G.S., 7½-minute quadrangles. Table B-5 delineates these data.

Table B-4

Cedar Ridge Reservoir Site
Summary of Net Evaporation Data
- Values in Feet -

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1941	0.18	0.00	0.18	0.06	-0.21	0.20	0.60	0.52	0.49	-0.28	0.36	0.17	2.27
1942	0.24	0.27	0.43	-0.10	0.36	0.55	0.78	0.62	0.29	0.04	0.23	0.03	3.74
1943	0.24	0.36	0.19	0.44	0.33	0.43	0.73	1.06	0.67	0.54	0.35	0.03	5.37
1944	0.04	-0.02	0.26	0.48	0.26	0.65	0.67	0.82	0.68	0.28	0.16	0.06	4.34
1945	0.12	0.09	0.18	0.21	0.64	0.56	0.42	0.77	0.72	0.24	0.45	0.27	4.67
1946	-0.02	0.21	0.38	0.48	0.35	0.59	1.04	0.92	0.27	0.44	0.22	0.08	4.96
1947	0.15	0.25	0.18	0.26	-0.03	0.69	0.96	0.83	0.85	0.47	0.19	0.08	4.88
1948	0.17	0.04	0.24	0.51	0.34	0.41	0.68	0.89	0.83	0.49	0.48	0.36	5.44
1949	-0.13	0.10	0.28	0.16	0.09	0.37	0.74	0.59	0.44	0.27	0.48	0.18	3.57
1950	0.15	0.21	0.48	0.24	0.04	0.45	0.22	0.62	0.23	0.61	0.52	0.29	4.06
1951	0.25	0.15	0.34	0.39	0.11	0.33	0.73	0.78	0.62	0.51	0.31	0.29	4.81
1952	0.22	0.27	0.32	0.25	0.35	0.90	0.82	1.26	0.82	0.81	0.23	0.17	6.42
1953	0.29	0.21	0.24	0.35	0.41	0.87	0.38	0.49	0.82	0.15	0.26	0.30	4.77
1954	0.14	0.36	0.41	0.12	-0.07	0.72	1.00	1.14	1.07	0.59	0.31	0.31	6.10
1955	0.11	0.15	0.34	0.40	0.15	0.29	0.79	0.88	0.39	0.52	0.54	0.31	4.87
1956	0.14	0.14	0.43	0.39	0.49	0.86	1.08	1.12	1.02	0.57	0.48	0.25	6.97
1957	0.20	-0.08	0.23	-0.21	-0.45	0.45	0.95	1.05	0.64	0.19	-0.04	0.30	3.23
1958	0.07	0.08	0.02	0.09	0.10	0.54	0.55	0.74	0.21	0.30	0.31	0.24	3.25
1959	0.19	0.15	0.43	0.34	0.23	0.20	0.41	0.80	0.73	0.02	0.35	0.04	3.89
1960	0.01	0.10	0.24	0.26	0.41	0.66	0.39	0.79	0.60	0.16	0.47	0.04	4.13

Table B-4, Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1961	-0.04	0.04	0.25	0.52	0.46	0.09	0.41	0.83	0.40	0.49	0.17	0.18	3.80
1962	0.19	0.29	0.30	0.21	0.62	0.12	0.48	0.90	-0.02	0.41	0.26	0.17	3.93
1963	0.17	0.19	0.26	0.23	0.00	0.31	0.76	0.71	0.49	0.50	0.12	0.14	3.88
1964	0.16	0.06	0.30	0.43	0.38	0.48	0.44	0.69	0.34	0.51	0.19	0.26	4.24
1965	0.19	0.15	0.29	0.20	-0.04	0.29	0.89	0.79	0.59	0.22	0.32	0.17	4.06
1966	0.11	0.16	0.44	0.08	0.43	0.60	0.87	0.42	0.16	0.50	0.45	0.32	4.54
1967	0.30	0.28	0.38	0.32	0.32	0.48	0.46	0.65	0.10	0.45	0.18	0.12	4.04
1968	-0.20	0.07	0.11	0.27	0.23	0.39	0.49	0.75	0.64	0.55	0.16	0.28	3.74
1969	0.21	0.10	0.11	0.18	0.09	0.45	0.82	0.53	0.11	0.23	0.27	0.08	3.18
1970	0.10	0.06	0.04	0.07	0.28	0.57	0.78	0.68	0.39	0.28	0.42	0.31	3.98
1971	0.26	0.27	0.45	0.41	0.47	0.61	0.77	0.26	0.33	0.20	0.25	0.04	4.32
1972	0.19	0.23	0.42	0.41	0.29	0.45	0.63	0.51	0.37	0.23	0.16	0.23	4.12
1973	-0.03	0.04	0.15	0.20	0.50	0.50	0.50	0.78	0.27	0.27	-0.31	0.34	3.83
1974	0.17	0.30	0.33	0.40	0.49	0.72	0.87	0.45	0.16	0.19	0.22	0.12	4.42
1975	0.15	0.04	0.24	0.31	0.21	0.49	0.43	0.62	0.30	0.50	0.21	0.16	3.66
1976	0.22	0.38	0.33	0.19	0.32	0.56	0.42	0.61	0.25	0.11	0.20	0.14	3.73
1977	0.02	0.21	0.30	0.17	0.27	0.60	0.71	0.58	0.74	0.43	0.32	0.37	4.72

Table B-5

Cedar Ridge Reservoir Site
Area and Capacity Characteristics

Elev.	0	1	2	3	4	5	6	7	8	9	
1280											
Area	0	0	0	8	16	24	32	40	48	56	Acres
Cap.	0	0	0	4	16	36	64	100	144	196	Ac-Ft
1290											
Area	72	80	88	96	104	112	120	128	130	134	Acres
Cap.	260	336	420	512	612	720	836	960	1,089	1,221	Ac-Ft
1300											
Area	136	154	173	192	211	229	248	267	286	304	Acres
Cap.	1,356	1,501	1,665	1,848	2,050	2,270	2,509	2,767	3,044	3,339	Ac-Ft
1310											
Area	323	345	368	390	412	434	456	479	501	523	Acres
Cap.	3,653	3,988	4,345	4,724	5,125	5,549	5,995	6,463	6,953	7,465	Ac-Ft
1320											
Area	545	581	617	653	689	725	761	797	833	869	Acres
Cap.	8,000	8,564	9,164	9,800	10,472	11,179	11,923	12,703	13,519	14,370	Ac-Ft
1330											
Area	905	946	986	1,027	1,068	1,108	1,149	1,189	1,230	1,271	Acres
Cap.	15,258	16,184	17,150	18,157	19,205	20,293	21,422	22,592	23,802	25,052	Ac-Ft
1340											
Area	1,311	1,347	1,384	1,420	1,456	1,493	1,529	1,565	1,602	1,638	Acres
Cap.	26,344	27,674	29,040	30,442	31,881	33,356	34,867	36,414	37,998	39,618	Ac-Ft

Table B-5, Continued

Elev.	0	1	2	3	4	5	6	7	8	9	
1350											
Area	1,674	1,713	1,751	1,790	1,828	1,867	1,905	1,944	1,982	2,021	Acres
Cap.	41,275	42,969	44,701	46,472	48,281	50,129	52,015	53,940	55,903	57,905	Ac-Ft
1360											
Area	2,059	2,099	2,139	2,179	2,219	2,259	2,299	2,339	2,379	2,419	Acres
Cap.	59,945	62,025	64,144	66,304	68,504	70,743	73,023	75,343	77,702	80,102	Ac-Ft
1370											
Area	2,459	2,499	2,538	2,578	2,617	2,657	2,696	2,736	2,775	2,815	Acres
Cap.	82,542	85,022	87,541	90,100	92,698	95,335	98,012	100,729	103,485	106,281	Ac-Ft
1380											
Area	2,854	2,906	2,957	3,009	3,060	3,112	3,163	3,215	3,267	3,318	Acres
Cap.	109,116	111,996	114,928	117,912	120,947	124,034	127,172	130,361	133,603	136,895	Ac-Ft
1390											
Area	3,370	3,428	3,486	3,544	3,602	3,661	3,719	3,777	3,835	3,893	Acres
Cap.	140,240	143,639	147,096	150,611	154,185	157,817	161,507	165,255	169,062	172,926	Ac-Ft
1400											
Area	3,951	4,022	4,093	4,163	4,234	4,305	4,375	4,446	4,516	4,587	Acres
Cap.	176,849	180,836	184,894	189,022	193,221	197,491	201,831	206,242	210,724	215,276	Ac-Ft
1410											
Area	4,658	4,739	4,821	4,903	4,985	5,067	5,149	5,230	5,312	5,394	Acres
Cap.	219,898	224,597	229,378	234,241	239,185	244,211	249,319	254,509	259,781	265,134	Ac-Ft
1420											
Area	5,476	5,567	5,658	5,749	5,840	5,931	6,022	6,113	6,204	6,295	Acres
Cap.	270,570	276,092	281,704	287,408	293,203	299,089	305,067	311,135	317,294	323,545	Ac-Ft

Table B-5, Continued

Elev.	0	1	2	3	4	5	6	7	8	9	
1430											
Area	6,387	6,496	6,606	6,716	6,826	6,936	7,046	7,156	7,266	7,376	Acres
Cap.	329,886	336,328	342,880	349,541	356,313	363,195	370,186	377,288	384,499	391,820	Ac-Ft

FREESE AND NICHOLS, INC.

Hubbard Creek Reservoir With Diversions from the Clear Fork

The Hubbard Creek Reservoir runoff has been previously estimated (1) and the data are presented in Table B-6. The potential diversions from the Clear Fork of the Brazos to Hubbard Creek Reservoir have been based on the daily flows at the Fort Griffin gage. Diversions were made when the average daily flow was above 300 cfs. When excess flow was available, up to a daily average flow of 1,000 cfs were diverted.

