REGIONAL WATER PLAN

FOR THE
BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

PREPARED FOR THE

BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT AUSTIN, TEXAS

AND THE

TEXAS WATER DEVELOPMENT BOARD Planning Grants Assistance Program Austin, Texas

PREPARED BY

DONALD G. RAUSCHUBER & ASSOCIATES, INC.
AUSTIN, TEXAS

SEPTEMBER 1990

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REGIONAL WATER PLAN

REPORT SECTIONS

EXECUTIVE SUMMARY

FACILITY PLANS FOR UTILITY INTERCONNECT

WATER CONSERVATION PLAN

PRELIMINARY RECHARGE ENHANCEMENT STUDY

DROUGHT CONTINGENCY PLAN

FACILITY PLANNING MAPS

**BARTON SPRINGS/EDWARDS AQUIFER
CONSERVATION DISTRICT
AUSTIN, TEXAS**

SEPTEMBER 1990

SECTION 1 REPORT

REGIONAL WATER PLAN
for the
BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

EXECUTIVE SUMMARY

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Austin, Texas

and

TEXAS WATER DEVELOPMENT BOARD
Planning Grants Assistance Program
Austin, Texas

TWDB CONTRACT NO. 9-483-732

prepared by

DONALD G. RAUSCHUBER & ASSOCIATES, INC.
Austin, Texas

in association with

FISHER, HAGOOD, HAMILTON & HEJL
Round Rock, Texas
R. J. BRANDES COMPANY
Austin, Texas
DAVID VENHUIZEN, P.E.
Uhland, Texas

SEPTEMBER 1990

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ACKNOWLEDGEMENTS

We gratefully acknowledge the support of the funding agencies, the Barton Springs/Edwards Aquifer Conservation District (BS/EACD) and the Texas Water Development Board (TWDB).

Special recognition is extended to Mr. Bill Couch, General Manager, BS/EACD; Mr. Tom Heathman, BS/EACD; Mr. Henry Alvarez, TWDB; Mr. Bernie Baker, TWDB; and personnel of the BS/EACD and Ground Water Unit of the TWDB, who were instrumental in planning, awarding, and supervising the Project contract.

Numerous individuals in the public and private sectors were involved in this Project in many capacities. We extend our thanks to them. Particularly, Mr. Raymond Slade, Hydrologist, United States Geological Survey; Mr. Kent Butler, Ph.D., University of Texas at Austin; and Mr. Mike Personett, Lower Colorado River Authority, provided their expertise and experience in the performance of this study.

We owe a special thanks to the members of the BS/EACD's Technical Review Advisory Committee (TRAC). Particularly we are indebted to Mr. J. L. Howze, Chairman of the TRAC, for his direction and continual support of this Project.

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1.0 INTRODUCTION

In July, 1989, the Barton Springs/Edwards Aquifer Conservation District (BS/EACD) obtained a grant from the Texas Water Development Board (TWDB) to partially fund the development of Facility Planning and Water Conservation/Enhancement Programs. Under TWDB Contract No. 9-483-732, the BS/EACD received $50,000 in grant funds. The BS/EACD provided an additional $50,000 of funds and in-kind services to perform this Project.

The overall purpose of this Project was to develop the following plans for the Barton Springs segment of the Edwards aquifer:

1. Facility Plans to Provide Emergency Interconnection of Public Water Systems;
2. District-Wide Water Conservation Plan;
3. Ground Water Enhancement Plan; and
4. Drought Contingency Plan.

2.0 PRINCIPAL INVESTIGATORS

Mr. Bill Couch, General Manager, and Mr. Tom Heathman, Geologist, both with the BS/EACD, provided general technical support and project management for this effort. In addition, the BS/EACD retained the services of the following professional consulting firms for specialized technical expertise:

1. Donald G. Rauschuber & Associates, Inc., Austin, Texas; Project Administration, Management, Drought Contingency and Ground Water Enhancement Programs;

2. Fisher, Hagood, Hamilton & Hejl, Round Rock, Texas; Civil Engineering and Facility Planning;
3. R.J. Brandes Company, Austin, Texas; Ground Water Enhancement Programs, Quality Control; and
4. David Venhuizen, P.E., Uhland, Texas; Water Conservation Planning.

During the course of this Project, numerous public meetings were held to obtain public input and guidance. In addition, a Technical Review Advisory Committee (TRAC) was formulated. The following TRAC members provided valuable technical direction and project oversight:

1. J.L. Howze, Chairman, GoForth Water Supply Corporation;
2. Raymond Slade, Hydrologist, U.S. Geological Survey;
3. Mike Personett, Lower Colorado River Authority;
4. Kent Butler, Ph.D., University of Texas;
5. Steve Musick, Texas Water Commission;
6. Larry Ham, P.E., Homeowner;
7. Fred Dippel, P.E., Consulting Engineer;
8. Charles Laws, General Manager, Creedmoor-Maha Water Supply Corporation; and
9. Bernie Baker, Texas Water Development Board.

3.0 REPORT ORGANIZATION

To facilitate presentation of each project element, the following report sections have been prepared:

1. SECTION 1 - EXECUTIVE SUMMARY;
2. SECTION 2 - FACILITY PLANS FOR UTILITY INTERCONNECT;
3. SECTION 3 - WATER CONSERVATION PLAN;
4. SECTION 4 - PRELIMINARY RECHARGE ENHANCEMENT STUDY;

5. SECTION 5 - DROUGHT CONTINGENCY PLAN; and
6. SECTION 6 - FACILITY PLANNING MAPS.

Section 1 - Executive Summary provides an overview of project findings, conclusions, and recommendations. This Summary presents a general discussion of each project element. Specific details regarding each Project objective are presented by respective report sections.

Section 2 - Facility Plans for Utility Interconnect describes plans that would provide for the interconnection of public water supply systems in times of emergency. This report presents the facility and administrative requirements to assist water systems located within the BS/EACD in the implementation of interconnect improvements that would extend their available water supplies during drought or other water short periods.

Section 3 - Water Conservation Plans presents a thorough discussion of the numerous water conservation options and alternatives available to the BS/EACD and the respective water supply companies, industries, and commercial users. This conservation manual surveys available and applicable conservation opportunities. In addition, data analyses are presented for specific water use categories, such as, domestic, landscape irrigation, industrial and unaccounted-for losses.

Section 4 - Preliminary Recharge Enhancement Study focuses on the assessment of alternatives that are available for enhancing the recharge to the Barton Springs segment of the Edwards aquifer. A summary and description of the various artificial recharge measures that could be implemented and that have been considered in other previous studies is presented along with a discussion of their recharge potential and implementation feasibility.

Section 5 - Drought Contingency Plan establishes guidelines and procedures by which the ground water resources of the Barton Springs segment of the Edwards aquifer can be managed during the occurrence of drought conditions. The plan defines drought stages and required responses for the BS/EACD, water suppliers and individuals. In addition, User Drought Contingency Plans are outlined, along with required BS/EACD actions.

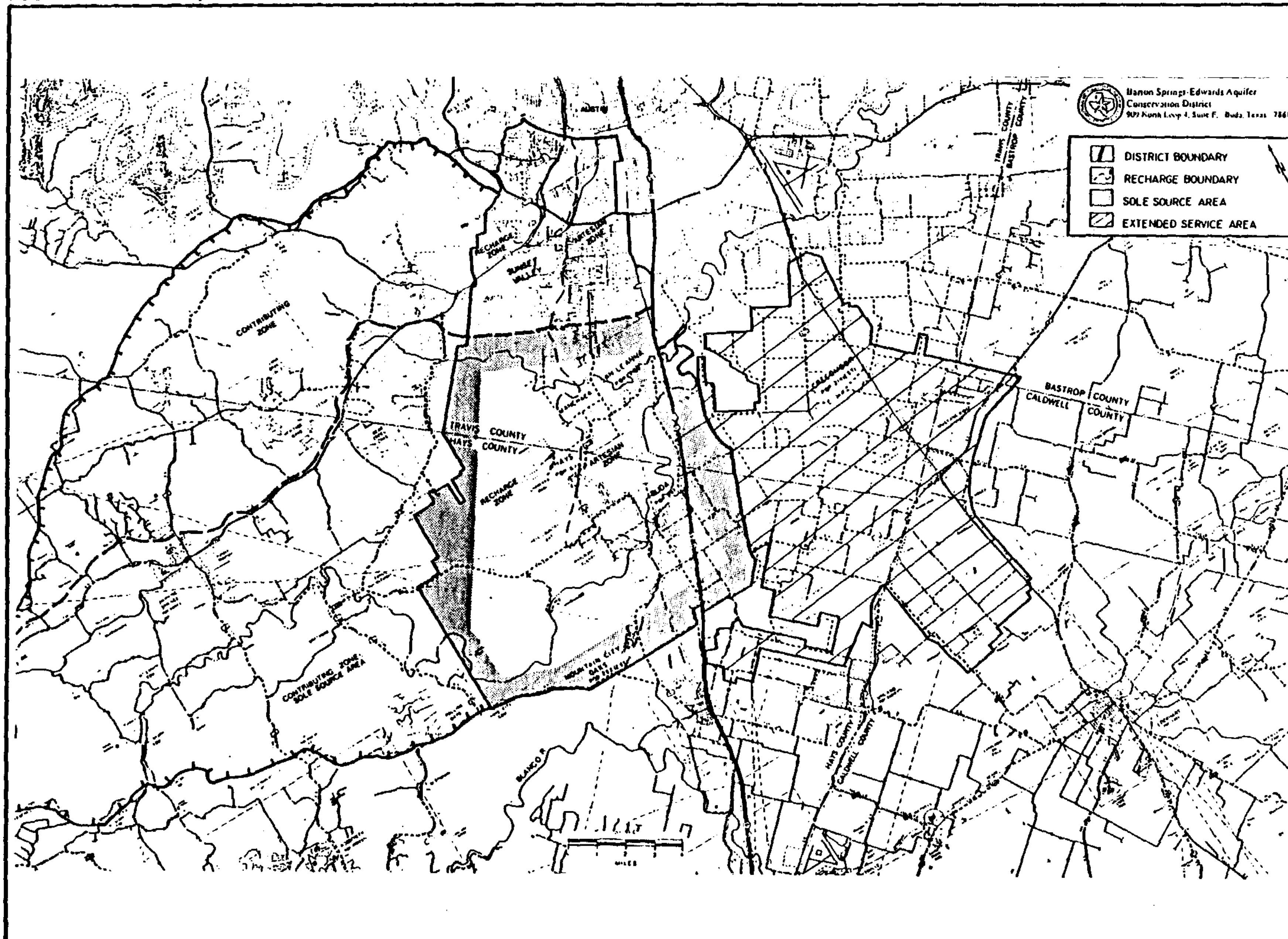
Section 6 - Facility Planning Maps contains oversized drawings and maps developed as part of the Facility Plans for Utility Interconnect Study.

4.0 BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT

The BS/EACD was created by the 70th Texas Legislature under Senate Bill 988 and Chapter 52 of the Texas Water Code with a mandate to conserve, protect, and enhance the ground water resources of the Barton Springs segment of the Edwards aquifer and other ground water resources located within its boundaries. The BS/EACD has the power and authority to undertake various studies and to implement structural facilities and non-structural programs to achieve its statutory mandate. The BS/EACD has rule making authority to implement its policies and procedures. The planning studies described in this Executive Summary and accompanying reports were performed by the BS/EACD as partial fulfillment of its statutory mandate.

The BS/EACD's jurisdictional area is delineated in Figure 1.1. It is bounded on the west by the western edge of the Edwards aquifer outcrop and on the north by the Colorado River. The eastern boundary is formed by the most easterly service area limits of the Creedmoor-Maha, GoForth, and Plum Creek Water Supply Corporations. The BS/EACD's southern boundary is generally along the established ground water divide or "high" between the Barton Springs and the

FIGURE 1.1 BS/EACD JURISDICTIONAL AREA



San Antonio segments of the Edwards aquifer. This area encompasses approximately 255 square miles, of which is estimated to be 10% urban/suburban, 45% ranchland, and 45% farmland. The Edwards aquifer is either a sole source or primary source of drinking water for approximately 30,000 people residing within the BS/EACD boundaries. Some wells in the BS/EACD also produce water from the Taylor, Glen Rose, and Trinity Formations, as well as, various alluvial deposits along stream banks. The area has a long history of farming, ranching, and rural domestic use of ground water.

5.0 STUDY AREA

The study area for this effort encompasses the BS/EACD's jurisdictional boundaries, which includes the entire Barton Springs segment of the Edwards aquifer. This segment is part of the Edwards (Balcones Fault Zone) aquifer system that lies within northern Hays and southern Travis Counties in Central Texas. The Edwards (Balcones Fault Zone) aquifer, which is comprised of massive, highly-fractured limestone, extends over a distance of about 250 miles along a narrow, arc-shaped band that crosses Southwestern and Central Texas in parts of ten counties from Kinney, near the Rio Grande, through Uvalde, Medina, Bexar, Comal, Guadalupe, Hays, Travis, Williamson and Bell Counties to the northeast.

Generally, the areal extent of the Barton Springs segment of the Edwards aquifer is considered to be bounded on the north by Town Lake on the Colorado River, on the west by its contact with the Glen Rose Formation of the Trinity Group, on the east by the dividing line between fresh and saline water, i.e. the "bad-water" line that distinguishes those parts of the aquifer with less than and more than 1,000 mg/L of total dissolved solids, and on the south by the ground water divide (high water level) near the Blanco River or FM 150. This area covers about 155 square miles, with most of the northern third of the area generally developed and urbanized as part of the City of Austin and several other outlying communities. Figure 1.2 identifies the boundaries of the Barton Springs segment of the Edwards aquifer as delineated for purposes of this study.

6.0 SUMMARY OF STUDY RESULTS

A summary of the results of the four project elements described in Section 1.0 of this Executive Summary is presented in the following paragraphs.

6.1 FACILITY PLANS FOR UTILITY INTERCONNECT

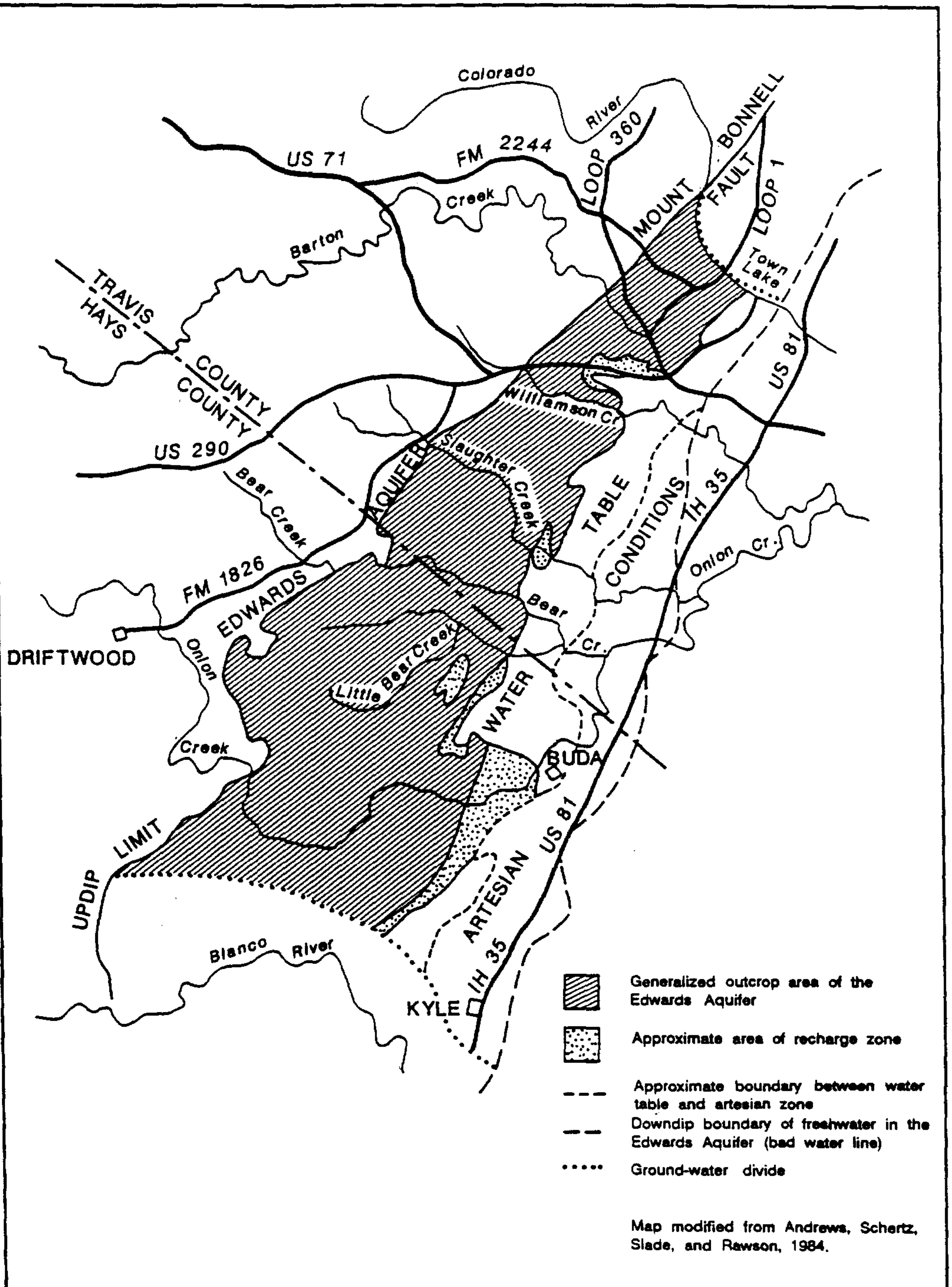
6.1.1 Purpose of Study

The purpose of the Utility Interconnect Study was to develop facility plans that would provide for the interconnection of public water supply systems in times of emergency. System interconnections may be short or long term depending on the type of emergency encountered, i.e., extended drought, hazardous/toxic contamination, power failures, and intrusion of bad water creating water quality problems.

6.1.2 Facility Planning

The initial phase of this effort was to perform an extensive inventory of existing water systems within the study area. This inventory was performed by forwarding a questionnaire to public and private water system companies. In addition, specific information on each water system was gathered from the records of the BS/EACD, Texas Water Commission (TWC), Texas Water Development Board (TWDB), and Texas Department of Health (TDH). The City of Austin provided existing water system maps for the study area. From these

FIGURE 1.2 DELINEATION OF BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER



information sources, a thorough compilation of individual system features was compiled, including rated pumping capacities and sizes of system components.

Within the study area, there are 37 organized water supply systems (see Table 6.1-1) that depend on the Barton Springs segment of the Edwards aquifer for their sole source of supply. In 1989, the approximate annual permitted pumpage for these suppliers was over 1 billion gallons (3,069 acre-feet). Collectively, these suppliers have 98 wells (see Table 6.1-2) with a combined pumping capacity of over 5,500 gallons per minute (gpm).

Table 6.1-3 lists current and projected population for the 37 water supply systems. The estimated year 1990 population served by these systems is 20,006 persons. System population is projected to increase to 27,924 people by the year 2010. This projection is based on growth rates and the "build-out" capability of systems serving established subdivisions. Using an average daily per capita water use rate of 137 gallons, the total projected annual water requirement for the 37 systems is 4,285 acre-feet by the year 2010.

For purposes of preliminary design (sizing) of facility interconnects, a threshold water use was developed. This was defined as an average per capita water use in gallons per day needed to satisfy basic human consumption needs. This value was determined to be 50 gallons per capita per day, and represents 60% of the daily average per capita water use for the months of December through February. The average daily threshold water use for each system is shown in Table 6.1-4.

Based on analyses of facility, demographic, geographic, and aquifer data for each water supplier, the systems were grouped to facilitate emergency interconnects. Fourteen groups of facility

TABLE 6.1-1 WATER SUPPLY SYSTEMS EVALUATED IN UTILITY INTERCONNECT STUDY

NO.	NAME	USER CLASS
1.	Aquatex Water Supply	Single Family
2.	Arroyo Doble Water System	Single Family
3.	CenTex Material	Industrial
4.	Chaparral Water Co.	Single Family
5.	Chatleff Control Inc.	Industrial
6.	Cimarron Park Water Co. Inc.	Single Family
7.	City of Austin	Irrigation
8.	City of Buda	Municipal
9.	City of Sunset Valley	Municipal
10.	Comal Tackle Company	Industrial
11.	Copper Hills Subdivision	Single Family
12.	Creedmoor-Maha WSC	Mixed Use
13.	Dellana Hills	Single Family
14.	Estate Utilities	Single Family
15.	G&J Water District	Single Family
16.	Goforth WSC	Mixed Use
17.	Harold Hicks & Al Schuster	Commercial
18.	Hays CISD-Dahlstrom MS	Institutional
19.	Hays CISD-Jack C. Hays HS	Institutional
20.	J.D. Malone	Single Family
21.	Liesurewoods Water	Single Family
22.	Marbridge Foundation	Institutional
23.	Mooreland Water System	Single Family
24.	Mountain City Oaks WS	Single Family
25.	Mystic Oaks Water Co-Op	Single Family
26.	Oak Forest Highlands	Mobile Homes
27.	Plum Creek Water	Mixed Use
28.	Shady Hollow Estates Water SC	Single Family
29.	Slaughter Creek Acres Water SC	Single Family
30.	Southwest Territory Water Co.	Single Family
31.	Ridgewood Village Water System	Single Family
32.	Bear Creek Park	Single Family
33.	Onion Creek Meadows	Single Family
34.	Texas-Lehigh Cement Co.	Industrial
35.	Tilson Custom Homes	Commercial
36.	Village of San Leanna	Residential
37.	Huntington Estates	Residential

TABLE 6.1-2 - MAJOR WATER SUPPLIERS AND WELL FACILITIES WITHIN THE BS/EACD

Water Supplier	Well #	Well ID#	Well Depth	Pumping Rate
1 AquaTex Water Supply	1	58-50-858	380'	60 GPM
	2	58-50-856	350'	N.A
	3	58-50-857	358'	N.A
2 Arroyo Doble WS	1	58-50-845	380'	142 GPM
	2	58-58-215	440'	119 GPM
3 CenTex Material	1	58-58-414	200'	1197 GPM
	2	58-58-414	200'	943 GPM
4 Chaparral Water Co.	1	58-49-910	400'	15 GPM
	2	58-49-911	420'	5 GPM
	3	58-49-915	400'	20 GPM
	4	58-49-918	400'	25 GPM
	5	58-49-912	720'	55 GPM
	6	58-49-913	850'	55 GPM
	7	58-49-914	850'	32 GPM
	8	58-49-919	420'	5 GPM
	9	58-49-920	420'	5 GPM
	10	58-49-916	420	5 GPM
	11	58-49-917	420'	5 GPM
5 Chatleff Control Inc.	1	58-58-509	500'	54 GPM
6 Cimarron Park WC Inc.	1	58-58-114	490'	175 GPM
	2	58-58-102	400'	675 GPM
7 City of Austin Wells	1	58-49-907	52'	350 GPM
	2	58-49-906	50'	503 GPM
	3	58-49-909	51'	465 GPM
	4	58-49-917	55'	503 GPM
8 City of Buda	1	58-58-403	390'	250 GPM
	2	58-58-106	380'	100 GPM
	3	58-58-413	740'	600 GPM
9 City of Sunset Valley	1	58-50-221	360'	N.A.
	2	58-50-222	360'	N.A.
	3	58-50-223	30'	120 GPM
10 Comal Tackle Company	1	58-58-416	240'	25 GPM
11 Copper Hills Subdivision	1	58-49-921	420'	5 GPM
	2	58-49-922	420'	23 GPM
	3	58-49-923	420'	19 GPM
	4	58-49-924	420'	6 GPM
12 Creedmoor-Maha WSC	1	3 WELLS	NOT.AV.	900 GPM
	2	3 WELLS	NOT.AV.	580 GPM
13 Dellana Hills	1	58-42-813	300'	25 GPM
	2	58-42-814	300'	20 GPM
14 Estate Utilities	1	58-58-115	325'	500 GPM
	2	58-58-111	303'	90 GPM
15 G&J Water District	1	58-42-622	300'	35 GPM
16 Goforth WSC	1	58-58-501	640'	300 GPM
	2	58-58-506	640'	450 GPM
	3	58-58-507	740'	1500 GPM
	4	58-58-508	740'	1500 GPM
17 Harold Hicks & Al Schuster	1	58-50-723	415'	55 GPM

TABLE 6.1-2 MAJOR WATER SUPPLIERS AND WELL FACILITIES WITHIN THE BS/EACD (CONTINUED)