Two adjustments to the estimated potential diversions based on the Clear Fork of the Brazos at Fort Griffin stream gaging records were made to obtain a better representation of the 2030 conditions. To account for the additional 203 square miles of drainage area between the Fort Griffin gage and the proposed diversion point, the potential diversions were increased by 6.4 percent.

The second adjustment multiplied the potential diversions by the ratio of the adjusted Fort Griffin gage flows modified for 2030 conditions to the record Fort Griffin gage flows. The adjusted Fort Griffin gage flows are presented in Table B-1. These gage flows were modified by adding the future Lake Fort Phantom Hill spills and the future Lake Stamford spills and subtracting the future Clear Fork Diversions to Lake Fort Phantom Hill and future Deadman Creek Diversions.

The computed potential diversions from the Clear Fork of the Brazos into Hubbard Creek Reservoir are summarized in Table B-7. The combined Hubbard Creek Reservoir runoff and diversions from the Clear Fork of the Brazos are presented in Table B-8.

Table B-6

Hubbard Creek Reservoir Runoff
- Quantities in 1,000 Acre-Feet -

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1941	.7	12.5	3.3	4.7	138.5	71.2	6.5	33.0	6.0	25.7	12.0	1.3	315.4
1942	.8	.3	.2	60.3	23.3	15.1	.4	1.3	29.2	52.9	2.6	2.2	188.6
1943	1.1	.6	3.8	9.8	0	0	0	0	0	0	0	0	15.3
1944	0	4.6	1.6	1.8	8.8	1.3	1.3	3.8	2.7	15.2	.3	.5	41.9
1945	0	.1	12.1	5.7	4.5	6.9	4.3	1.2	0	6.7	.4	.1	42.0
1946	1.1	0	0	.7	7.8	1.9	0	9.6	22.6	0	5.0	1.8	50.5
1947	.1	0	.1	0	3.2	0	0	0	0	7.3	0	2.9	13.6
1948	.1	.3	.1	1.5	7.0	12.7	4.1	.1	0	0	0	0	25.9
1949	0	0	.4	1.3	41.6	21.1	2.4	5.6	7.8	11.9	1.2	.1	93.4
1950	.1	.6	.1	7.1	20.1	3.6	37.8	3.4	6.5	.2	.1	.1	79.7
1951	.1	.1	0	0	15.6	21.1	.6	0	0	1.1	0	.2	38.8
1952	.5	.4	.1	6.5	13.2	10.2	0	.8	.2	.5	1.4	2.3	36.1
1953	.6	0	3.8	9.0	28.5	2.5	16.6	6.2	2.6	19.1	.2	.4	89.5
1954	.2	1.3	.9	30.1	14.1	.5	1.8	1.2	1.6	1.3	3.5	.2	56.7
1955	.2	1.7	1.0	6.1	26.2	17.3	1.4	9.1	28.2	2.4	0	0	93.6
1956	0	.1	0	.1	11.0	1.8	0	1.0	0	.6	5.5	2.9	23.0
1957	0	45.4	.4	123.1	240.7	32.9	2.1	1.1	3.5	49.2	9.9	.7	509.0
1958	.4	.3	3.9	4.2	25.9	3.2	44.4	2.2	3.5	.1	0	0	88.1
1959	.1	0	0	0	14.0	16.2	3.8	.2	.2	40.8	0	0	75.3
1960	3.9	1.0	1.8	7.2	.5	0	4.7	.2	.1	7.1	0	0	26.5

Table B-6, Continued

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
1961	11.9	2.4	.1	0	0	48.9	12.3	0	14.3	.9	5.1	.6	96.5
1962	.4	.1	.1	.6	0	25.5	10.4	1.9	3.9	3.6	.8	.5	47.8
1963	0	0	0	4.4	26.1	1.8	.5	1.4	1.1	2.3	18.0	1.5	57.1
1964	1.7	7.7	.4	0	.3	.1	.1	7.1	6.4	0	18.6	0	42.4
1965	0	0	0	1.9	80.2	.4	.3	1.9	4.5	4.0	0	0	93.2
1966	0	0	.2	35.2	22.8	8.7	.4	3.9	24.3	0	.2	0	95.7
1967	.6	.4	2.7	0	3.8	10.2	3.8	1.0	12.1	.1	.6	.6	35.9
1968	100.6	10.2	18.2	34.5	5.3	5.4	2.4	1.2	0	2.0	1.6	.8	182.2
1969	1.5	0	14.1	12.5	78.6	5.8	.8	0	0	2.7	0	12.3	128.3
1970	.3	2.9	5.3	24.0	7.5	1.1	1.2	.9	0	0	0	0	43.2
1971	0	.1	.4	0	15.8	2.0	.7	5.1	5.1	1.7	0	2.5	33.4
1972	0	1.0	.5	3.2	4.3	.5	0	.7	.3	11.1	.2	.7	22.5
1973	4.1	2.6	2.0	5.2	.9	0	7.0	2.8	0	4.4	0	0	29.0
1974	0	.2	0	13.9	.4	0	1.3	5.2	80.2	63.6	23.6	.3	188.7
1975	3.8	28.5	3.7	4.1	9.8	3.3	2.2	1.1	1.0	.5	0	0	58.0
1976	0	.3	1.5	2.9	3.7	0	0	2.0	0	4.0	0	0	14.4
1977	0	0	10.0	4.4	1.3	5.4	0	0	0	9.3	3.4	1.1	34.9

Table B-7

Potential Diversions From Clear Fork of the Brazos
Into Hubbard Creek Reservoir
- Values in Acre-Feet -

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1941	0	0	1,100	11,600	36,100	32,100	15,400	10,200	1,700	36,500	8,600	4,600	157,900
1942	0	0	0	0	0	0	0	0	0	9,900	0	0	9,900
1943	0	0	0	0	2,700	6,200	0	0	0	0	0	0	8,900
1944	0	0	1,400	0	3,800	1,000	1,500	0	200	6,100	0	0	14,000
1945	0	0	5,400	8,600	500	5,800	14,100	2,000	0	5,700	0	0	42,100
1946	0	0	0	0	0	1,200	0	3,300	9,600	7,800	400	4,300	26,600
1947	0	0	0	0	24,300	3,000	0	0	1,700	2,400	0	1,300	32,700
1948	0	0	300	0	3,300	10,300	5,000	0	0	1,300	0	0	20,200
1949	0	0	0	400	8,500	5,400	0	0	1,500	1,600	0	0	17,400
1950	0	0	0	4,400	8,200	0	3,900	1,000	4,400	0	0	0	21,900
1951	0	0	0	0	3,500	12,000	1,400	0	0	0	0	0	16,900
1952	0	0	0	0	0	900	0	0	0	0	0	0	900
1953	0	0	0	0	400	2,100	17,000	2,900	0	5,700	0	0	28,100
1954	0	0	0	0	18,400	500	0	0	0	0	0	0	18,900
1955	1,800	0	0	0	8,200	6,900	600	0	10,300	10,500	0	0	38,300
1956	0	0	0	0	500	0	0	0	0	0	0	0	500
1957	0	10,400	100	14,400	67,900	26,200	1,300	400	0	900	0	0	121,600
1958	0	0	0	0	3,300	2,200	6,700	0	13,000	0	0	0	25,200
1959	0	0	0	0	4,500	9,100	1,500	0	0	7,200	0	0	22,300
1960	0	0	0	0	0	0	13,800	0	0	4,600	0	0	18,400

Table B-7, Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1961	0	0	0	0	200	23,600	24,600	0	5,300	0	2,600	0	56,300
1962	0	0	0	100	0	18,000	2,800	0	19,200	1,000	0	0	41,100
1963	0	0	0	1,200	6,300	9,700	0	0	0	0	0	0	17,200
1964	0	500	0	0	0	0	0	0	0	0	0	0	500
1965	0	0	0	600	17,700	0	0	0	900	9,200	0	0	28,400
1966	0	0	0	11,100	9,700	0	0	100	7,300	0	0	0	28,200
1967	0	0	0	0	0	700	400	0	900	0	0	0	2,000
1968	7,800	200	6,500	8,600	1,500	0	0	0	0	0	0	0	24,600
1969	0	0	0	800	26,300	0	0	0	10,300	0	0	0	37,400
1970	0	0	100	1,700	700	500	0	0	0	0	0	0	3,000
1971	0	0	0	0	2,300	2,400	0	24,000	13,800	2,800	0	0	45,300
1972	0	0	0	0	500	0	0	1,300	2,900	3,200	7,800	0	15,700
1973	2,900	2,300	9,800	2,700	0	700	0	0	1,500	0	0	0	19,900
1974	0	0	0	0	0	0	0	0	23,600	23,400	23,000	0	70,000
1975	100	9,000	0	0	6,100	0	18,400	100	0	0	200	0	33,900
1976	0	0	0	100	0	0	0	1,000	2,300	8,000	2,600	0	14,000
1977	0	0	2,000	4,300	3,400	0	0	0	200	0	0	0	9,900

Table B-8

Combined Hubbard Creek Reservoir Runoff and Diversions from Clear Fork of the Brazos River