Water Supplier	Well No.	Well ID#	Well Depth	Pumping Rate
18 Hays CISD - MS	1	58-57-307	470'	150 GPM
19 Hays CISD - HS	1	58-57-901	575'	N.A.
20 J.D.Malone	1	58-50-852	425'	40 GPM
21 Liesurewoods Water	1	58-58-102	400'	140 GPM
	2	58-58-118	440'	135 GPM
	3	58-58-119	440'	105 GPM
	4	58-58-120	406'	150 GPM
	5	58-58-121	410'	375 GPM
	6	58-58-108	548'	0 GPM
22 Marbridge Foundation	1	58-50-703	500'	90 GPM
	2	58-50-704	400'	400 GPM
	3	58-50-725	500'	90 GPM
	4	57-50-727	500'	90 GPM
	5	58-50-728	400'	90 GPM
23 Mooreland WS	1	58-50-8S	408'	100 GPM
24 Mountain City Oaks WS	1	58-57-910	405'	175 GPM
25 Mystic Oaks WC	1	58-58-202	400'	38 GPM
	2	58-58-216	400'	16 GPM
26 Oak Forest Highlands	1	58-50-843	450'	100 GPM
	2	58-50-843	450'	100 GPM
27 Plum Creek WC	1	58-58-409	670'	N.A.
	2	58-58-412	720'	500 GPM
	3	58-58-419	700'	N.A.
	4	58-58-708	675'	N.A.
28 Shady Hollow Estates WSC	1	58-50-731	438'	200 GPM
29 Slaughter Creek Acres WSC	1	58-50-829	420'	75 GPM
	2	58-50-830	420'	45 GPM
30 Southwest Territory WC	1	58-49-927	500'	36 GPM
	2	58-49-928	820'	120 GPM
	3	58-49-929	420'	24 GPM
31 Ridgewood Village WS	1	58-42-823	310'	165 GPM
32 Bear Creek Park	1	58-50-732	320'	63 GPM
	2	58-50-733	280'	39 GPM
33 Onion Creek Meadows	1	58-58-207	445'	85 GPM
	2	58-58-208	520'	83 GPM
34 Texas-Lehigh Cement Co	1	58-58-406	N.A.	N.A.
	2	58-58-407	343'	700 GPM
	3	58-58-408	N.A.	N.A.
35 Tilson Custom Homes	1	58-58-7B	450'	20 GPM
36 Village of San Leanna	1	58-50-827	473'	70 GPM
	2	58-50-838	475'	68 GPM
	3	58-50-855	500'	115 GPM
37 Huntington Estates	1	58-57-308	405'	192 GPM

SOURCE: BS/EACD

TABLE 6.1-3 BS/EACD CURRENT AND PROJECTED POPULATION FOR ORGANIZED WATER SUPPLY SYSTEMS

NO.	NAME	YEAR		
		1990	2000	2010
1.	Aquatex Water Supply	180	217	238
2.	Arroyo Doble Water System	800	974	977
3.	CenTex Material	-	-	-
4.	Chaparral Water Co.	400	414	414
5.	Chatleff Control Inc.	-	-	-
6.	Cimarron Park Water Co. Inc.	1250	1523	1649
7.	City of Austin Wells	-	-	-
8.	City of Buda	1500	1828	2228
9.	City of Sunset Valley	231	282	345
10.	Comal Tackle Company	-	-	-
11.	Copper Hills Subdivision	18	48	84
12.	Creedmoor-Maha WSC	4500	5487	6688
13.	Dellana Hills	75	78	78
14.	Estate Utilities	310	378	461
15.	G&J Water District	68	68	68
16.	Goforth WSC	3615	4407	5373
17.	Harold Hicks & Al Schuster	160	180	200
18.	Hays CISD-Dahlstrom MS	-	-	-
19.	Hays CISD-Jack C. Hays HS	-	-	-
20.	J.D. Malone	140	160	180
21.	Liesurewoods Water	1100	1155	1155
22.	Marbridge Foundation	364	397	430
23.	Mooreland Water System	200	200	200
24.	Mountain City Oaks WS	405	493	602
25.	Mystic Oaks Water Co-Op	135	156	156
26.	Oak Forest Highlands	84	120	154
27.	Plum Creek Water	2200	2683	3270
28.	Shady Hollow Estates Water SC	126	153	186
29.	Slaughter Creek Acres Water SC	250	304	357
30.	Southwest Territory Water Co.	300	339	339
31.	Ridgewood Village Water System	200	243	297
32.	Bear Creek Park	260	272	272
33.	Onion Creek Meadows	650	763	763
34.	Texas-Lehigh Cement Co.	-	-	-
35.	Tilson Custom Homes	15	15	15
36.	Village of San Leanna	380	464	566
37.	Huntington Estates	35	70	140
	TOTAL	19,919	23,874	27,885

TABLE 6.1-4 PROJECTED THRESHOLD DAILY WATER USE (GPD) BY WATER SUPPLY SYSTEM

NO.	NAME	YEAR 1990	2000	2010
1.	Aquatex Water Supply	9,000	10,850	11,900
2.	Arroyo Doble Water System	40,000	48,700	48,850
3.	CenTex Material	-	-	-
4.	Chaparral Water Co.	20,000	20,700	20,700
5.	Chatleff Control Inc.	-	-	-
6.	Cimarron Park Water Co. Inc.	62,500	76,150	82,450
7.	City of Austin Wells	-	-	-
8.	City of Buda	75,000	91,400	111,400
9.	City of Sunset Valley	11,550	14,100	17,250
10.	Comal Tackle Company	-	-	-
11.	Copper Hills Subdivision	900	2,400	4,200
12.	Creedmoor-Maha WSC	225,000	274,350	334,400
13.	Dellana Hills	3,750	3,900	3,900
14.	Estate Utilities	15,500	18,900	23,050
15.	G&J Water District	3,400	3,400	3,400
16.	Goforth WSC	180,750	220,350	268,650
17.	Harold Hicks & Al Schuster	8,000	9,000	10,000
18.	Hays CISD-Dahlstrom MS	6,250	7,600	9,200
19.	Hays CISD-Jack C. Hays HS	30,000	36,600	44,600
20.	J.D. Malone	7,000	8,000	9,000
21.	Liesurewoods Water	55,000	57,750	57,750
22.	Marbridge Foundation	18,200	19,850	21,500
23.	Mooreland Water System	10,000	12,000	13,400
24.	Mountain City Oaks WS	20,250	24,650	30,100
25.	Mystic Oaks Water Co-Op	6,750	7,800	7,800
26.	Oak Forest Highlands	4,200	6,000	7,700
27.	Plum Creek Water	110,000	134,150	163,500
28.	Shady Hollow Estates Water SC	6,300	7,650	9,300
29.	Slaughter Creek Acres Water SC	12,500	15,200	17,850
30.	Southwest Territory Water Co.	15,000	16,950	16,950
31.	Ridgewood Village Water System	10,000	12,150	14,850
32.	Bear Creek Park	13,000	13,600	13,600
33.	Onion Creek Meadows	32,500	38,150	38,150
34.	Texas-Lehigh Cement Co.	-	-	-
35.	Tilson Custom Homes	750	750	,750
36.	Village of San Leanna	19,000	23,200	28,300
37.	Huntington Estates	140	2,800	5,600

interconnects for the 37 water systems were evaluated. Facility plans for each group of utility interconnects were developed. These plans included sizing and location of pipes, valves, and ground storage facilities. A detailed facility description of each interconnect scenario is presented in Section 2 - Facility Plans for Utility Interconnect. In addition, a map of the proposed interconnection of ground water suppliers is presented as Exhibit No. 3 in Section 6 - Facility Planning Maps. A summary of recommended interconnects and projected cost by system is shown in Table 6.1-5.

6.1.3 Institutional Considerations

Facility interconnect financing could be provided either by the local entities involved or through loans obtained from the Texas Water Development Board. This would require the execution of interconnect agreements among respective water suppliers.

The Texas Department of Health (TDH) would review interconnect plans as they are developed. Rule 337.206 (f) Interconnections, of the TDH Rules and Regulations for Public Water Supply Systems, addresses interconnect requirements. TDH recognizes that "emergency interconnects" are a "temporary" source of supply, rather than secondary source of supply. This clarification is critical to implementation of the emergency interconnects. Suppliers of "emergency" water will not have to permanently allocate reserve supplies which could be utilized to serve future customers.

The following items will be required for the TDH review process:

1. Engineer's report detailing design guidelines for facility sizing;
2. Agreement between participating utilities interconnecting;

TABLE 6.1-5 RECOMMENDED UTILITY INTERCONNECT FOR WATER SUPPLY SYSTEMS

GROUP NO.	SYS. NO.	SYSTEM NAME	NO. OF PRIMARY SYSTEM CONN.	ESTIMATED COST (1990 $)
I	1.	Aquatex Water Supply	12	$ 4,250
	2.	Arroyo Doble Water System	12	34,600
	12.	Creedmoor-Maha WSC	N.C.	0
	25.	Mystic Oaks Water Co-Op	12	4,900
	33.	Onion Creek Meadows	12	8,800
II	3.	CenTex Material[1]	N.C.	0
	10.	Comal Tackle Company	N.C.	0
	34.	Texas-Lehigh Cement Co.	N.C.	0
III	4.	Chaparral Water Co.	11,30	9,550
	11.	Copper Hills Subdivision	4, 30	1,500
	30.	Southwest Territory WC	4,11	9,550
IV	5.	Chatleff Control Inc.	N.C.	0
	8.	City of Buda	5,16,27	13,500
	16.	Goforth WSC	8,12,27	13,500
	27.	Plum Creek Water	8,12,16	13,500
	35.	Tilson Custom Homes	27	15,400
V	6.	Cimarron Park WC Inc.	21	5,000
	14.	Estate Utilities	21	7,000
	21.	Liesurewoods Water	6	5,000
	37.	Huntington Estates	N.C.	0
VI	7.	City of Austin Wells	N.C.	0
VII	9.	City of Sunset Valley[2]	-	2,200
VIII	13.	Dellana Hills	15,31	7,000
	15.	G&J Water District	15,31	1,000
	31.	Ridgewood Village WS[3]		2,600
IX	17.	Harold Hicks/Al Schuster[2]	-	17,000
	23.	Mooreland Water System[2]	-	13,000
	26.	Oak Forest Highlands[2]	-	19,500
	29.	Slaughter Crk. Acres WSC[2]	-	4,500
	36.	Village of San Leanna[2]	-	25,500

[1]Not considered.

[2]Connect to City of Austin.

[3]Connect to the City of Rollingwood.

TABLE 6.1-5 RECOMMENDED UTILITY INTERCONNECT FOR WATER SUPPLY SYSTEMS (CONTINUED)

GROUP NO.	SYS. NO.	SYSTEM NAME	NO. OF PRIMARY SYSTEM CONN.	ESTIMATED COST (1990 $)
X	18.	Hays CISD-Dahlstrom MS[4]	21	45,000
XI	19.	Hays CISD-Jack C. Hays HS	24	13,000
	24.	Mountain City Oaks WS	19	13,000
XII	20.	J.D. Malone[2]		14,500
XIII	22.	Marbridge Foundation	32	16,250
	32.	Bear Creek Park	22	16,250
XIV	28.	Shady Hollow Estates WSC[5]		

[4]Connect to Leisurewoods WC or drill new well.

[5]Has existing connection with City of Austin.

3. Any necessary easements required; and
4. Miscellaneous "other" data as required by the TDH.

The Texas Water Commission (TWC) must be informed when water systems are interconnected. Any tariff modifications by suppliers to accommodate the interconnects must be on file with the suppliers' Certificate of Convenience and Necessity (CCN) documents. However, amendments to CCN service areas are not anticipated for the proposed emergency interconnect plans.

The BS/EACD could adopt policies and procedures to sponsor and coordinate the implementation of water supply facility interconnects. This could include assistance with the design, permitting, regulatory review, contract administration, and financing of the proposed interconnect improvements.

6.2 WATER CONSERVATION PLAN

6.2.1 Introduction

This portion of the study focused on the development of a water conservation plan for the BS/EACD with the following goal and objectives:

1. GOAL: To preserve and protect the waters in the Barton Springs segment of the Edwards aquifer, including maintaining the quality of Barton Springs
2. OBJECTIVE: To reduce per capita demand, to reduce peak summer demand usage, and to maintain or improve the water quality in the Edwards aquifer. General methods of obtaining these objectives include:

   A. public education and information;
   B. interior water use efficiency enhancement;

C. exterior water use efficiency enhancement and demand reduction;

D. adjustments in water pricing policies;

E. beneficial reuse or substitution of non-potable water for demands where potable water is not required; and

F. leak detection and repair.

These objectives form a good overall framework within which to explore the opportunities for water conservation. They also highlight a crucial point about the nature of a "real" conservation effort.

Too often "conservation" is equated to the types of short term curtailment efforts embodied in drought contingency plans. The plan developed for this effort does not propose doing without, nor with enforcing changes of lifestyle or habit to meet a crisis situation. Rather, it focuses on measures which can be taken to avoid a crisis.

The plan stresses means of reducing per capita demand by the water users. Three distinct types of changes are readily identified:

1. Changes in how water using tasks are "formulated", e.g., Xeriscape to reduce landscape irrigation requirements;
2. Changes in how water using components are designed, e.g., ultra-low volume toilets; and
3. Changes in how water system components are maintained, e.g., leak detection and repair.

Results from analyses of available data indicate that domestic interior supply, landscape irrigation, industrial usage, and unaccounted-for losses dominate water use in the BS/EACD area. This study focused on developing water conservation measures that would effectively reduce water consumption in these categories.

These measures, summarized in Table 6.2-1, are discussed in the following paragraphs.

6.2.2 Interior Water Use

Regarding interior use, the U.S. Department of Housing and Urban Development (HUD) conducted extensive studies of water use which can be used as a guide to estimate demands from various types of fixtures. According to HUD data, in a home fitted with "state-of-the-art" fixtures, expected demand per capita per day should be about 45 gallons. The HUD estimate was based on observed average behavior in homes with efficient hardware. The HUD study indicates that the 45 gpcd goal is attainable over time as fixtures are replaced, leaks are eliminated, and people are educated on the importance of using water wisely.