- Values in Acre-Feet -

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1941	700	12,500	3,300	4,700	138,500	71,200	6,500	33,000	6,000	25,700	12,000	1,300	315,400
1942	800	300	200	60,300	23,300	15,100	400	1,300	29,200	52,900	2,600	2,200	188,600
1943	1,100	600	3,800	9,800	2,700	6,200	0	0	0	0	0	0	24,200
1944	0	4,600	3,000	1,800	12,600	2,300	2,800	3,800	2,900	21,300	300	500	55,900
1945	0	100	17,500	14,300	5,000	12,700	18,400	3,200	0	12,400	400	100	84,100
1946	1,100	0	0	700	7,800	3,100	0	12,900	32,200	7,800	5,400	6,100	77,100
1947	100	0	100	0	27,500	3,000	0	0	1,700	9,700	0	4,200	46,300
1948	100	300	400	1,500	10,300	23,000	9,100	100	0	1,300	0	0	46,100
1949	0	0	400	1,700	50,100	26,500	2,400	5,600	9,300	13,500	1,200	100	110,800
1950	100	600	100	11,500	28,300	3,600	41,700	4,400	10,900	200	100	100	101,600
1951	100	100	0	0	19,100	33,100	2,000	0	0	1,100	0	200	55,700
1952	500	400	100	6,500	13,200	11,100	0	800	200	500	1,400	2,300	37,000
1953	600	0	3,800	9,000	28,900	4,600	33,600	9,100	2,600	24,800	200	400	117,600
1954	200	1,300	900	30,100	32,500	1,000	1,800	1,200	1,600	1,300	3,500	200	75,600
1955	2,000	1,700	1,000	6,100	34,400	24,200	2,000	9,100	38,500	12,900	0	0	131,900
1956	0	100	0	100	11,500	1,800	0	1,000	0	600	5,500	2,900	23,500
1957	0	55,800	500	137,500	308,600	59,100	3,400	1,500	3,500	49,200	9,900	700	629,700
1958	400	300	3,900	4,200	25,900	3,200	44,400	2,200	16,500	100	0	0	101,100
1959	100	0	0	0	18,500	25,300	5,300	200	200	48,000	0	0	97,600
1960	3,900	1,000	1,800	7,200	500	0	18,500	200	100	11,700	0	0	44,900

Table B-8, Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1961	11,900	2,400	100	0	200	72,500	36,900	0	19,600	900	7,700	600	152,800
1962	400	100	100	700	0	43,500	13,200	1,900	23,100	4,600	800	500	88,900
1963	0	0	0	5,600	32,400	11,500	500	1,400	1,100	2,300	18,000	1,500	74,300
1964	1,700	8,200	400	0	300	100	100	7,100	6,400	0	18,600	0	42,900
1965	0	0	0	2,500	97,900	400	300	1,900	5,400	13,200	0	0	121,600
1966	0	0	200	46,300	32,500	8,700	400	4,000	31,600	0	200	0	123,900
1967	600	400	2,700	0	3,800	10,900	4,200	1,000	13,000	100	600	600	37,900
1968	108,400	10,400	24,700	43,100	6,800	5,400	2,400	1,200	0	2,000	1,600	800	206,800
1969	1,500	0	14,100	13,300	104,900	5,800	800	0	10,300	2,700	0	12,300	165,700
1970	300	2,900	5,400	25,700	8,200	1,600	1,200	900	0	0	0	0	46,200
1971	0	100	400	0	18,100	4,400	700	29,100	18,900	4,500	0	2,500	78,700
1972	0	1,000	500	3,200	4,800	500	0	2,000	3,200	14,500	8,000	700	38,200
1973	7,000	4,900	11,800	7,900	900	700	7,000	2,800	1,500	4,400	0	0	48,900
1974	0	200	0	13,900	400	0	1,300	5,200	103,800	87,000	46,600	300	258,700
1975	3,900	37,500	3,700	4,100	15,900	3,300	20,600	1,200	1,000	500	200	0	91,900
1976	0	300	1,500	3,000	3,700	0	0	3,000	2,300	12,000	2,600	0	28,400
1977	0	0	12,000	8,700	4,700	5,400	0	0	200	9,300	3,400	1,100	44,800

Hubbard Creek Reservoir Evaporation Data

Monthly depths of evaporation losses from the reservoir surfaces, from 1940 through 1965, were derived from Texas Water Development Board Report 64, which is a compilation of net evaporation rates throughout the State. Although the original Water Development Board study covered only the period from 1940 through 1965, data for the next 10 years (1966-1975) have subsequently been prepared as supplemental material and are available from the Board in the form of computer printouts. The monthly rates at Hubbard Creek Reservoir were calculated from Quadrangles E-8 and E-9, Plate 2, of Report 64. The factors developed were 0.224 for E-8 and 0.776 for E-9. These rates were also used for Lake Daniel and Lake McCarty.

Since 1976, the evaporation rates for Hubbard Creek Reservoir were based on published records of the Texas Agricultural Experiment Station System. The gross evaporation measured at Throckmorton was reduced by the rainfall observed at Breckenridge by the U. S. Weather Bureau and adjusted by a pan factor.

Hubbard Creek Reservoir Area and Capacity Data

Table B-10 details the expected area and capacity at each foot of elevation in Hubbard Creek Reservoir in the year 2030.

Table B-9

Hubbard Creek Reservoir
Summary of Net Evaporation Data
- Values in Feet -

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1941	0.22	-0.09	0.20	0.12	0.02	0.34	0.63	0.48	0.57	-0.06	0.41	0.18	3.02
1942	0.26	0.27	0.43	-0.28	0.23	0.41	0.81	0.58	0.12	-0.10	0.43	0.07	3.23
1943	0.24	0.37	0.17	0.51	0.35	0.51	0.71	1.04	0.59	0.52	0.41	0.02	5.44
1944	0.02	0.00	0.25	0.46	0.17	0.78	0.73	0.85	0.65	0.41	0.15	0.06	4.53
1945	0.15	0.01	0.12	0.19	0.62	0.57	0.48	0.87	0.73	0.29	0.48	0.29	4.80
1946	0.07	0.17	0.34	0.45	0.24	0.62	0.99	0.91	0.28	0.43	0.17	0.16	4.83
1947	0.12	0.27	0.13	0.26	0.22	0.68	1.03	0.79	0.90	0.50	0.29	0.06	5.25
1948	0.12	0.03	0.33	0.46	0.38	0.48	0.68	0.90	0.78	0.56	0.48	0.35	5.55
1949	-0.13	0.06	0.19	0.05	-0.01	0.36	0.76	0.54	0.52	0.15	0.51	0.13	3.13
1950	0.12	0.15	0.52	0.17	0.11	0.51	0.33	0.90	0.33	0.68	0.61	0.36	4.79
1951	0.25	0.06	0.32	0.35	0.08	0.20	0.74	0.82	0.71	0.51	0.29	0.27	4.60
1952	0.22	0.26	0.28	0.17	0.20	0.85	0.92	1.26	0.78	0.82	0.14	0.13	6.03
1953	0.29	0.19	0.21	0.28	0.19	0.91	0.58	0.64	0.81	0.09	0.21	0.28	4.68
1954	0.04	0.30	0.35	0.10	0.11	0.79	0.88	1.16	1.03	0.52	0.21	0.35	5.84
1955	0.11	0.12	0.34	0.29	0.04	0.26	0.83	0.85	0.52	0.72	0.53	0.25	4.86
1956	0.05	0.00	0.34	0.26	0.26	0.79	1.12	1.24	0.98	0.61	0.53	0.18	6.36
1957	0.19	-0.09	0.22	-0.37	-0.63	0.47	0.99	1.14	0.50	0.10	-0.04	0.26	2.74
1958	0.05	0.09	-0.02	0.00	0.12	0.56	0.58	0.78	0.41	0.40	0.36	0.22	3.55
1959	0.19	0.11	0.40	0.31	0.18	0.11	0.36	0.85	0.70	-0.04	0.34	0.07	3.58
1960	-0.03	0.10	0.19	0.20	0.33	0.67	0.58	0.76	0.73	0.33	0.36	0.05	4.27

Table B-9, Continued

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1961	-0.21	0.02	0.23	0.44	0.46	0.05	0.50	0.82	0.46	0.35	0.14	0.14	3.40
1962	0.17	0.24	0.22	0.13	0.60	0.08	0.30	0.90	0.02	0.34	0.23	0.15	3.38
1963	0.18	0.20	0.34	0.15	0.01	0.37	1.07	0.82	0.51	0.55	0.07	0.18	4.45
1964	0.04	0.07	0.21	0.24	0.37	0.66	1.08	0.66	0.21	0.45	0.03	0.27	4.29
1965	0.11	0.02	0.23	0.17	-0.35	0.41	0.94	0.66	0.60	0.29	0.22	0.10	3.40
1966	0.10	0.11	0.34	0.06	0.33	0.45	0.70	0.41	0.13	0.45	0.40	0.28	3.76
1967	0.27	0.24	0.37	0.33	0.27	0.55	0.59	0.80	0.14	0.40	0.15	0.16	4.27
1968	-0.27	0.05	0.10	0.18	0.18	0.38	0.55	0.79	0.57	0.57	0.12	0.26	3.48
1969	0.22	0.09	0.00	0.14	0.16	-0.48	0.75	0.46	0.28	0.24	0.27	0.04	3.13
1970	0.11	0.01	0.07	0.06	0.23	0.55	0.86	0.66	0.28	0.31	0.42	0.36	3.92
1971	0.28	0.25	0.43	0.30	0.43	0.60	0.61	0.21	0.34	0.14	0.26	0.04	3.89
1972	0.15	0.22	0.43	0.36	0.25	0.49	0.47	0.39	0.38	0.23	0.19	0.24	3.80
1973	-0.04	0.02	0.18	0.16	0.43	0.35	0.43	0.73	0.04	0.13	0.27	0.33	3.23
1974	0.15	0.24	0.35	0.39	0.48	0.67	0.80	0.32	0.11	0.18	0.18	0.10	3.97
1975	0.12	0.05	0.22	0.24	0.18	0.45	0.51	0.65	0.43	0.51	0.26	0.16	3.78
1976	0.22	0.36	0.37	0.08	0.34	0.34	0.16	0.73	-0.19	-0.27	0.16	0.10	2.40
1977	-0.15	0.22	0.10	0.20	0.15	0.46	0.51	0.55	0.66	0.00	0.00	0.00	2.70

Table B-10

Hubbard Creek Reservoir
Area and Capacity Characteristics as of the Year 2030

Elev.	0	1	2	3	4	5	6	7	8	9	
1130											
Area	0	0	0	0	0	130	250	370	510	650	Acres
Cap.	0	0	0	0	0	70	260	570	1,010	1,590	Ac-Ft
1140											
Area	810	980	1,150	1,130	1,520	1,720	1,920	2,130	2,340	2,570	Acres
Cap.	2,320	3,210	4,280	5,520	6,940	8,560	10,380	12,410	14,640	17,100	Ac-Ft
1150											
Area	2,810	3,040	3,290	3,550	3,810	4,080	4,360	4,650	4,930	5,200	Acres
Cap.	19,790	22,710	25,880	29,380	32,980	36,920	41,140	45,650	50,440	55,500	Ac-Ft
1160											
Area	5,500	5,810	6,120	6,440	6,760	7,080	7,430	7,790	8,140	8,500	Acres
Cap.	60,850	66,510	72,470	78,750	85,350	92,270	99,350	107,140	115,100	123,420	Ac-Ft
1170											
Area	8,870	9,230	9,620	10,020	10,440	10,870	11,300	11,730	12,170	12,630	Acres
Cap.	132,110	141,160	150,580	160,400	170,630	181,290	192,370	203,890	215,840	228,240	Ac-Ft
1180											
Area	13,100	13,580	14,070	14,450							Acres
Cap.	241,100	254,440	268,270	282,450							Ac-Ft

APPENDIX C

RESERVOIR OPERATION STUDIES

APPENDIX C

RESERVOIR OPERATION STUDIES

Table C-1

Summary of Cedar Ridge Reservoir Site Operation Study
With Estimated 2030 Runoff
- Quantities in Acre-Feet -

Year	Evaporative Loss	Demand	Inflow	Spills	End-of-Year Content
Initial					342,880
1941	14,974	28,200	361,340	318,166	342,880
1-10-42	22,712	25,190	59,570	10,790	342,880
11-12-42	1,712	3,010	3,090	0	341,248
1943	33,815	28,200	20,650	0	299,883
1944	24,543	28,200	22,070	0	269,210
1945	26,642	28,200	78,510	0	292,878
1946	27,437	28,200	32,990	0	270,231
1947	26,873	28,200	51,390	0	266,548
1948	28,115	28,200	23,580	0	233,813
1949	16,816	28,200	20,710	0	209,507
1950	17,765	28,200	28,490	0	192,032
1951	19,179	28,200	18,280	0	162,933
1952	21,494	28,200	5,150	0	118,389
1953	14,138	28,200	43,030	0	119,081
1954	17,549	28,200	20,810	0	94,142
1955	13,221	28,200	70,450	0	123,171
1956	18,846	28,200	2,840	0	78,965
1/57	477	1,490	0	0	76,998
2-12-57	19,986	26,710	647,720	355,802	322,220
1958	19,907	28,200	30,580	0	304,693
1959	22,997	28,200	39,530	0	293,026
1960	23,200	28,200	25,400	0	267,026
1961	22,305	28,200	104,030	0	320,551
1962	25,127	28,200	120,810	47,931	340,103
1963	24,906	28,200	27,550	2,287	312,260
1964	24,408	28,200	5,580	0	265,232
1965	22,800	28,200	65,520	0	279,752
1966	26,420	28,200	58,760	0	283,892
1967	21,724	28,200	11,260	0	245,228
1968	20,033	28,200	48,700	0	245,695
1969	17,065	28,200	76,700	0	277,100
1970	21,513	28,200	20,180	0	247,567

Table C-1, Continued

Year	Evaporative Loss	Demand	Inflow	Spills	End-of-Year Content
1971	22,129	28,200	114,470	0	311,708
1972	24,415	28,200	36,400	0	295,493
1973	22,808	28,200	42,470	0	286,955
1974	24,640	28,200	139,370	30,605	342,880
1975	23,969	28,200	108,540	67,266	331,985
1976	23,235	28,200	33,750	0	314,300
1977	28,032	28,200	22,650	0	280,718

Table C-2

Summary of Hubbard Creek Reservoir Operation Study With Diversions From the Clear Fork of the Brazos
- Quantities in Acre-Feet -

Year	Evaporative Loss	Demand	Inflow	Spills	End-of-Year Content
Initial					282,200
1941	43,370	44,000	315,400	231,640	278,590
1-10-42	38,360	39,300	183,800	102,530	282,200
11-12-42	7,170	4,700	4,800	0	275,130
1943	69,660	44,000	24,200	0	185,670
1944	45,990	44,000	55,900	0	151,580
1945	47,480	44,000	84,100	0	143,840
1946	40,460	44,000	77,100	0	136,480
1947	42,770	44,000	46,300	0	96,010
1948	36,840	44,000	46,100	0	61,270
1949	23,840	44,000	110,800	0	104,230
1950	41,020	44,000	101,600	0	120,810
1951	37,720	44,000	55,700	0	94,790
1952	37,720	44,000	37,000	0	50,070
1-3-53	3,220	7,660	4,400	0	43,590
4-12-53	25,440	36,340	113,200	0	95,010
1954	44,780	44,000	75,600	0	81,830
1955	39,470	44,000	131,900	0	130,260
1956	44,690	44,000	23,500	0	65,070
1957	36,830	44,000	629,700	337,090	276,850
1958	50,130	44,000	101,100	29,720	254,100
1959	47,220	44,000	97,600	0	260,480
1960	54,500	44,000	44,900	0	206,880
1961	45,690	44,000	152,800	2,360	267,630
1962	46,520	44,000	88,900	0	266,010
1963	59,790	44,000	74,300	0	236,520
1964	49,910	44,000	42,900	0	185,510
1965	43,150	44,000	121,600	0	219,960
1966	50,550	44,000	123,900	0	249,310
1967	52,250	44,000	37,900	0	190,960
1968	47,330	44,000	206,800	82,900	223,530
1969	42,390	44,000	165,700	51,400	251,440
1970	50,970	44,000	46,200	0	202,670

Table C-2, Continued

Year	Evaporative Loss	Demand	Inflow	Spills	End-of-Year Content
1971	42,970	44,000	78,700	0	194,400
1972	38,610	44,000	38,200	0	149,990
1973	30,510	44,000	48,900	0	124,380
1974	33,420	44,000	258,700	26,920	278,740
1975	52,920	44,000	91,900	34,080	239,640
1976	29,200	44,000	28,400	0	194,840
1977	40,240	44,000	44,800	0	155,400

APPENDIX D

WATER QUALITY DATA

APPENDIX D

WATER QUALITY DATA

Clear Fork of The Brazos at Nugent (1948-1952)

From October of 1948 through September of 1952, the U.S. Geological Survey maintained continuous water quality monitors at the Nugent gage on the Clear Fork of the Brazos River. Table D-1 delineated the monthly recorded discharge and the flow weighted tons of total dissolved solids during the 1948 through 1952 period. These data were fitted with an equation utilizing a least squares analysis as illustrated in Figure D-1.

This best fit least squares equation was used to derive an equation that could be used in the water quality simulation operation studies for the Cedar Ridge Reservoir. The drived equation was

$$C_{CR} = 5{,}990\ Q_{CR}^{-.281}$$

where: C_{CR} = concentration of TDS in mg/l
Q_{CR} = monthly Cedar Ridge Reservoir inflow in acre feet

Table D-1

Results of Water Quality Observations on Clear Fork of the Brazos at Nugent 1948-1952

Year	Month	Discharge (Acre-Feet/Month)	Total Dissolved Solids (Tons/Month)
1948	Oct	12,542	3,944
	Nov	172	184
	Dec	133	327
1949	Jan	540	1,962
	Feb	383	914
	Mar	218	978
	Apr	2,750	3,322
	May	12,909	6,175
	Jun	4,668	3,567
	Jul	525	240
	Aug	257	372
	Sep	6,958	776
	Oct	4,755	1,627
	Nov	100	88
	Dec	142	175
1950	Jan	209	584
	Feb	148	507
	Mar	75	320
	Apr	171	3,386
	May	18,675	7,684
	Jun	1,590	1,100
	Jul	6,322	4,819
	Aug	2,417	1,350
	Sep	11,022	5,529
	Oct	277	381
	Nov	324	814
	Dec	210	717

Table D-1, Continued

Year	Month	Discharge (Acre-Feet/Month)	Total Dissolved Solids (Tons/Month)
1951	Jan	350	1,410
	Feb	238	1,103
	Mar	1,516	1,771
	Apr	431	1,344
	May	8,612	6,949
	Jun	13,700	7,578
	Jul	4,111	2,148
	Aug	705	600
	Sep	25	20
	Oct	249	436
	Nov	161	496
	Dec	1,437	790
1952	Jan	137	277
	Feb	94	262
	Mar	79	247
	Apr	615	816
	May	2,701	1,489
	Jun	525	309
	Jul	2	3
	Aug	3	5
	Sep	1,747	805