The current water demand rates of 20 selected water suppliers in the BS/EACD with a total permitted pumpage of 864.7 million gallons per year have been compared with the 45 gpcd goal. Totalling the apparent savings potential yields a figure of about 213 million gallons per year. This is about 19% of total permitted pumpage and about 25% of the permitted pumpage for this sample group of suppliers.

An example of how potential water savings can be achieved is provided by considering toilet fixtures. A rough estimate, based upon data from 22 water suppliers, indicates that broadscale toilet replacement could save about 85 million gallons per year. Examining the fiscal implications, payback periods of eight to eighteen years for replacement of a 3.5 gallon model were derived, depending upon the assumed cost of the new toilet. Clearly this is not a good fiscal investment. To obtain a 5-year payback requires a water rate of $2.85 to $6.28 per 1,000 gallons for replacing an "old" toilet and of $5.71 to $12.56 per 1,000 gallons

TABLE 6.2-1 SUMMARY OF RECOMMENDED WATER CONSERVATION MEASURES

Measures for Reduction of Interior Domestic Demands: * Minimize--if not eliminate--toilet leakage * Install toilets dams or displacement devices * Replace toilets with "ultra-low" volume models * Replace showerheads with "low-flow" models * Replace washing machines and dishwashers with more water-efficient models * Install aerators on all faucets which lack them * Repair leaks in faucets, building plumbing, etc. * Reduce pressure to 30-50 psi range to minimize leakage losses * Institute efficiency standards for new construction * Disseminate informational material about how to attain interior conservation, where to obtain necessary materials, the fiscal and economic efficiency of each measure, etc.
Measures for Reduction of Irrigation Demands: * Collect weather data and offer "real time" advisories on how much water to apply onto various landscapes or crops * Provide irrigation schedule by season to assist in setting up system to obtain proper application rates * Offer general guidance on when and how much to water * Provide information on more efficient application equipment particularly for drip irrigation systems * Provide information on better control systems--more flexible timers, wet soil override switches * Promote Xeriscape * Promote use of grasses with lower water demands * Provide dual distribution systems for wastewater reuse * Implement on-site/small scale systems for wastewater reuse * Plan developments to minimize irrigation demand
Measures for Reduction of Demands by Industry, Institutions, Etc.: * Fixture retrofit and/or replacement * Flush water recycling * Treatment and reuse of greywater, process water, etc. * Reuse of wastewater effluent from centralized systems * Utilize Trinity aquifer for non-potable demands * Recruit "dry" industries * Plan industrial complexes to facilitate reuse
Measures for Reduction of Water System Losses: * Water audits, leak detection surveys * Internal operations improvements * Water line and appurtenance repair and replacement * Upgrade construction standards

TABLE 6.2-1 SUMMARY OF RECOMMENDED WATER CONSERVATION MEASURES (CONTINUED)

Price-Related Measures to Encourage Implementation of Conservation Opportunities:

* Alter rate structures using marginal cost pricing principles
* Implement seasonal rates
* Modify capacity charges to give credit for conservation measures
* Surcharge on pumpage fee for volume due to losses
* Surcharge or higher rate for non-potable demands
* Seasonal surcharge on pumpage fee

for replacing a 3.5 gallon toilet. This indicates that replacing "old" toilets would be economically efficient as long as the replacement cost is in the lower half of the range considered. It is estimated that about two-thirds of all existing toilets in this area are "old" models.

The high first cost barrier and the fiscal inefficiency at current prices would retard broadscale implementation of this conservation measure. These problems could be minimized through a program to finance the replacement toilets interest-free, allowing the cost to be paid back over time through surcharges on the water bill. Analysis of such a program indicated that, after accounting for savings due to decreased water demand (at the current average marginal rate of $1.70 per 1,000 gallons), the net payout for a 36-month repayment period would be $3.62 per month, which is not a significant burden to the user. For the supplier, the cost would be the interest foregone, $22.76 under the assumptions made. This is likely to be economically efficient. Looking at the long term, assuming that a toilet fixture has a useful life of 15 years, the water saved would cost only 17 cents per 1,000 gallons.

Other opportunities for interior use conservation appear more implementable. Replacing showerheads with "low-flow" models would have a payback period of about 4 months at prevailing water rates, largely due to electricity savings. Installing toilet dams or displacement devices would have instantaneous payback, since these devices are generally available at no cost. Placing aerators on any faucets is expected to be highly fiscally efficient. Most leakage control measures--especially toilet leakage elimination--would also be fiscally efficient.

6.2.3 Landscape Irrigation

For landscape irrigation, data from 20 suppliers indicates that their combined annual demand for landscape irrigation is in the range of 254 million gallons, which is about 23% of total permitted pumpage and 29% of the permitted pumage of the suppliers surveyed. This demand could be decreased through a number of strategies. These strategies include assisting homeowners with setting up efficient watering systems or using more efficient hardware in hose-end systems. Such strategies can be put in place for little cost, making them fiscally and economically efficient. Public education and rising water prices would spur the implementation of these strategies. Other approaches, such as Xeriscape or switching to efficient drip irrigation systems, may incur significant initial expense. Though quite dependent upon the individual circumstances, it is expected that much of this activity would be economically efficient. Implementation of some form of incentive or aid program to spur these activities would be economically efficient to the suppliers.

6.2.4 Industrial Water Use

The savings potential in the industrial use sector is indeterminant. Being in large part a non-potable demand, transfer to lower quality supplies and recycling would provide major conservation opportunities. The fiscal and economic efficiency and practical feasibility of these activities would be specific to the circumstances of the individual users. Exploration and encouragement of these activities through an industrial water use audit program is likely to be an economically efficient means of pursuing these opportunities.

6.2.5 Unaccounted for Losses

Unaccounted-for losses can be reduced through leak detection surveys and system water audits. Available data indicate that about 10% of the water suppliers' permitted pumpage, about 90 million gallons per year, may be a reasonable estimate of the losses that can be recovered efficiently. Whether these efforts are only economically or fiscally efficient depends upon the particular circumstances.

6.2.6 Implementation Strategies

Even neglecting the industrial use sector, over 50% of the currently permitted pumpage within the BS/EACD area is subject to various conservation opportunities. Deriving means of purveying these measures to achieve significant water savings is the challenge facing BS/EACD. It is imperative that residential interior and landscape irrigation demand reductions be encouraged through direct interaction with the end users rather than conducting programs through the suppliers. Home water audits and landscape water audits could serve as the primary vehicles for informing the end users about their conservation opportunities and about the fiscal and economic efficiencies of their options. Other possibilities for direct aid include distributing toilet dams, low flow showerheads and efficient hose-end sprinklers; offering incentives for replacing turf with Xeriscaped areas; arranging for leaks to be repaired; providing real-time advisories on irrigation demand; providing an efficient irrigation schedule; and assisting in the purchase of timers and wet soil override switches.

Water suppliers should be sympathetic to efforts at reducing unaccounted-for losses, since those directly impact their cost margins. Leak detection surveys and water audits could be made affordable to small supply companies by collectively funding these activities, with the BS/EACD either providing the services directly or arranging for them to be passed through to the suppliers by other entities already possessing the capability to execute these programs.

Alterations in price structure is another opportunity for encouraging conservation. At present, the average price among suppliers at their winter average demand volume is about $3.39 per 1,000 gallons, while the average marginal rate is $1.70 per 1,000 gallons. It is suggested that, if it is expected that marginal costs would increase by any amount, marginal rates should at least approximate average rates in the base demand period. Systems should not subsidize "excess" use if it is expected that continuing to demand water at these "excess" rates would lead to increased supply system costs at some point in the foreseeable future. This is an area in which BS/EACD must invest considerable effort, because more economically efficient pricing structures would naturally promote the implementation of conservation opportunities by moving them from the economically efficient to the fiscally efficient category.

The BS/EACD conservation program should begin with a consideration of the necessity of conservation, which derives from the nature of the Edwards aquifer and the high costs of alternative supplies. Then, examination of the possibilities for conservation reveal the huge potential magnitude of possible savings. The attainable savings then derive from a consideration of what is practical to implement, with the primary determinant being cost efficiency. For those actions which appear economically efficient but not fiscally efficient at prevailing prices, various assistance and incentive programs can be considered to encourage their implementation. Those actions which appear fiscally efficient at present would be the subject of public education and general assistance programs. Finally, restructuring of prices to a more economically efficient form would enhance the fiscal efficiency of all conservation opportunities.

6.2.7 Summary of Recommendation

Listed below is a summary of the specific recommendations for action by the BS/EACD which are offered by this study. It is recommended that the issues impacting upon any given action be thoroughly reviewed before adopting these or any other set of recommendations.

6.2.7.1 Recommendations on Educational Programs

Educational efforts do not directly save any water. Rather, they sensitize people to the need to take water-conserving actions and facilitate obtaining information needed to pursue those actions. Any given educational effort may be more or less successful in reaching a specific audience, so it is not possible to assign a water savings potential to each effort. The following is a list of recommended educational programs (not shown in order of priority):

1. BS/EACD should participate in the funding of public school programs on water conservation;
2. BS/EACD should continue to serve as an information clearing-house, disseminating materials provided by other entities;
3. BS/EACD should develop its newsletter "The Water Line" into a source of information dealing directly with local conservation issues, such as providing information on the fiscal and economic efficiency of a given measure, sources of aid, sources of materials, etc.;
4. BS/EACD should, unilaterally or in conjunction with other local entities, produce a locally oriented Xeriscape brochure/booklet;

5. BS/EACD should conduct seminars and/or produce videos detailing the specifics of given conservation measures; and
6. BS/EACD should, unilaterally or in conjunction with other local entities and/or universities, implement demonstration programs.

6.2.7.2 Recommendations on Interior Water Demand

The recommendations for this category are listed below in order of priority, based upon the expected effort/expense for implementation and expected water savings which can be derived. It is projected that water savings available from all interior use efficiency measures could total over 200 million gallons per year if implemented throughout the BS/EACD. The following measures should be augmented by providing general information on the cost and availability of water conserving fixtures and appliances.

1. BS/EACD should, unilaterally or in conjunction with other local entities, implement a home water audit/leak repair/fixture retrofit program. The LCRA/PEC effort being planned might serve as an excellent vehicle for this effort;
2. BS/EACD should require that all toilets installed within its jurisdiction, whether in new construction or retrofit into existing buildings, meet a 1.6 gallon per flush standard; and
3. BS/EACD should implement a program to assist/encourage the replacement of all "old" toilets.

6.2.7.3 Recommendations on Landscape Irrigation

BS/EACD should implement a landscape audit program as a means of purveying opportunities for reduction of landscape irrigation demands. Most of the measures listed in Table 6.2-1 can be assisted and encouraged through this program. This program should be augmented by providing general information on Xeriscape and water efficient irrigation methods. Available data indicates that landscape irrigation demand within the district currently totals over 250 million gallons per year. Vigorous pursuit of all measures listed in Table 6.2-1 should reduce this demand by at least 50%.

6.2.7.4 Recommendations on Industrial Water Demand

Since demands in this category are almost exclusively non-potable, the potential for water savings approaches, at least theoretically, the permitted pumpage of about 209 million gallons per year.

1. BS/EACD should assist industries in evaluating the cost and feasibility of shifting their demands to alternate sources; and
2. BS/EACD should implement an industrial water audit program, as a vehicle for assisting and encouraging the implementation of the measures listed in Table 6.2-1.

6.2.7.5 Recommendations on Unaccounted-for Losses

It appears reasonable that about 10% of the permitted pumpage among all water supply systems may be saved by attainable reductions in unaccounted-for losses. This would total about 90 million gallons per year. BS/EACD should implement a water audit/leak detection service for its water supply systems, as a vehicle for achieving these savings.

6.2.7.6 Recommendations on Price-Related Issues

While it is not possible to assign a specific water savings potential to price-related measures, it is to be expected that creating a more economically efficient price structure would help the implementation of many water-saving measures.

1. BS/EACD should revise its rule regarding increasing block rate structures, affirming that the intent is to render tariffs more economically efficient;
2. BS/EACD should encourage the implementation of tariffs by its supply systems which reflect marginal cost pricing principles; and
3. BS/EACD should evaluate means of using its fee structure to penalize waste and to encourage the implementation of water-saving measures. If these evaluations indicate that those goals can be achieved by altering the fee structure in a non-regressive manner, this strategy should be implemented.

6.3 PRELIMINARY RECHARGE ENHANCEMENT STUDY

6.3.1 Background

The concept of aquifer recharge enhancement, or artificial recharge, as a means for augmenting the available supply of groundwater from an aquifer system has been studied and utilized across the country for many years. A variety of methods have been developed, including water spreading on the land surface, recharging through pits and channels, and well injection. The choice of a particular method for a given area is governed by local topographic, geologic and soil conditions; the quantity of water to be recharged; and the ultimate water use. Other factors that can influence the design and operation of an artificial recharge project include environmental considerations, climatic conditions, land values, water rights, legal constraints, and water quality.