LEAST SQUARES FIT OF OBSERVED WATER QUALITY DATA
CLEAR FORK OF THE BRAZOS AT NUGENT

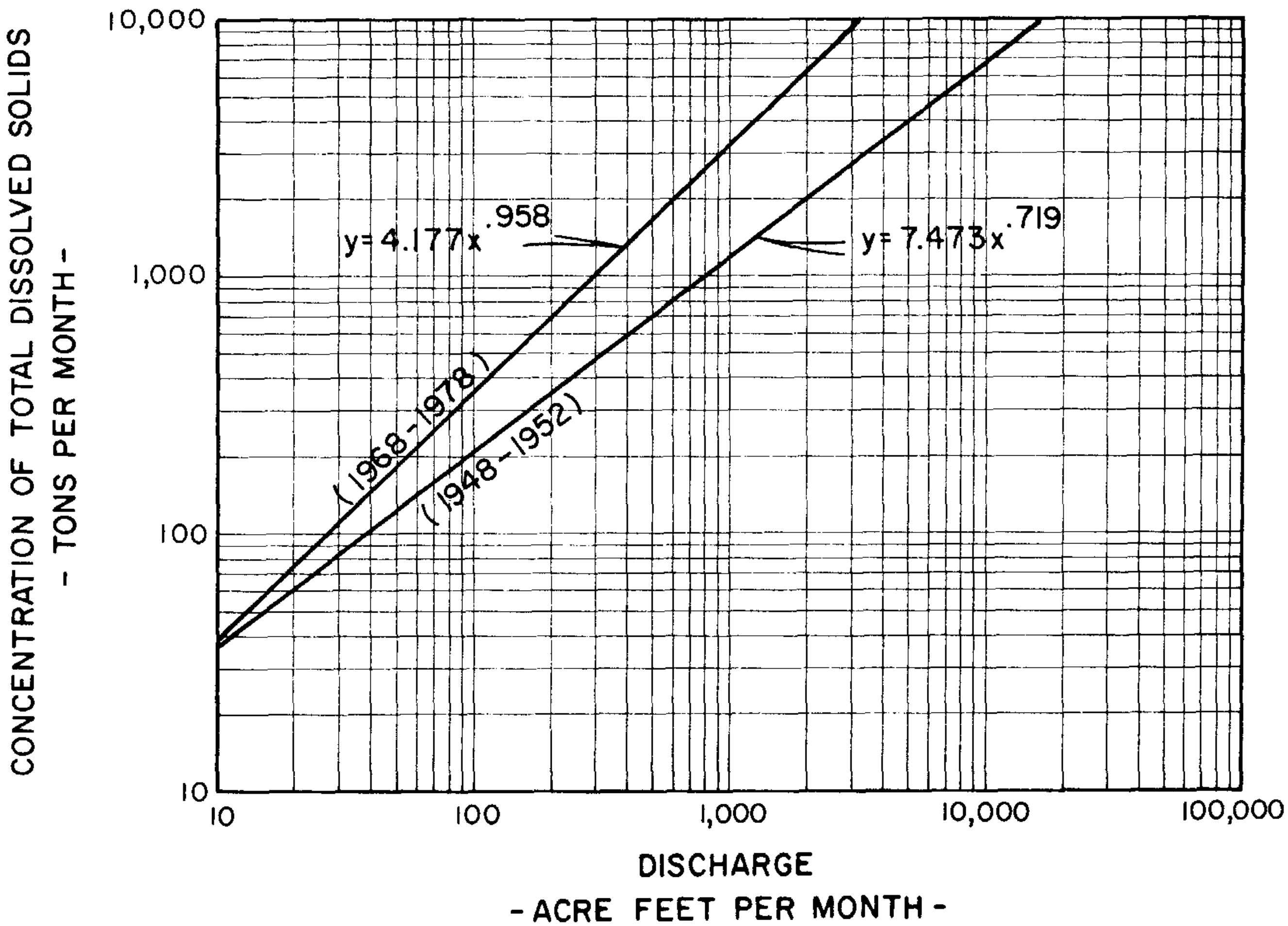

FIGURE D-1

Clear Fork of The Brazos at Nugent (1969-1972)

Between September of 1952 and November of 1969, water quality monitoring at the Nugent gage was discontinued by the USGS. In November of 1969, the USGS started maintaining intermittent instantaneous (i.e. grab samples) water quality data records. Table D-2 lists the recorded data since November of 1969. Assuming that the discharge rate for each day was maintained throughout the day, the data was translated into discharge in acre-feet per day and TDS quality in tons per day. A best-fit equation was established for these data utilizing a least squares analysis:

$$C_N = 3.640\ Q_N^{.961}$$

where: C_N = concentration of TDS at Nugent in tons/day
Q_N = discharge at Nugent in acre-feet/day

This daily equation was then used with the recorded daily flows at the Nugent gage to calculate a set of flow-weighted monthly data for the 1968 through 1978 time period. Utilizing a least squares analysis, a best fit equation was established for the calculated monthly quality data described above. Figure D-1 illustrates the best fit equation for the monthly data of the 1968-1978 time period.

The later data shows substantially higher total dissolved solids concentrations than the 1948-1952 period. The differences may be due, in part, to the fact that water quality data in the 1968-1978 period is primarily from low flows which would tend to skew the calculated monthly data.

However, a subsequent analysis of the daily data for the two time periods within the same lower flow ranges of the 1968-1978 data also showed the same relationship as indicated in Figure D-1.

In order to utilize the best fit equation for the monthly data of the 1968-1978 period in the water quality modeling of the proposed Cedar Ridge Reservoir Site, the following equation was derived:

$$C_{CR} = 3{,}119\ Q_{CR}^{-.042}$$

where: C_{CR} = concentration of TDS in mg/l
Q_{CR} = monthly Cedar Ridge Reservoir inflow in acre feet

Table D-2

Results of Water Quality Observations on Clear Fork of the Brazos at Nugent 1969-1978

Date	Flow (cfs)	TDS (mg/l)	Flow (Ac-Ft/day)	TDS (tons/day)
11/12/69	0.06	1,940	0.12	0.31
6/ 3/70	730	694	1,448	1,363
8/11/70	2.6	3,710	5.2	25.9
9/14/70	39	2,290	77	240
1/ 6/71	8.7	4,340	17	102
2/12/71	8.0	4,150	16	89
3/29/71	5.2	3,910	10	55
5/17/71	4.5	4,070	8.9	49.3
7/19/71	.10	1,420	0.20	0.38
9/13/71	59	3,590	117	570
11/16/71	52	3,400	103	476
1/17/72	37	3,860	73	384
3/20/72	26	3,770	52	264
5/23/72	11	1,550	22	46
7/11/72	7.9	899	15.7	19.1
9/19/72	16	1,910	32	82
11/14/72	30	2,230	60	180
1/30/73	40	3,460	79	372
3/20/73	50	2,480	99	334
5/14/73	35	4,020	69	378
8/28/73	7.5	1,370	15	28
10/11/73	225	1,870	446	1,132
12/ 7/73	13	4,510	26	158
1/30/74	12	3,740	24	121
3/16/74	13	3,610	26	126
7/22/74	0.01	3,250	0.02	0.09
9/10/74	2.6	1,860	5.2	13.0
10/26/74	460	952	912	1,178
12/20/74	75	2,600	149	524
2/22/75	90	2,650	179	641
4/18/75	28	3,030	56	228
6/13/75	50	1,210	99	163
8/ 8/75	35	1,610	69	152
10/ 7/75	15	2,640	30	107
12/16/75	25	3,510	50	236
2/24/76	20	3,810	40	205
4/ 6/76	26	1,750	52	122
6/ 8/76	13	2,940	26	103
8/ 3/76	150	1,220	298	492
10/13/76	26	836	52	58
12/ 7/76	33	3,930	65	349
2/23/77	30	3,760	60	303

Table D-2, Continued

Date	Flow (cfs)	TDS (mg/l)	Flow (Ac-Ft/day)	TDS (tons/day)
4/19/77	370	1,400	734	1,393
6/14/77	18	2,420	36	117
8/13/77	12	2,620	24	85
10/18/77	78	2,200	15	46
12/ 3/77	12	3,420	24	110
3/ 2/78	14	3,150	28	119
4/13/78	16	3,470	32	149
6/15/78	5.8	782	11.5	12.1
8/17/78	4.5	884	8.9	10.7

Clear Fork of the Brazos at Ft. Griffin (1967-1978)

Since November of 1967, the USGS has maintained water quality records at the Ft. Griffin gage. These include flow weighted data from November of 1967 through September of 1972 and instantaneous data since October of 1972. These data are listed in Table D-3 and Table D-4.

A best fit equation was established for these daily data utilizing a least squares analysis. The instantaneous discharges of Table D-4 were assumed valid for the entire day. Figure D-2 illustrates the best fit equation:

$$C_{FG} = 2{,}354\ Q_{FG}^{-.155}$$

where: C_{FG} = concentration of TDS in mg/l
Q_{FG} = discharge at the Ft. Griffin gage in cfs

The best fit equation was then used to establish the quality of water on the days that water could have been diverted from the Clear Fork of the Brazos into Hubbard Creek Reservoir assuming the lake had been operational throughout the available historical record. The daily quality of the diversions were then flow-weighted and summed for each month so that a monthly average quality of the available monthly diversions could be obtained and then be routed through Hubbard Creek Reservoir.

Table D-3

Results of Water Quality Observations on Clear Fork of the Brazos at Ft. Griffin 1967-1972

Date (s)	Mean Daily Discharge (cfs)	Total Dissolved Solids (mg/l)
11/02-09/67	9.6	486
11/10-13/67	26	611
11/14-30/67	18	611
12/01-20/67	19	703
12/21-22/67	40	1,390
12/23-31/67	31	703
01/01-05/68	25	664
01/06-19/68	30	1,140
01/20 /68	397	716
01/21-31/68	1,290	461
02/01-16/68	52	630
02/17-29/68	151	1,140
03/01-10/68	192	1,540
03/11-13/68	326	861
03/14-19/68	366	1,140
03/20-29/68	538	850
03/30-31/68	182	464
04/01-09-68	183	834
04/10-11/68	783	1,180
04/12-13/68	924	763
04/14-15/68	665	555
04/16 /68	469	1,210
04/17-30/68	349	555
05/01-13/68	188	1,150
05/14-15/68	448	676
05/16-31/68	111	1,150
06/01-30/68	61	1,100
07/01 /68	17	1,420
07/02-03/68	126	416
7/04-26/68	40	1,420
08/01-31/68	8.7	1,170
09/01-10/68	.37	1,260
09/11-18/68	.31	884
09/19-30/68	.12	612
10/01-02/68	.02	298
12/01-31/68	19	1,780
01/01-31/69	14	1,660
02/01-28/69	26	1,830
03/01-31/69	32	1,850
04/01-26/69	12	2,020
04/27 /69	700	319

Table D-3, Continued

Date (s)	Mean Daily Discharge (cfs)	Total Dissolved Solids (mg/l)
04/28-29/69	142	882
04/30 /69	10	2,020
05/01-03/69	12	2,040
05/04-05/69	2,600	298
05/06 /69	1,830	851
05/07 /69	8,300	502
05/08 /69	12,400	211
05/09 /69	4,730	298
05/10-12/69	1,430	502
05/13 /69	817	298
05/14-19/69	1,740	502
05/20-23/69	1,090	851
05/24-31/69	313	502
06/01-30/69	99	876
07/01-21/69	6.2	1,020
08/26-31/69	21	2,630
09/01-11/69	44	1,200
09/12 /69	1,280	1,690
09/13-21/69	1,190	256
09/22 /69	1,830	482
09/23 /69	3,220	256
09/24-29/69	446	482
09/30 /69	158	1,200
10/01-19/69	86	1,730
10/20-31/69	77	2,650
11/01-30/69	62	2,170
12/01-31/69	67	2,050
01/01-08/70	108	1,860
01/09-31/70	58	2,750
02/01-13/70	51	2,250
02/14-28/70	61	3,380
03/01-31/70	97	2,800
04/01-25/70	83	2,700
04/26-27/70	313	1,630
04/28-29/70	312	2,700
04/30 /70	1,020	699
05/01-10/70	193	1,300
05/11-31/70	78	2,060
06/01-04/70	323	2,140
06/05 /70	448	1,220
06/06-21/70	97	837
06/22-30/70	14	1,220
07/01-11/70	3.3	1,550
08/14-27/70	11	1,600
09/13-30/70	31	850

Table D-3, Continued

Date (s)	Mean Daily Discharge (cfs)	Total Dissolved Solids (mg/l)
10/01-31/70	8.2	1,220
11/01-30/70	1.9	1,380
12/01-31/70	8.1	2,830
01/01-31/71	9.8	2,250
02/01-28/71	11	1,750
03/01-08/71	9.3	1,890
03/09-31/71	5.1	2,910
04/01-30/71	11	3,390
05/01-27/71	2.5	3,610
05/28-30/71	824	1,740
05/31 /71	3,480	339
06/01-04/71	927	287
06/05-10/71	126	475
06/11 /71	119	885
06/12-14/71	64	1,890
06/15-17/71	34	885
06/18-30/71	48	475
07/01-13/71	3.9	554
07/24-31/71	39	801
08/01-24/71	560	745
08/25-31/71	6,070	257
09/01-02/71	912	439
09/03-11/71	371	760
09/12-24/71	174	1,630
09/25-30/71	3,890	362
10/01-09/71	527	1,000
10/10-15/71	289	1,840
10/16-19/71	214	1,000
10/20-31/71	199	1,840
11/01-15/71	168	1,560
11/16-30/71	100	2,260
12/01-31/71	112	2,960
01/02 /72	93	1,710
01/02 /72	92	3,060
01/03 /72	88	1,710
01/04-31/72	75	3,060
02/01-29/72	71	3,440
03/01-31/72	53	3,260
04/01-30/72	39	3,390
05/01-11/72	70	2,920
05/12-21/72	138	1,900
05/22-31/72	22	2,920
06/01-30/72	15	3,020
07/01-03/72	130	2,260

Table D-3, Continued

Date (s)	Mean Daily Discharge (cfs)	Total Dissolved Solids (mg/l)
07/04-07/72	164	1,720
07/08-31/72	10	2,260
08/01-03/72	.03	2,110
08/10-14/72	2.8	2,110
08/15-18/72	711	696
08/19-22/72	84	497
08/23-24/72	40	2,110
08/25-31/72	33	696
09/01-22/72	181	587
09/23 /72	988	1,100
09/24-30/72	247	373

Table D-4

Results of Water Quality Observations on Clear Fork of the Brazos at Ft. Griffin 1972-1978

Date	Instantaneous Discharge (cfs)	Total Dissolved Solids (mg/l)
10/31/72	1,220	332
11/17/72	64	1,130
12/21/72	53	2,600
01/31/73	218	1,520
02/28/73	256	1,760
03/14/73	1,220	1,920
04/04/73	248	1,230
05/09/73	68	2,480
06/05/73	257	418
07/18/73	22	2,860
08/01/73	59	486
09/27/73	97	267
10/03/73	23	1,140
11/13/73	22	1,350
12/05/73	24	1,960
01/14/74	17	2,410
02/27/74	25	2,820
03/27/74	22	2,580
04/17/74	1.9	3,240
05/29/74	.08	3,790
08/13/74	52	725
09/20/74	5,740	224
10/31/74	3,850	415
11/26/74	239	1,140
12/31/74	180	1,900
01/31/75	140	2,100
02/04/75	740	2,250
03/18/75	105	2,130
04/28/75	46	2,580
05/31/75	430	1,030
06/10/75	46	815
07/24/75	555	285
08/27/75	31	1,320
09/30/75	28	1,840
10/15/75	27	2,040
11/25/75	34	1,650
12/31/75	58	2,150
01/31/76	33	2,860
02/19/76	24	2,580
03/31/76	13	3,310
04/30/76	52	2,830

Table D-4, Continued

Date	Instantaneous Discharge (cfs)	Total Dissolved Solids (mg/l)
05/12/76	45	1,910
06/23/76	9.4	2,300
07/02/76	2.2	2,360
08/31/76	2.7	772
09/21/76	159	345
10/22/76	38	821
12/07/76	55	2,080
01/18/77	85	2,740
03/01/77	35	2,920
03/30/77	398	1,580
04/22/77	896	958
05/23/77	1,730	1,090
06/27/77	17	1,190
07/13/77	44	2,680
11/30/77	14	2,300
12/02/77	21	1,500
02/28/78	24	2,000
03/06/78	24	2,050
04/30/78	2.6	2,410
06/30/78	.90	2,660
07/04/78	.53	2,710
08/06/78	16,200	206

LEAST SQUARES FIT OF OBSERVED QUALITY DATA
CLEAR FORK OF THE BRAZOS AT FT. GRIFFIN (1968-1978)

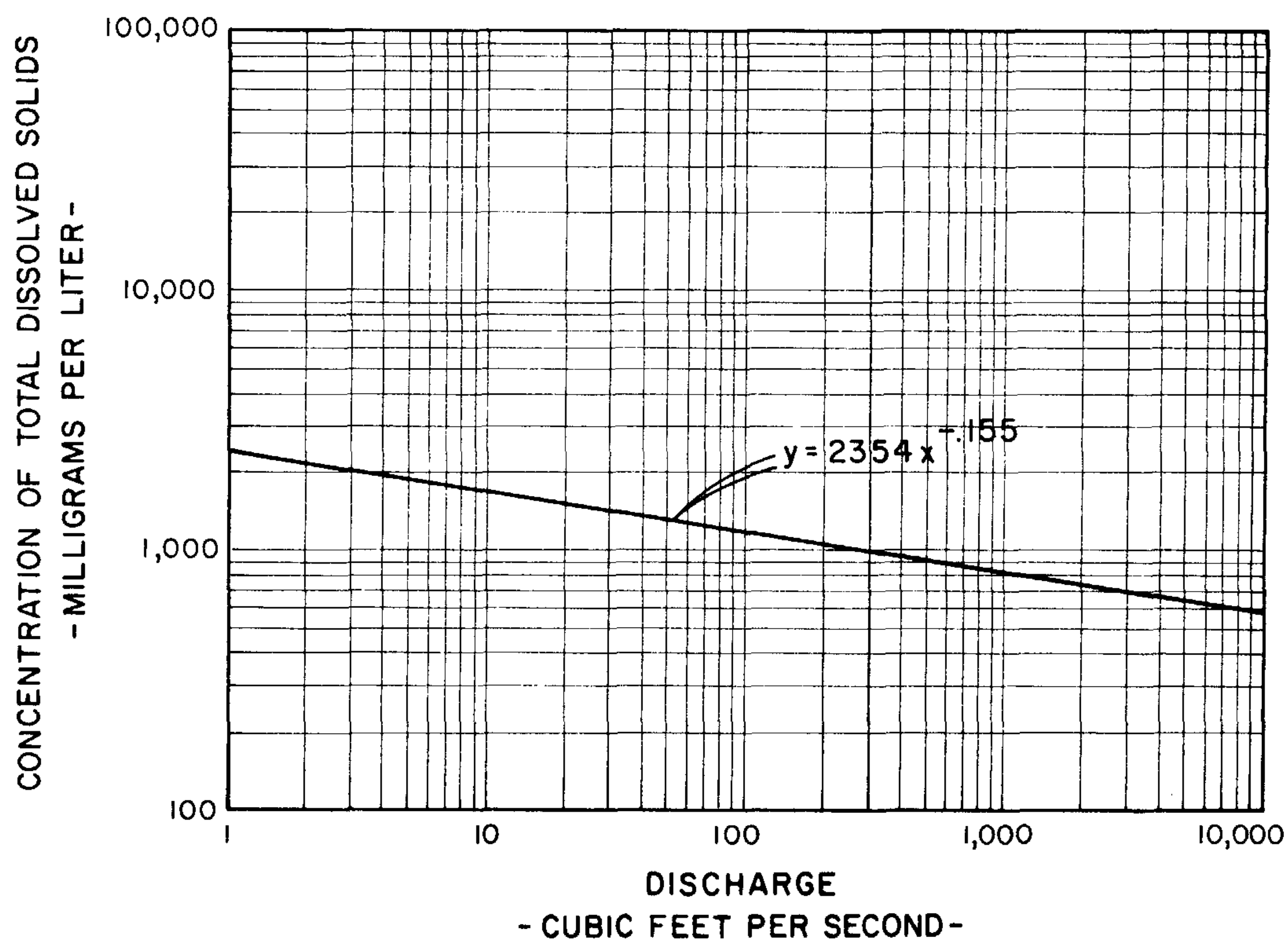

FIGURE D-2

APPENDIX E

RESERVOIR QUALITY OPERATION STUDIES

APPENDIX E

RESERVOIR QUALITY OPERATION STUDIES

Table E-1

Summary of Cedar Ridge Reservoir Site Water Quality Study
Based on Clear Fork of Brazos at Nugent (1948-1952)
- Quantities in Acre-Feet -