For the Barton Springs segment of the Edwards aquifer, the most effective approach for recharge enhancement involves the use of dams and reservoirs on the recharging streams to capture and store stormwater runoff, which then can be infiltrated into the groundwater system either as seepage directly from the impoundments or, once released, as channel losses through the fractures and openings along the streambeds below the dams. In effect, these types of recharge facilities function to increase the volume of water that enters the aquifer naturally along the creeks and streams that cross the recharge zone.

During intense and/or extended rainfall periods, the quantity of stormwater runoff flowing down watercourses across the outcrop area often exceeds the available capacity for channel infiltration. For example, the peak discharge rates for streams in the BS/EACD area often exceed several hundred cubic feet per second during even the more frequent, smaller magnitude storm events, but, as indicated in Table 6.3-1, the maximum recharge rates of these streams generally are considerably less than these flow levels. Consequently, the excess runoff that cannot be infiltrated is discharged as streamflow past the downstream boundary of the recharge zone and, therefore, lost as a potential source of recharge water for the aquifer. By constructing dams on the watercourses either just upstream of or over the recharge zone, a portion of this excess runoff can be detained and, subsequently, allowed to infiltrate into the groundwater system. Releases from the impoundments can be made at prescribed rates that provide for maximum infiltration along the streambeds while minimizing the streamflow discharge downstream.

The use of off-channel reservoirs to capture stormwater runoff for direct infiltration into surface recharge features such as caves, sinkholes and fractures also offers some potential for recharge enhancement. The possibility of diverting either surface runoff or streamflows to these types of natural recharge features through channels or pipe systems may be an effective means for significantly increasing instantaneous recharge rates in local areas.

TABLE 6.3-1 WATERSHED RECHARGE CHARACTERISTICS FOR THE BARTON SPRINGS/EDWARDS AQUIFER

WATERCOURSE	RELATIVE RECHARGE CONTRIBUTION	MAXIMUM MEAN-DAILY RECHARGE RATE	DRAINAGE AREAS		
			ABOVE RECHARGE ZONE	WITHIN RECHARGE ZONE	TOTAL
	Percent	cfs	Sq. Mi.	Sq. Mi.	Sq. Mi.
Barton Creek	28	30 to about 70	111	9	120
Williamson Creek	6	13	6	7	13
Slaughter Creek	12	52	9	7	16
Bear Creek	10	33	14	6	20
Little Bear Creek	10	about 30	0	19	19
Onion Creek	34	about 120	124	42	166
Combined Watershed	100		264	90	354

6.3.2 Previously Investigated Recharge Projects

There have been several recharge projects previously evaluated by other investigators. In the mid 1980's prior to creation of the BS/EACD, several communities and governmental entities undertook preliminary studies to investigate the feasibility of constructing a major dam and reservoir on Onion Creek for purposes of developing an additional surface water supply and enhancing the natural recharge of the Barton Springs segment of the Edwards aquifer. As originally planned, this facility (Driftwood Dam and Reservoir) was to be located on the mainstem of Onion Creek immediately upstream of the recharge zone in northern Hays County about four miles southeast of the town of Driftwood and about eight miles west of the City of Buda.

This project was controversial because of local landowner opposition and environmental concerns. The proposed dam and reservoir were projected to cost over $35 million and to increase the natural annual recharge from about 12,300 acre-feet to over 21,500 acre-feet. Based on these figures the estimated unit cost of water in the ground resulting from this project has been calculated to be $1.32 per 1,000 gallons.

Another water supply reservoir on Onion Creek, referred to as Lake Dripping Springs, also has been proposed by the Hays County Water Development Board to serve the City of Dripping Springs and the surrounding area. The proposed site for this dam is approximately five miles south-southeast of Dripping Springs on Onion Creek. Lake Dripping Springs would be considerably smaller than the proposed Driftwood Reservoir, and based on firm annual yield studies, it potentially could provide a dependable water supply of about 4,700 acre-feet per year. This results in a raw water cost in the reservoir of about $0.80 per 1,000 gallons, including debt service and operation/maintenance costs.

The two projects described above could be incorporated into the long term goals of the BS/EACD. However, they are not projects that should be undertaken by the BS/EACD on a near-term basis due to high capital costs and complex institutional and environmental constraints.

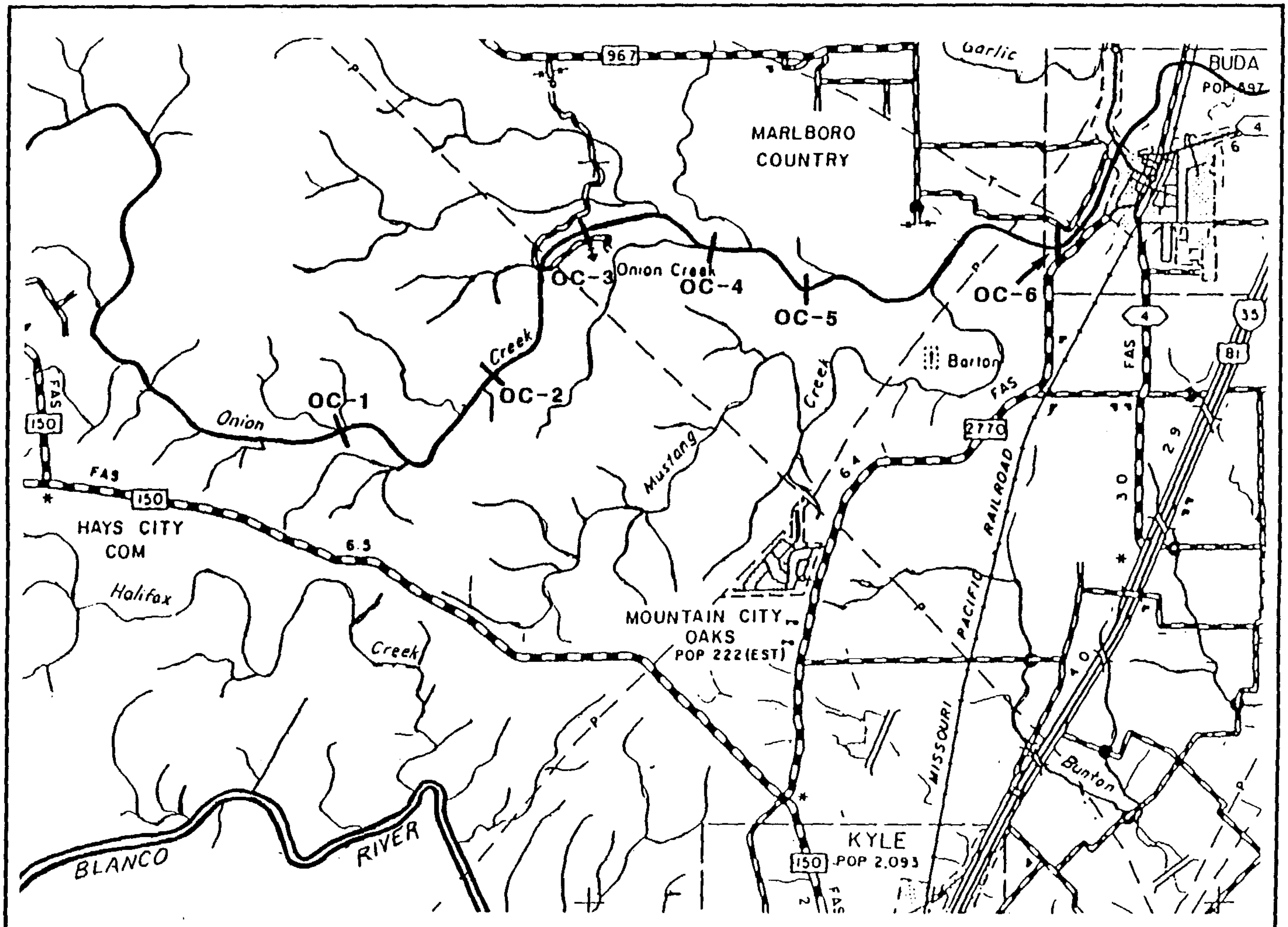
6.3.3 Recommended Recharge Facilities

As part of this, the preliminary feasibility of constructing a series of six channel dams on Onion Creek along the reach across the recharge zone and within the BS/EACD jurisdictional area has been investigated. As currently proposed, these facilities (see Figure 6.3-1) would have a combined capacity of approximately 815 acre-feet. Hydrologic analyses indicate that these projects could capture, on an average, 815 acre-feet of water approximately twelve times per year. This could potentially increase recharge to the Barton Springs segment of the Edwards aquifer by about 9,800 acre-feet per year.

Preliminary costs estimates indicate that all six projects could be implemented and constructed at a cost of about $3 million. The actual construction of the dams probably could be completed for about $250,000 each, with the remainder of the costs required for detailed engineering and hydrologic studies, facilities design, environmental impact assessments and mitigation, land acquisition and flood easements, state and federal permitting, general management and administrative activities, and contingencies.

Assuming that the six reservoirs on Onion Creek will provide an additional 5,000 acre-feet of recharge water to the Barton Springs segment of the Edwards aquifer and, therefore, will supplement the available groundwater supply by this amount, the unit cost of this water would be less than $0.25/1,000 gallons. This figure is based on a total capital cost of $3,000,000, annual operation and

FIGURE 6.3-1 MAP OF ONION CREEK SHOWING CHANNEL RESERVOIR LOCATIONS



maintenance costs of $30,000, and 10-percent, 25-year financing. This unit cost of water compares favorably with that estimated for the recharge water provided by the mainstem Driftwood Reservoir project of $1.32/1,000 gallons.

6.3.4 Conclusions and Recommendations

The study of recharge enhancement for the Barton Springs segment of the Edwards aquifer has identified the following specific conclusions and recommendations regarding the potential for implementing projects to increase the available water supply of the groundwater system:

1. There is substantial surface water runoff available in the watersheds that drain to and across the recharge zone of the Barton Springs segment of the Edwards aquifer that could be captured and used to increase the natural recharge of the aquifer;

2. Successful recharge enhancement projects have been implemented for other portions of the Edwards aquifer, particularly west of San Antonio in Medina County by the Edwards Underground Water District;

3. Preliminary cost estimates for implementing large-scale mainstem dam and reservoir projects for enhancing the recharge of the Barton Springs segment of the Edwards aquifer indicate that the unit costs of water developed by these projects generally would be consistent with those of other large reservoir projects in Texas;

4. Based on preliminary studies, the construction of small channel dams and reservoirs on the creeks and streams that cross the recharge zone appears to be the most attractive

alternative for recharge enhancement, with affordable unit costs of water and reduced environmental impacts. It is recommended that the BS/EACD proceed with more detailed studies to develop a specific channel dam recharge enhancement project on one or more of the contributing creeks and streams;

5. Onion Creek offers the most potential for increasing the available groundwater supply through recharge enhancement because it has the largest drainage area upstream of and over the recharge zone, its streambed exhibits high rates of infiltration capacity, and it is the farthest removed from the principal outlet of the aquifer at Barton Springs, such that any additional recharge from the creek must move through the entire length of the groundwater system where it would be available for pumpage;

6. It is recommended that more detailed geologic, hydrologic, siting, and cost analyses of a recharge enhancement channel dam and reservoir facility be undertaken to develop a specific project for implementation on Onion Creek;

7. With results available from the detailed studies, it is recommended that the BS/EACD undertake preparation of an Engineering Report for the recharge enhancement project using guidelines in Section 363.55 of the Texas Water Code titled "Required Engineering Feasibility Data for Water Supply Projects";

8. Following preparation of the Engineering Report, it is recommended that the BS/EACD submit an application to the Texas Water Development Board for financing assistance for construction of the recharge enhancement project; and

9. The BS/EACD should initiate efforts to coordinate the development of a comprehensive recharge enhancement and management program for the Barton Springs segment of the Edwards aquifer with the LCRA, the City of Austin, Travis County, Hays County, and the USGS.

6.4 DROUGHT CONTINGENCY PLAN (DCP)

This DCP provides recommended standards for determining the extent and duration of drought conditions, including stages of drought severity. Severity stages are defined by hydrologic and water level parameters for wells and springs to be monitored by the BS/EACD. The recommended actions and demand reduction measures discussed in the remaining sections of this report generally followed the BS/EACD Conservation/Drought Committee guidelines.

Upon declaration of a drought, users should be encouraged and, possibly, required to initiate demand reduction measures to reduce aquifer pumping. Minimum demand reduction measures are defined herein. Additional measures may be identified and implemented by the BS/EACD, as needed, to ensure the fulfillment of the goals of this DCP.

The goals and objectives set-forth by the BS/EACD Conservation/Drought Committee requires that the following criteria be addressed and achieved:

1. Assure an adequate quantity of water is available at all wells;
2. Assure that a suitable quality of water is available for supply; and
3. Assure that Barton Springs discharges do not fall appreciably below historic low levels.

6.4.1 Stages and Triggers

There are three defined stages of drought severity and associated triggers. The stages are as follows:

1. Alert Status
2. Alarm Status
3. Critical Status

Implementation of demand reduction measures will always begin with the requirements of the Alert Status. Each subsequent drought management stage will be declared by the BS/EACD in progression. When management conditions are not prescribed with those outlined in the section, the BS/EACD will exercise discretion in determining when to declare respective stages.