Year	Evaporative Loss	Demand	Inflow	Spills	End-of-Year Content	TDS (mg/l)
Initial					342,880	450
1941	14,974	28,200	361,340	318,166	342,880	395
1-10/42	22,712	25,190	59,570	10,790	342,880	431
11-12/42	1,712	3,010	3,090	0	341,248	436
1943	33,815	28,200	20,650	0	299,883	493
1944	24,543	28,200	22,070	0	269,210	546
1945	26,642	28,200	78,510	0	292,878	566
1946	27,437	28,200	32,990	0	270,231	624
1947	26,873	28,200	51,390	0	266,548	653
1948	28,115	28,200	23,580	0	233,813	725
1949	16,816	28,200	20,710	0	209,507	771
1950	17,765	28,200	28,490	0	192,032	808
1951	19,179	28,200	18,280	0	162,933	876
1952	21,494	28,200	5,150	0	118,389	1,022
1953	14,138	28,200	43,030	0	119,081	935
1954	17,549	28,200	20,810	0	94,142	1,003
1955	13,221	28,200	70,450	0	123,171	768
1956	18,846	28,200	2,840	0	78,965	938
1/57	477	1,490	0	0	76,998	944
2-12/57	19,986	26,710	647,720	355,802	322,220	307
1958	19,907	28,200	30,580	0	304,693	354
1959	22,997	28,200	39,530	0	293,026	399
1960	23,200	28,200	25,400	0	267,026	446
1961	22,305	28,200	104,030	0	320,551	457
1962	25,127	28,200	120,810	47,931	340,103	464
1963	24,906	28,200	27,550	2,287	312,260	506
1964	24,408	28,200	5,580	0	265,232	560
1965	22,800	28,200	65,520	0	279,752	566
1966	26,420	28,200	58,760	0	283,892	592
1967	21,724	28,200	11,260	0	245,228	651
1968	20,033	28,200	48,700	0	245,695	674
1969	17,065	28,200	76,700	0	277,100	639
1970	21,513	28,200	20,180	0	247,567	696

Table E-1, Continued

Year	Evaporative Loss	Demand	Inflow	Spills	End-of-Year Content	TDS (mg/l)
1971	22,129	28,200	114,470	0	311,708	622
1972	24,415	28,200	36,400	0	295,493	668
1973	22,808	28,200	42,470	0	286,955	706
1974	24,640	28,200	139,370	30,605	342,880	621
1975	23,969	28,200	108,540	67,266	331,955	626
1976	23,235	28,200	33,750	0	314,300	669
1977	28,032	28,200	22,650	0	280,718	735

Table E-2

Summary of Cedar Ridge Reservoir Site Water Quality Study
Based on Clear Fork of Brazos at Nugent (1968-1978)
- Quantities in Acre-Feet -

Year	Evaporative Loss	Demand	Inflow	Spills	End-of-Year Content	TDS (mg/l)
Initial					342,880	2,000
1941	14,974	28,200	361,340	318,166	342,880	2,060
1-10-42	22,712	25,190	59,570	10,790	342,880	2,199
11-12-42	1,712	3,010	3,090	0	341,248	2,210
1943	33,815	28,200	20,650	0	299,883	2,448
1944	24,543	28,200	22,070	0	269,210	2,643
1945	26,642	28,200	78,510	0	292,878	2,735
1946	27,437	28,200	32,990	0	270,231	2,935
1947	26,873	28,200	51,390	0	266,548	3,066
1948	28,115	28,200	23,580	0	233,813	3,338
1949	16,816	28,200	20,710	0	209,507	3,490
1950	17,765	28,200	28,490	0	192,032	3,613
1951	19,179	28,200	18,280	0	162,933	3,864
1952	21,494	28,200	5,150	0	118,389	4,443
1953	14,138	28,200	43,030	0	119,081	4,141
1954	17,549	28,200	20,810	0	94,142	4,455
1955	13,221	28,200	70,450	0	123,171	3,607
1956	18,846	28,200	2,840	0	78,965	4,322
1/57	477	1,490	0	0	76,998	4,349
2-12-57	19,986	26,710	647,720	355,802	322,220	2,264
1958	19,907	28,200	30,580	0	304,693	2,400
1959	22,997	28,200	39,530	0	293,026	2,547
1960	23,200	28,200	25,400	0	267,026	2,723
1961	22,305	28,200	104,030	0	320,551	2,698
1962	25,127	28,200	120,810	47,931	340,103	2,706
1963	24,906	28,200	27,550	2,287	312,260	2,871
1964	24,408	28,200	5,580	0	265,232	3,113
1965	22,800	28,200	65,520	0	279,752	3,122
1966	26,420	28,200	58,760	0	283,892	3,200
1967	21,724	28,200	11,260	0	245,228	3,429
1968	20,033	28,200	48,700	0	245,695	3,463
1969	17,065	28,200	76,700	0	277,100	3,296
1970	21,513	28,200	20,180	0	247,567	3,492

Table E-2, Continued

Year	Evaporative Loss	Demand	Inflow	Spills	End-of-Year Content	TDS (mg/l)
1971	22,129	28,200	114,470	0	311,708	3,205
1972	24,415	28,200	36,400	0	295,493	3,338
1973	22,808	28,200	139,370	0	286,955	3,434
1974	24,640	28,200	139,370	30,605	342,880	3,169
1975	23,969	28,200	108,540	67,266	331,955	3,165
1976	23,235	28,200	33,750	0	314,300	3,289
1977	28,032	28,200	22,650	0	280,718	3,526

Table E-3

Summary of Hubbard Creek Reservoir Water Quality Study With Diversions From the Clear Fork of the Brazos

- Quantities in Acre-Feet -

Year	Evaporative Loss	Demand	Inflow	Spills	End-of-Year Content	TDS (mg/l)
Initial					282,200	450
1941	43,370	44,000	315,400	231,640	278,590	395
1-10-42	38,360	39,300	183,800	102,530	282,200	383
11-12-42	7,170	4,700	4,800	0	275,130	394
1943	69,660	44,000	24,200	0	185,670	543
1944	45,990	44,000	55,900	0	151,580	663
1945	47,840	44,000	84,100	0	143,840	813
1946	40,460	44,000	77,100	0	136,480	844
1947	42,770	44,000	46,300	0	96,010	1,062
1948	36,840	44,000	46,100	0	61,270	1,288
1949	23,840	44,000	110,800	0	104,230	758
1950	41,020	44,000	101,600	0	120,810	735
1951	37,720	44,000	55,700	0	94,790	854
1952	37,720	44,000	37,000	0	50,070	1,089
1-2-53	3,220	7,660	4,400	0	43,590	1,136
4-12-53	25,440	36,340	113,200	0	95,010	671
1954	44,780	44,000	75,600	0	81,830	808
1955	39,470	44,000	131,900	0	130,260	692
1956	44,690	44,000	23,500	0	65,070	984
1957	36,830	44,000	629,700	337,090	276,850	393
1958	50,130	44,000	101,100	29,720	154,100	457
1959	47,220	44,000	97,600	0	260,480	505
1960	54,500	44,000	44,900	0	206,880	633
1961	45,690	44,000	152,800	2,360	267,630	637
1962	46,520	44,000	88,900	0	266,010	696
1963	59,790	44,000	74,300	0	236,520	778
1964	49,910	44,000	42,900	0	185,510	872
1965	43,150	44,000	121,600	0	219,960	774
1966	50,550	44,000	123,900	0	249,310	743
1967	52,250	44,000	37,900	0	190,960	862
1968	47,330	44,000	206,800	82,900	223,530	713
1969	42,390	44,000	165,700	51,400	251,440	659
1970	50,970	44,000	46,200	0	202,670	754

Table E-3, Continued

Year	Evaporative Loss	Demand	Inflow	Spills	End-of-Year Content	TDS (mg/l)
1971	42,970	44,000	78,700	0	194,400	829
1972	38,610	44,000	38,200	0	149,990	946
1973	30,510	44,000	48,900	0	124,380	1,028
1974	33,420	44,000	258,700	26,920	278,740	594
1975	52,920	44,000	91,900	34,080	239,640	696
1976	29,200	44,000	28,400	0	194,840	774
1977	40,240	44,000	44,800	0	155,400	877