6.4.1.1 Alert Status

The Alert Status should commence when the following conditions are observed on 14 consecutive days[1] (moving average) at any or all of the following wells (see Table 6.4-1 and Figure 6.4-1) and in the opinion of the BS/EACD and its Board of Directors aquifer conditions warrant the execution of this status:

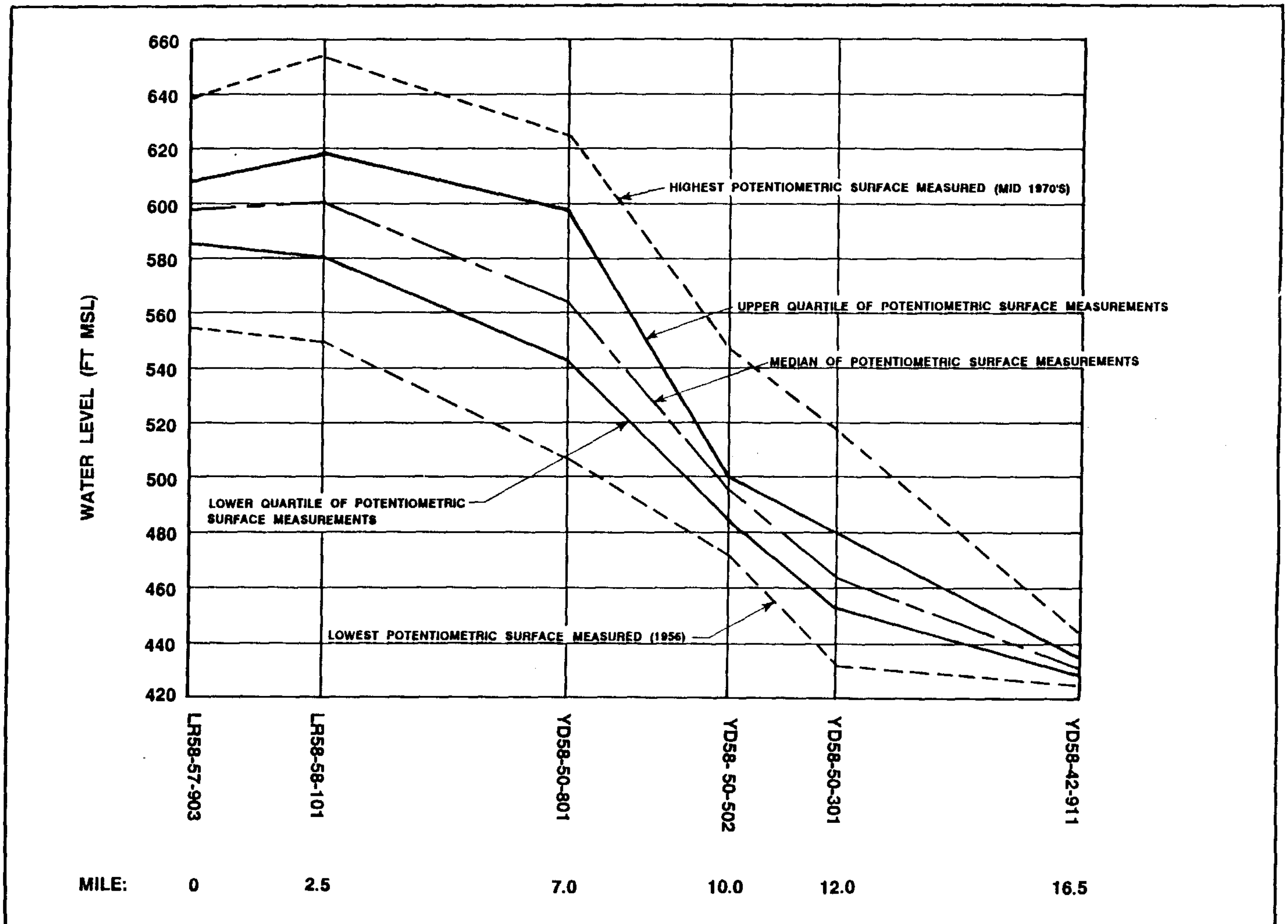
For Well Nos:	Water Levels Decline Below Historic Median Values:
LR58-57-903	596.77 ft msl
LR58-58-101	599.81 ft msl
YD58-50-801	564.55 ft msl

[1] If hydrologic events unfold more rapidly than within 14 days, the BS/EACD may respond as necessary.

TABLE 6.4-1 PHYSICAL DESCRIPTION OF SELECTED EDWARDS AQUIFER WELLS

WELL NO.	OWNER	AQUIFER CONDITION	DATE COMP.	WELL DEPTH	ALT. (MSL)	PURPOSE OF WELL
LR58-57-903	MOUNTAIN CITY RANCH	WATER TABLE	1943	400	822	TWDB OBSERVATION WELL
LR58-58-101	FRANKLIN	WATER TABLE	1907	243	707.2	TWDB OBSERVATION WELL
YD58-50-801	C. H. BIRD	ARTESIAN	1939	277	662	TWDB OBSERVATION WELL
YD58-50-502	R. W. HERNDON	ARTESIAN	1937	300	740	TDWB OBSERVATION WELL
YD58-50-301	JOHN LOVELADY	ARTESIAN	1949	388	640	TWDB OBSERVATION WELL
YD58-42-911	BEE CAVE PROPERTIES	ARTESIAN	1920'	135	517	USGS OBSERVATION WELL

FIGURE 6.4-1 PLOT OF HISTORICAL WATER LEVEL STATISTICS FOR SELECTED WELLS



YD58-50-502	495.90 ft msl
YD58-50-301	463.40 ft msl

The observation wells shown above represent different (1) portions of the Edwards aquifer, (2) water use sectors, and (3) localized recharge conditions. Therefore, it is possible that one or more wells may trigger an Alert Status, while others will not. In this case, localized Alert Status could be issued in accordance with the provision described below.

During this stage, the BS/EACD could provide bi-weekly (every two weeks) press releases to local newspapers and electronic media notifying the public of the Alert Status. The BS/EACD may request voluntary lawn watering curtailment and a reduction in irrigation. In addition, the BS/EACD could commence weekly water level monitoring of the wells listed above.

This trigger could be discontinued when water levels rise in the observation wells for more than 14 consecutive days (moving average), or in the judgement of the BS/EACD that this condition no longer exists.

6.4.1.2 Alarm Status

The Alarm Status should commence when any or all of the following conditions are observed for 14 (see Table 6.4-1 and Figure 6.4-1) consecutive days[2] and in the opinion of the BS/EACD and its Board of Directors aquifer conditions warrant the execution of the status:

[2] If hydrologic events unfold more rapidly than within 14 days, the BS/EACD may respond as necessary.

I. Observation Wells

For Well Nos:	Water Levels Decline Below Historic Lower Quartile:
LR58-57-903	584.44 ft msl
LR58-58-101	580.19 ft msl
YD58-50-801	541.22 ft msl
YD58-50-502	485.20 ft msl
YD58-50-301	452.82 ft msl

II. Water Quality

A. As aquifer water levels approach historical lows, public supply wells along and near the bad water line, and in the water table zone should be monitored for total dissolved solids (TDS) on a weekly basis. This monitoring program should begin when water level conditions shown above prevail and/or Barton Springs monthly-mean discharge falls below 30 cfs. The BS/EACD should maintain a high degree of flexibility in using these conditions for initiating a more intensive monitoring program.

B. The District should verify that the quality changes observed in the impacted public water supply are a result of decreased water levels.

C. The District should review data from the monitor wells along the saline water line and other public water supply wells to determine if other wells are exhibiting increased TDS concentrations which correlate to decreasing water levels.

In this stage, the BS/EACD could provide weekly press releases to local newspapers and electronic media. The BS/EACD could publish water level, quality information, and projections of ground water declines. Forecast of remaining local supplies should be made available to the public.

In addition, the BS/EACD should monitor observation wells at a minimum of three times per week. Mandatory curtailment of outside water use for industrial and commercial should be enforced. All major water suppliers should be advised that mandatory curtailments in water usage are forth-coming if "system" water use is not reduced. Voluntary curtailment for individual well supplies could be requested.

The Alarm Status could cease when the above described conditions do not exist for 14 consecutive days or in the judgement of the BS/EACD that an emergency condition no longer exists.

6.4.1.3 Critical Status

The Critical Status should commence when any or all of the conditions presented herein are observed for 14 (see Table 6.4-1 and Figure 6.4-1) consecutive days[3] and in the opinion of the BS/EACD and its Board of Directors aquifer conditions warrant the execution of this status.

I. Observation Wells

For Well Nos:	Water Levels Decline Below Historic Low:
LR58-57-903	554.02 ft msl
LR58-58-101	550.66 ft msl
YD58-50-801	505.88 ft msl
YD58-50-502	479.27 ft msl
YD58-50-301	431.00 ft msl

[3] If hydrologic events unfold more rapidly than within 14 days, the BS/EACD may respond as necessary.

II. Water Quality

The BS/EACD could declare an Aquifer Emergency Warning when the concentration of TDS or conductivity in any public water supply well increases to 30% above the historical average and exceeds previous maximum concentrations. An Aquifer Emergency Warning does not signify that unacceptable deterioration of water quality has actually occurred. The purpose of the Warning is to initiate further detailed analyses to determine whether significant changes in water quality are occurring in the aquifer and, if so, appropriate responses to those changes.

The BS/EACD should also monitor wells along and near the bad water line, artesian zone and water table zone at a minimum of three times a week. This monitoring program should begin when water level conditions shown above prevail and/or Barton Springs monthly-mean discharge falls below 10 cfs. The BS/EACD should maintain a high degree of flexibility in using these conditions for initiating a more intensive monitoring program.

If the water level and quality analyses indicate that supplies will be depleted or water quality is deteriorating to a point of being non-potable, the BS/EACD should identify emergency supply options and develop a schedule for implementation. If an Aquifer Emergency Warning is declared, the BS/EACD should identify additional measures that may include a maximum per capita allotment for utilities, and reduction or cessation of industrial output and agricultural irrigation. In the most critical situation, the BS/EACD may instigate the interconnect of public water systems to prevent localized water shortages or depletions.

The Critical Status should cease when the above described conditions do not exist for 14 consecutive days or in the judgement of the BS/EACD that an emergency condition no longer exists.

6.4.2 Water User's Responses

Upon declaration of each drought management stage, water users should be expected to reduce their water use. To this end, two mechanisms could be used. The first mechanism is to achieve recommended water use reduction goals established for each stage. The goals define percentage reductions in base usage. The second recommended mechanism is to require each user to implement specific minimum demand reduction measures. Users could develop individual User Drought Contingency Plan (UDCP), which describe how each of these two mechanisms could be implemented within their respective service areas or operations.

6.4.3 Reduction Goals

Reduction goals of 10%, 20%, and 30% should be established for each drought management stage, respectively. All water purveyors (BS/EACD permittees) should be required to achieve these reductions, or at a minimum these reductions should be achieved on an aquifer-wide basis. Each of these entities should be required to develop UDCPs which achieve the recommended reduction goals.

6.4.4 Target Pumpage Volume

The reduction goal percentage should be applied to the volume pumped by each user based on a fixed three year pumping average (usage). The target pumpage volume should be the total amount which can be used during any successive 12-month period, unless either a more restrictive or a less restrictive drought management stage is declared. The target pumpage volume may be prorated over the coming year by the user in accordance with the user's requirements. A monthly water budget may be established by the BS/EACD for each permitted in each drought stage. Use in excess of the water budget could be subject to a "punitive" water rate or other penalty.

Excess revenues derived from any punitive water rate could be dedicated to water conservation programs.

If no pumpage data are available for a user, the user could calculate the average annual use per connection for similar users in the area. The target pumpage volume could be this per connection average, minus the reduction goal for the applicable stage.

6.4.5 User Drought Contingency Plans

The BS/EACD's DCP could require the development of User Drought Contingency Plan (UDCP). Each permittee could be required to prepare, adopt, and implement UDCPs consistent with this DCP.

Upon receiving notification from the BS/EACD that drought response measures are needed, users could be required to initiate action according to their approved UDCPs. They could also be required to enforce use restrictions in their respective service areas.

6.4.5.1 Required UDCP Content

UDCPs developed by BS/EACD permittees could, at a minimum, include the following:

1. Those demand reduction measures specified above;
2. Additional demand reduction measures developed by the permittee which, when combined with the required measures achieve the reduction goals of this plan;
3. Financial measures which encourage compliance with the DCP and maintain financial stability of the permittee during a drought;

4. Provision for the ordinances, regulations or contractual requirements necessary for the permittee to enforce the DCP and the UDCP; and
5. Provisions for reporting water pumpage.

6.4.5.2 UDCP Implementation

For Alert Status, the reduction goal of 10% could be met through voluntary compliance with restrictions achieved through increased public awareness. If a 10% reduction goal is not achieved, the BS/EACD may implement non-voluntary reduction measures. Water waste could be prohibited. Waste is defined as any use which allows water to run off into a gutter, ditch or drain, or the failure to repair a controllable leak. This definition includes, hosing down sidewalks and driveways and allowing a hose to run while washing vehicles.

Beginning with Alarm Status, mandatory compliance could be required to achieve the reduction goals of 20%. Water purveyors could consider technical assistance programs, which encourage, alternative and/or supplemental water supply sources, and adjustments in water rates to offset lost revenues. Industrial users could be encouraged to consider alternative and/or supplemental water supply sources.

During the Critical Status stage, a 30% reduction in water use could be required. Water purveyors may need to establish allocations for customers, enact penalties for exceeding the allocations and place flow restrictors on meters of customers who repeatedly exceed their allocation. Industrial users could consider alternative and/or supplemental water supply sources.

6.4.6 Reporting

Users should report volumes pumped from the aquifer during both drought and non-drought conditions. The frequency of reporting should increase upon declaration of Alert Status, and continue at the increased frequency until drought conditions cease to exist. Larger users should report more frequently than smaller users. Recommended reporting frequency requirements for each category of user are shown in Table 6.4-2.

6.4.7 Recommended BS/EACD Actions

The BS/EACD could adopt rules to implement this recommended DCP. The BS/EACD could also review and approve variances from the requirements of this plan. It could monitor the hydrologic parameters used as trigger conditions, notify news media and permittees of water resource conditions and appropriate drought management responses, enforce the DCP, and review and revise the plan as necessary.

The BS/EACD should perform forecasts of water level and water quality changes. If drought conditions or changes in stages are projected, the BS/EACD should notify all permittees by mail at least 20-days in advance, whenever possible. Notification should include a description of pending drought or non-drought conditions (stages) and expected user response.

The BS/EACD could assist non-exempt well permittees and water users by providing concise descriptions of TWC's rules and regulations concerning water tariffs/rates and emergency water rationing programs. The BS/EACD could make available educational materials on rate structure and related tariff changes that may be necessary to successfully implement this recommended DCP and UDCPs. The

BS/EACD could submit this DCP and associated rules, if developed, to the TWC for review and comment.

6.4.8 Rules

The BS/EACD should begin the procedure to adopt rules for implementing the DCP. The BS/EACD could conduct public hearings to receive comments on the proposed rules.

6.4.9 Variances

The BS/EACD could institute a mechanism whereby variances can be obtained to this plan or adopted rules. Any user seeking a variance could file the appropriate request or include the variance request in its UDCP in accordance with procedures established by the BS/EACD. The user should be required to identify the requirement(s) for which the variance(s) is sought, to justify the variance and to identify the demand reduction measures which may be implemented. A variance request should be justified by a unique economic or financial hardship which is not experienced by other similar users. The user could also provide the BS/EACD with information and data supporting the request.

The BS/EACD should evaluate each variance request on the merits described in the application. In evaluating a request, the BS/EACD should consider factors such as the user's water use efficiency, demonstrated health and safety concerns, and economic/financial considerations. The BS/EACD may conduct a public hearing on variance requests, and it could approve or disapprove each request in accordance with established procedures. The approval should specify the period of time that the variance will be in effect. The user should receive written notification of the BS/EACD's action.

6.4.10 Monitoring

The BS/EACD should monitor the hydrologic parameters used as trigger conditions. Data should be collected and analyzed as frequently as necessary to provide advance information about trends.

The BS/EACD could be responsible for monitoring aquifer pumpage and developing report forms for users required to report pumpage.

SECTION 2 REPORT

REGIONAL WATER PLAN
for the
BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

FACILITY PLANS FOR UTILITY INTERCONNECT

prepared for

BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT
Austin, Texas

and

TEXAS WATER DEVELOPMENT BOARD
Planning Grants Assistance Program
Austin, Texas

TWDB CONTRACT NO. 9-483-732

prepared by

DONALD G. RAUSCHUBER & ASSOCIATES, INC.
Austin, Texas

in association with

FISHER, HAGOOD, HAMILTON & HEJL
Round Rock, Texas
(PRINCIPAL INVESTIGATOR)

SEPTEMBER 1990

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2.0 PUBLIC WATER SYSTEMS EMERGENCY INTERCONNECTION

2.1 PURPOSE OF STUDY

The purpose of this study was to develop facility plans that would provide for the interconnection of public water supply systems, located within the Barton Springs/Edwards Aquifer Conservation District (BS/EACD), in times of emergency. System interconnections may be short or long term depending on the type of emergency, i.e., extended drought, hazardous/toxic chemical or material contamination, power failures, intrusion of bad water creating water quality problems and so forth.

Recommendations are made for facility and administrative requirements to assist BS/EACD water systems in implementation of the interconnect improvements. The interconnect facilities were sized to provide a "threshold value" of water use. This value will be discussed in Section 2.7.

2.2 INVENTORY OF EXISTING WATER SYSTEMS

An inventory of existing water systems for the interconnect study was performed. Table 2.1 presents a list of the major water systems evaluated in this interconnect study by primary user class identification, Texas Water Commission Certificate of Convenience and Necessity (CCN) number, and system name.

Exhibit No. 1 (Section 6 - Facility Planning Maps) presents Certificate of Convenience and Necessity service area limits for the above water suppliers as of December, 1989, records on file at the Texas Water Commission. The CCN service areas are an integral

TABLE 2.1 INTERCONNECT STUDY WATER SYSTEM LIST

NO.	CCN NO.	NAME	USER CLASS
1.	11341	Aquatex Water Supply	Single Family
2.	11117	Arroyo Doble Water System	Single Family
3.	None	CenTex Material	Industrial
4.	11247	Chaparral Water Co.	Single Family
5.	None	Chatleff Control Inc.	Industrial
6.	12140	Cimarron Park Water Co. Inc.	Single Family
7.	None	City of Austin	Irrigation
8.	11953	City of Buda	Single Family and Commercial
9.	10300	City of Sunset Valley	Single Family
10.	None	Comal Tackle Company	Industrial
11.	None	Copper Hills Subdivision	Single Family
12.	11029	Creedmoor-Maha WSC	Mixed Use
13.	None	Dellana Hills	Single Family
14.	11457	Estate Utilities	Single Family
15.	None	G&J Water District	Single Family
16.	11356	Goforth WSC	Mixed Use
17.	None	Harold Hicks & Al Schuster	Mobile Homes
18.	None	Hays CISD Dahlstrom MS	Supplies
19.	None	Hays CISD Jack C. Hays HS	Supplies
20.	None	J.D. Malone	Single Family
21.	10880	Liesurewoods Water	Single Family
22.	None	Marbridge Foundation	Mental Health/ Mental Impaired
23.	None	Mooreland Water System	Single Family
24.	11427	Mountain City Oaks WS	Single Family
25.	None	Mystic Oaks Water Co-Op	Single Family
26.	12086	Oak Forest Highlands	Mobile Homes
27.	10299	Plum Creek Water	Mixed Use
28.	11846	Shady Hollow Estates WSC	Single Family
29.	11725	Slaughter Creek Acres WSC	Single Family
30.	11813	Southwest Territory WC	Single Family
31.	10303	Ridgewood Village WS	Single Family
32.	Under Chaparral CCN No.	Bear Creek Park (by Chaparral Water Co.)	Single Family
33.	Under Chaparral CCN. No.	Onion Creek Meadows (by Chaparral Water Co.)	Single Family
34.	None	Texas-Lehigh Cement Co.	Industrial
35.	None	Tilson Custom Homes	Commercial
36.	None	Village of San Leanna	Residential
37.	11971	Huntington Estates	Residential

part of the interconnect recommendations presented later in this chapter.

2.3 IDENTIFY EXISTING MAJOR FACILITIES

Operators of the water systems inventoried in Table 2.1 were requested to respond to a questionnaire (see Appendix A) concerning identification of major facilities, including facility maps. Exhibit No. 2 (Section 6 - Facility Planning Maps) presents location of existing facilities as provided by water suppliers. Resources from the Texas Water Commission (TWC), Texas Water Development Board (TWDB), and Texas Department of Health (TDH) were utilized for additional information not available from the water suppliers. The City of Austin provided existing water system maps for the study. A compilation of systems showing their respective facilities, including rated capacities and sizes of system components is shown in Appendix B.

The potential for water system interconnections is illustrated in Exhibit No. 2 (Section 6 - Facility Planning Maps). Several systems at various locations within the BS/EACD are clustered. The logistics of these systems make it viable for interconnecting facilities. A more detailed discussion for system interconnections is presented in Section 2.8.

2.3.1 SUPPLY SOURCES

2.3.1.1 Groundwater

Other than the City of Austin water system, the remaining BS/EACD water suppliers are dependent on groundwater as the sole source of potable water supply. The Creedmoor-Maha Water Supply Corporation does have an emergency interconnection with the City of Austin water line as shown in Exhibit No. 2. All the BS/EACD service area suppliers rely on the Barton Springs segment of the Edwards aquifer for water supply. Table 2.2 presents well identification number, depths of wells, and pumping capacities for each of the study water suppliers.

In 1989, the approximate annual permitted pumpage for the suppliers was over one billion gallons. The aquifer provides a high quality of water which in most cases requires only chlorination as treatment prior to delivery.

The U.S. Geological Survey (USGS, 1986) provided a thorough investigation of the hydrogeological makeup of the Barton Springs segment of the Edwards Aquifer. Appendices C, D, E, and F contain graphs from the above referenced report that illustrate depths of the aquifer measured by monitor wells located at cross-sections within the BS/EACD Service Area. Some conclusions reached by the USGS (1986) that are relevant to this investigation are as follows:

1. Outcrop of the Barton Springs segment of the Edwards aquifer is widest at the most southern location in Hays County located approximately three miles west of the City of Kyle along Highway 150, extending approximately 8 miles wide west along FM 150 and FM 3237;

2. Outcrop of the Barton Springs segment of the Edwards aquifer narrows as it approaches Town Lake in Austin. Its width is approximately 2.5 miles with Barton Springs bordering the eastern edge and the City of Rollingwood bordering the western edge;

3. The thickness of available "potable" water in the Edwards Formation is approximately 400 feet in a north-south direction extending from Interstate Highway 35 (IH 35) on the east edge to approximately 3 miles to the west;

TABLE 2.2 WATER SUPPLIERS AND WELL FACILITIES

Water Supplier	Well #	Well ID#	Well Depth	Pumping Rate
1 AquaTex Water Supply	1	58-50-858	380'	60 GPM
	2	58-50-856	350'	N.A
	3	58-50-857	358'	N.A
2 Arroyo Doble WS	1	58-50-845	380'	142 GPM
	2	58-58-215	440'	119 GPM
3 CenTex Material	1	58-58-414	200'	1197 GPM
	2	58-58-414	200'	943 GPM
4 Chaparral Water Co.	1	58-49-910	400'	15 GPM
	2	58-49-911	420'	5 GPM
	3	58-49-915	400'	20 GPM
	4	58-49-918	400'	25 GPM
	5	58-49-912	720'	55 GPM
	6	58-49-913	850'	55 GPM
	7	58-49-914	850'	32 GPM
	8	58-49-919	420'	5 GPM
	9	58-49-920	420'	5 GPM
	10	58-49-916	420	5 GPM
	11	58-49-917	420'	5 GPM
5 Chatleff Control Inc.	1	58-58-509	500'	54 GPM
6 Cimarron Park WC Inc.	1	58-58-114	490'	175 GPM
	2	58-58-102	400'	675 GPM
7 City of Austin Wells	1	58-49-907	52'	350 GPM
	2	58-49-906	50'	503 GPM
	3	58-49-909	51'	465 GPM
	4	58-49-917	55'	503 GPM
8 City of Buda	1	58-58-403	390'	250 GPM
	2	58-58-106	380'	100 GPM
	3	58-58-413	740'	600 GPM
9 City of Sunset Valley	1	58-50-221	360'	N.A.
	2	58-50-222	360'	N.A.
	3	58-50-223	30'	120 GPM
10 Comal Tackle Company	1	58-58-416	240'	25 GPM
11 Copper Hills Subdivision	1	58-49-921	420'	5 GPM
	2	58-49-922	420'	23 GPM
	3	58-49-923	420'	19 GPM
	4	58-49-924	420'	6 GPM
12 Creedmoor-Maha WSC	1	3 WELLS	NOT.AV.	900 GPM
	2	3 WELLS	NOT.AV.	580 GPM
13 Dellana Hills	1	58-42-813	300'	25 GPM
	2	58-42-814	300'	20 GPM
14 Estate Utilities	1	58-58-115	325'	500 GPM
	2	58-58-111	303'	90 GPM
15 G&J Water District	1	58-42-622	300'	35 GPM
16 Goforth WSC	1	58-58-501	640'	300 GPM
	2	58-58-506	640'	450 GPM
	3	58-58-507	740'	1500 GPM
	4	58-58-508	740'	1500 GPM
17 Harold Hicks & Al Schuster	1	58-50-723	415'	55 GPM

TABLE 2.2 WATER SUPPLIERS AND WELL FACILITIES (CONTINUED)