APPENDIX F

COST ESTIMATES

APPENDIX F

COST ESTIMATES

Table F-1

Estimated Cost of Cedar Ridge Reservoir

Item	Unit	Unit Cost	Quantity	Amount
Preparation of site	A.C.	$1,500.00	31	$ 46,500
Core trench excavation	C.Y.	2.00	250,200	500,400
Wetted and rolled embankment	C.Y.	1.50	6,213,200	9,319,800
Sand filter	C.Y.	10.00	331,000	3,311,000
Riprap blanket	C.Y.	25.00	9,500	237,500
Riprap	C.Y.	25.00	114,500	2,862,500
Service spillway and outlet	L.S.	-	-	43,106,000
Mulching	Ac.	2,500.00	9	22,500
Irrigation system	L.S.	-	-	15,000
Land clearing	Ac.	100.00	7,750	775,000
Emergency spillway excavation	C.Y.	1.10	1,994,300	2,193,700
	Subtotal			$62,389,900
Land purchase in fee	Ac.	500.00	7,750	3,875,000
Flood easement	Ac.	250.00	1,500	375,000
Land acquisition	L.S.	-	-	25,000
	Subtotal			$66,664,900
Water permit	L.S.	-	-	25,000
Soils and foundation investigation	L.S.	-	-	75,000
Mapping of reservoir	L.S.	-	-	25,000
	Total			$66,789,900

Table F-2

Estimated Cost of Cedar Ridge Reservoir
15.0-MGD Pump Station

Item		Estimated Cost
Pumps and motors		$ 267,200
Structures and improvements		501,600
Miscellaneous equipment		27,900
Accessory electrical equipment		167,400
Discharge manifold		127,200
Intake structure		250,800
Site work		10,000
Access road		651,000
	Subtotal	$2,003,100
Engineering and contingencies at 25%		500,800
	Total	$2,503,900

Table F-3

Estimated Cost of Pipeline from Cedar Ridge Reservoir to Lake Fort Phantom Hill

Item	Unit	Unit Cost	Quantity	Amount
33-inch pipe, class 250	L.F.	$ 70.00	4,700	$ 329,000
33-inch pipe, class 200	L.F.	62.00	25,400	1,574,800
33-inch pipe, class 150	L.F.	54.00	50,500	2,727,000
33-inch pipe, class 100	L.F.	46.00	90,900	4,181,400
U.S. Highway crossing	Ea.	60,000.00	1	60,000
State road crossing	Ea.	50,000.00	2	100,000
Light duty road crossing	Ea.	20,000.00	5	100,000
Stream crossing	Ea.	30,000.00	15	450,000
Railroad crossing	Ea.	50,000.00	1	50,000
Discharge structure	L.S.	-	-	10,000
	Subtotal			$ 9,582,200
Engineering and contingencies at 25%				2,395,600
	Subtotal			11,977,800
Right-of-way				171,500
	Total			$12,149,300

Table F-4

Estimated Cost of 650-MGD Diversion Pump Station on the Clear Fork, Brazos River

Item		Estimated Cost
Pumps and motors		$ 5,567,000
Structures and improvements		6,864,000
Miscellaneous equipment		348,800
Accessory electrical equipment		1,161,000
Discharge manifold		1,325,000
Site work		10,000
Access road		63,000
	Subtotal	$15,338,800
Diversion weir and intake canal		4,000,000
	Subtotal	$19,338,800
Engineering and administration at 25%		4,834,700
	Total	$24,173,500

Table F-5

Estimated Cost of Pipeline from
Clear Fork, Brazos River to Hubbard Creek Reservoir

Item	Unit	Unit Cost	Quantity	Amount
120-inch pipe, class 100	L.F.	$ 465.00	48,800	$22,692,000
Light duty road crossing	Ea.	40,000.00	2	80,000
Stream crossings	Ea.	60,000.00	1	60,000
Pipeline crossing	Ea.	60,000.00	2	120,000
Discharge structure	L.S.	-	-	60,000
	Subtotal			$23,012,000
Engineering and contingencies at 25%				5,753,000
	Subtotal			$28,765,000
Right-of-way				36,600
	Total			$28,801,600

Table F-6

Estimated Cost of 9.2-MGD Pump Station at Possum Kingdom Reservoir

Item		Estimated Cost
Pumps and motors		$108,100
Structures and improvements		184,800
Miscellaneous equipment		13,400
Accessory electrical equipment		135,000
Discharge manifold		51,500
Intake structure		92,400
Site work		10,000
Access road		63,000
	Subtotal	$658,200
Engineering and contingencies at 25%		164,600
	Subtotal	$822,800
Land		3,000
	Total	$825,800

Table F-7

Estimated Cost of 9.2-MGD Booster Pump Station on Possum Kingdom Reservoir Pipeline

Item		Estimated Cost
Pumps and motors		$ 53,900
Structures and improvements		89,800
Miscellaneous equipment		5,800
Accessory electrical equipment		97,200
Intake and discharge manifold		51,300
Site work		10,000
Access road		2,100
1.0-MG ground storage tank		206,000
	Subtotal	$516,100
Engineering and contingencies at 25%		129,000
	Subtotal	$645,100
Land		500
	Total	$645,600

Table F-8

Estimated Cost of Pipeline from Possum Kingdom Reservoir to Booster Station at End of Existing 36-inch Pipeline

Item	Unit	Unit Cost	Quantity	Amount
36-inch pipe, class 150	L.F.	$ 62.00	3,000	$ 186,000
36-inch pipe, class 100	L.F.	56.00	45,000	2,520,000
U.S. Highway crossing	Ea.	60,000.00	1	60,000
State road crossing	Ea.	50,000.00	1	50,000
Light duty road crossing	Ea.	20,000.00	3	60,000
Railroad crossing	Ea.	50,000.00	1	50,000
Stream crossing	Ea.	30,000.00	1	30,000
	Subtotal			$2,956,000
Engineering and contingencies at 25%				739,000
	Subtotal			$3,695,000
Right-of-way				48,000
	Total			$3,743,000

Table F-9

Estimated Cost of Pipeline from Booster Station on Possum Kingdom Reservoir Supply Line to Hubbard Creek Reservoir

Item	Unit	Unit Cost	Quantity	Amount
36-inch pipe, class 150	L.F.	$ 62.00	1,200	$ 74,400
36-inch pipe, class 100	L.F.	56.00	71,300	3,992,800
State road crossing	Ea.	50,000.00	2	100,000
Light duty road crossing	Ea.	20,000.00	3	60,000
Discharge structure	L.S.	-	-	10,000
	Subtotal			$4,237,200
Engineering and contingencies at 25%				1,059,300
	Subtotal			$5,296,500
Right-of-way				72,500
	Total			$5,369,000

Table F-10

Estimated Cost of 15.0-MGD Expansion of the WCTMWD Hubbard Creek Reservoir Lake Pump Station

Item		Estimated Cost
Pumps and motors		$200,600
Miscellaneous equipment		22,300
Accessory electrical equipment		216,000
Discharge manifold		95,500
Site work		10,000
	Subtotal	$544,400
Engineering and contingencies at 25%		136,100
	Total	$680,500

Table F-11

Estimated Cost of 15.0-MGD Expansion of the WCTMWD Booster Station No. 1

Item		Estimated Cost
Pumps and motors		$133,700
1.0-MG ground storage tank		206,000
Miscellaneous equipment		16,700
Accessory electrical equipment		216,000
Intake and discharge manifolds		127,300
Site work		10,000
	Subtotal	$709,700
Engineering and contingencies at 25%		177,400
	Total	$887,100

Table F-12

Estimated Cost of 15.0-MGD Expansion of WCTMWD Booster Station No. 2

Item		Estimated Cost
Pumps and motors		$127,000
1.0-MG ground storage tank		206,000
Miscellaneous equipment		14,000
Accessory electrical equipment		108,000
Intake and discharge manifolds		95,500
Site work		10,000
	Subtotal	$560,500
Engineering and Contingencies at 25%		140,100
	Total	$700,600

Table F-13

Estimated Cost of Pipeline from WCTMWD Lake Pump Station to Booster Station No. 1

Item	Unit	Unit Cost	Quantity	Amount
33-inch pipe, class 150	L.F.	$ 54.00	2,200	$ 118,800
33-inch pipe, class 100	L.F.	46.00	51,383	2,363,600
U.S. Highway crossing	Ea.	60,000.00	1	60,000
Light duty road crossing	Ea.	20,000.00	3	60,000
Stream crossing	Ea.	30,000.00	1	30,000
	Subtotal			$2,632,400
Engineering and contingencies at 25%				658,100
	Total			$3,290,500

Table F-14

Estimated Cost of Pipeline from WCTMWD Booster Station No. 1 to Booster Station No. 2

Item	Unit	Unit Cost	Quantity	Amount
33-inch pipe, class 200	L.F.	$ 62.00	14,000	$ 868,000
33-inch pipe, class 150	L.F.	54.00	22,000	1,188,000
33-inch pipe, class 100	L.F.	46.00	26,850	1,235,100
U.S. Highway crossing	Ea.	60,000.00	1	60,000
State road crossing	Ea.	50,000.00	2	100,000
Light duty road crossing	Ea.	20,000.00	3	60,000
Subtotal				$3,511,100
Engineering and contingencies at 25%				877,800
Total				$4,388,900

Table F-15

Estimated Cost of Pipeline from WCTMWD
Booster Station No. 2 to Lake Fort Phantom Hill

Item	Unit	Unit Cost	Quantity	Amount
33-inch pipe, class 200	L.F.	$ 62.00	2,900	$ 179,800
33-inch pipe, class 150	L.F.	54.00	7,500	405,000
33-inch pipe, class 100	L.F.	46.00	78,374	3,605,200
State road crossing	Ea.	50,000.00	2	100,000
Light duty road crossing	Ea.	20,000.00	4	80,000
Stream crossing	Ea.	30,000.00	1	30,000
Discharge structure	L.S.	-	-	10,000
	Subtotal			$4,410,000
Engineering and contingencies at 25%				1,102,500
	Total			$5,512,500