Water Supplier	Well No.	Well ID#	Well Depth	Pumping Rate
18 Hays CISD - MS	1	58-57-307	470'	150 GPM
19 Hays CISD - HS	1	58-57-901	575'	N.A.
20 J.D.Malone	1	58-50-852	425'	40 GPM
21 Liesurewoods Water	1	58-58-102	400'	140 GPM
	2	58-58-118	440'	135 GPM
	3	58-58-119	440'	105 GPM
	4	58-58-120	406'	150 GPM
	5	58-58-121	410'	375 GPM
	6	58-58-108	548'	0 GPM
22 Marbridge Foundation	1	58-50-703	500'	90 GPM
	2	58-50-704	400'	400 GPM
	3	58-50-725	500'	90 GPM
	4	57-50-727	500'	90 GPM
	5	58-50-728	400'	90 GPM
23 Mooreland WS	1	58-50-8S	408'	100 GPM
24 Mountain City Oaks WS	1	58-57-910	405'	175 GPM
25 Mystic Oaks WC	1	58-58-202	400'	38 GPM
	2	58-58-216	400'	16 GPM
26 Oak Forest Highlands	1	58-50-843	450'	100 GPM
	2	58-50-843	450'	100 GPM
27 Plum Creek WC	1	58-58-409	670'	N.A.
	2	58-58-412	720'	500 GPM
	3	58-58-419	700'	N.A.
	4	58-58-708	675'	N.A.
28 Shady Hollow Estates WSC	1	58-50-731	438'	200 GPM
29 Slaughter Creek Acres WSC	1	58-50-829	420'	75 GPM
	2	58-50-830	420'	45 GPM
30 Southwest Territory WC	1	58-49-927	500'	36 GPM
	2	58-49-928	820'	120 GPM
	3	58-49-929	420'	24 GPM
31 Ridgewood Village WS	1	58-42-823	310'	165 GPM
32 Bear Creek Park	1	58-50-732	320'	63 GPM
	2	58-50-733	280'	39 GPM
33 Onion Creek Meadows	1	58-58-207	445'	85 GPM
	2	58-58-208	520'	83 GPM
34 Texas-Lehigh Cement Co	1	58-58-406	N.A.	N.A.
	2	58-58-407	343'	700 GPM
	3	58-58-408	N.A.	N.A.
35 Tilson Custom Homes	1	58-58-7B	450'	20 GPM
36 Village of San Leanna	1	58-50-827	473'	70 GPM
	2	58-50-838	475'	68 GPM
	3	58-50-855	500'	115 GPM
37 Huntington Estates	1	58-57-308	405'	192 GPM

SOURCE: BS/EACD

4. The saturated thickness of the "potable" water zone in the Edwards Formation ranges from 120 to 400 feet in an westerly direction for approximately 10.5 miles west of IH 35; and

5. Edwards water immediately east of IH 35 generally contains over 1,000 milligrams per liter (mg/l) total dissolved solids and in most cases exceeds 3,000 mg/l total dissolved solids further east of IH 35.

In summary, aquifer water suppliers having well locations west of IH 35 in the thickest available water sections of the Barton Springs segment of the Edwards aquifer provide the best potential for interconnects to suppliers located further west in the BS/EACD.

2.3.1.2 Surface Water

The only source of surface water within the BS/EACD service area is the City of Austin. Austin's existing treated water transmission lines are presented on Exhibit No. 2 (Section 6 - Facility Planning Maps). Hays County Water Development Board prepared a study (HCWDB, 1988) for Hays County which developed and evaluated future water supply alternatives.

2.4 PREPARE LOCATION MAP OF EXISTING FACILITIES/WATER SYSTEMS

As discussed earlier, there are groups of systems logistically located near one another. This clustering of systems provides the best potential for emergency interconnections. Exhibit No. 2 (Section 6 - Facility Planning Maps) presents existing facility locations for the major water suppliers located within the BS/EACD. This information seemed to be most important for use in the interconnect facility plans. Exhibit No. 2 provided the base data for developing Exhibit No. 3 - Proposed Facility Plan Map of

Interconnecting Water Suppliers (see Section 6 - Facility Planning Maps).

2.5 DETERMINE SERVICE AREA AND CUSTOMER BASE

The combined water service area of existing suppliers generally comprises all of the BS/EACD jurisdictional boundaries. Due to geographical location of certain water systems, a few water suppliers could not be practically or economically interconnected.

2.6 POPULATION ESTIMATES

Table 2.3 presents years 1990 through 2010 population estimates. This information was developed by using projections provided in the HCWDB Study and from annual TDH water system survey reports. As can be noted, several systems are limited to "build out" growth in the subdivision in which they are located. These systems were estimated to grow at an annual growth rate of 2% until all lots within the Subdivision were provided service. As "build out" occurred a no growth condition was used.

2.7 CALCULATE WATER DEMANDS

Water demands for facility interconnects were based on a threshold water use. For this analysis, threshold water use was defined as an average per capita water use in gallons per day needed to satisfy basic human consumption purposes. This value has been determined to be 50 gallons per capita per day. The threshold value represents an average 60% of daily per capita water use for December through February recorded water uses in the BS/EACD.

Applying this established gpcd usage to population projections shown in Table 2.3 provides the estimated average daily threshold water use presented in Table 2.4.

TABLE 2.3 BS/EACD PROJECTED POPULATION GROWTH FOR WATER SUPPLY SYSTEMS

Water Supplier	1990 Meters	1990 Pop	2000 Meters	2000 Pop	2010 Meters	2010 Pop
1 AquaTex Water Supply	68	180	82	217	90	238
2 Arroyo Doble Water System	266	800	324	974	325	977
3 CenTex Material-Industrial	-	-	-	-	-	-
4 Chaparral Water Co.	138	400	143	414	143	414
5 Chatleff Control-Indust.	-	-	-	-	-	-
6 Cimarron Park WC Inc.	426	1250	519	1523	562	1649
7 City of Austin Wells-Irrg.	-	-	-	-	-	-
8 City of Buda	544	1500	663	1828	808	2228
9 City of Sunset Valley	77	231	94	282	115	345
10 Comal Tackle Co.-Indust.	-	-	-	-	-	-
11 Copper Hills Subdivision	6	18	16	48	26	84
12 Creedmoor-Maha WSC	1300	4500	1585	5487	1932	6688
13 Dellana Hills	25	75	26	78	26	78
14 Estate Utilities	82	310	100	378	122	461
15 G&J Water District	16	68	16	68	16	68
16 Goforth WSC	1205	3615	1469	4407	1791	5373
17 Harold Hicks & Al Schuster	50	160	57	180	62	200
18 Hays CISD - Dahlstrom MS	-	-	-	-	-	-
19 Hays CISD - Jack C.Hays HS	-	-	-	-	-	-
20 J.D.Malone	47	140	53	160	60	180
21 Liesurewoods Water	400	1100	420	1155	420	1155
22 Marbridge Foundation	33	364	33	397	33	430
23 Mooreland Water System	33	200	33	200	33	200
24 Mountain City Oaks WS	138	405	168	493	205	602
25 Mystic Oaks Water Co-op	39	135	45	156	45	156
26 Oak Forest Highlands	28	84	40	120	51	154
27 Plum Creek Water	733	2200	894	2683	1090	3270
28 Shady Hollow Estates WSC	42	126	51	153	62	186
29 Slaughter Creek Acres WSC	70	250	85	304	100	357
30 Southwest Territory WC	100	300	113	339	113	339
31 Ridgewood Village WS	74	200	90	243	110	297
32 Bear Creek Park	89	260	93	272	93	272
33 Onion Creek Meadows	224	650	263	763	263	763
34 Texas-Lehigh Cement	-	-	-	-	-	-
35 Tilson Custom Homes	5	15	5	15	5	15
36 Village of San Leanna	131	380	160	464	195	566
37 Huntington Estates	1	3.5	20	70	40	140
TOTAL	6390	19919	7660	23874	8936	27885

TABLE 2.4 THRESHOLD VALUE FOR ESTIMATED DAILY WATER USE (GPD)

NAME	Year 1990	Year 2000	Year 2010
AquaTex Water Supply	9,000	10,850	11,900
Arroyo Doble Water System	40,000	48,700	48,850
CenTex Material[1]	-	-	-
Chaparral Water Co.	20,000	20,700	20,700
Chatleff Control Inc.[2]	-	-	-
Cimarron Park Water Co.Inc.	62,500	76,150	82,450
City of Austin Wells[3]	-	-	-
City of Buda	75,000	91,400	111,400
City of Sunset Valley	11,550	14,100	17,250
Comal Tackle Co.[4]	-	-	-
Copper Hills Subdivision	900	2,400	4,200
Creedmoor-Maha WSC	225,000	274,350	334,400
Dellana Hills	3,750	3,900	3,900
Estate Utilities	15,500	18,900	23,050
G&J Water District	3,400	3,400	3,400

[1]Industrial user permitted for 11,000,000 gallons per year. Currently, permit amendment is pending to increase limits to 100,000,000 gallons per year.

[2]Industrial user permitted for 1,000,000 gallons per year.

[3]Irrigation wells only - shallow well system.

[4]Industrial user permitted for 5,000,000 gallons per year.

TABLE 2.4 THRESHOLD VALUE FOR ESTIMATED DAILY WATER USE (GPD) (CONTINUED)

NAME	Year 1990	Year 2000	Year 2010
Goforth WSC	180,750	220,350	268,650
Harold Hicks & Al Schuster	8,000	9,000	10,000
Hays CISD Dahlstrom MS	6,250	7,600	9,200
Hays CISD Jack C. Hays HS	30,000	36,600	44,600
J.D. Malone	7,000	8,000	9,000
Liesurewoods Water	55,000	57,750	57,750
Marbridge Foundation	18,200	19,850	21,500
Mooreland Water System	10,000	12,000	13,400
Mountain City Oaks WS	20,250	24,650	30,100
Mystic Oaks Water Co-op	6,750	7,800	7,800
Oak Forest Highlands	4,200	6,000	7,700
Plum Creek Water	110,000	134,150	163,500
Shady Hollow Estates WSC	6,300	7,650	9,300
Slaughter Creek Acres WSC	12,500	15,200	17,850
Southwest Territory WC	15,000	16,950	16,950
Ridgewood Village Water System	10,000	12,150	14,850
Bear Creek Park	13,000	13,600	13,600

TABLE 2.4 THRESHOLD VALUE FOR ESTIMATED DAILY WATER USE (GPD) (CONTINUED)

NAME	Year 1990	Year 2000	Year 2010
Onion Creek Meadows	32,500	38,150	38,150
Texas-Lehigh Cement Company[5]	-	-	-
Tilson Custom Homes	750	750	750
Village of San Leanna	19,000	23,200	28,300
Huntington Estates	140	2,800	5,600

[5]Industrial user permitted for 73,438,000 gallons per year.

2.8 PREPARATION OF FACILITY PLANS FOR INTERCONNECTION

A Facility Plan Map for proposed interconnects of ground water suppliers is presented on Exhibit No. 3 (Section 6 - Facility Planning Maps). Facility line sizing was based on the threshold water use calculated in Section 2.7 and the ability to pump water between water systems during off-peak hours (12:00 midnight to 6:00 A.M.).

The following is an explanation of proposed interconnect of suppliers. The Group Numbers discussed correspond to those presented on Exhibit No. 3.

2.8.1 GROUP NO. I UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
I.	1. AquaTex Water Supply
	2. Arroyo Doble Water System
	12. Creedmoor-Maha Water Supply Corp.
	25. Mystic Oaks Water Co-Op
	33. Onion Creek Meadows

2.8.1.1 Description Of Facilities Required For Interconnects

Group No. I includes four (4) water suppliers that could benefit through a series of interconnects or direct connections with the Creedmoor-Maha Water Supply Corporation. This Corporation, which has an existing interconnection with the City of Austin, would be the water supplier in this scenario.

AquaTex's estimated threshold water demand for year 2010 is 11,900 gallons per day (gpd). Pumping 11,900 gpd, during off-peak hours (12:00 midnight to 6:00 a.m.), would require facilities sized for an approximate 33 gallons per minute (gpm) flow rate. A new 2" waterline approximately 500 feet long could interconnect AquaTex with Arroyo Doble. Friction loss in the 500 feet of 2" line at 33 gpm is approximately 4 to 5 pounds per square inch (psi). A meter assembly could be placed between the two systems which would be activated during emergency conditions. Aquatex has the necessary ground storage capacity to store their projected year 2010 estimated daily threshold water use.

Arroyo Doble estimated threshold water demand for year 2010 is 48,850 gpd. Pumping 48,850 gpd, during off-peak hours, would require facilities sized for an approximate 136 gpm flow rate. A new 4" waterline approximately 3,200 feet long could interconnect Arroyo Doble with Creedmoor-Maha WSC. A crossing of Onion Creek would be required. Friction loss in the 3,200 feet of 4" line at 136 gpm is approximately 16 to 17 psi. A meter assembly could be placed between the two systems which would be activated during emergency conditions. Arroyo Doble has the necessary ground storage capacity to store their estimated daily year 2010 threshold water use.

Mystic Oaks estimated threshold water demand for year 2010 is 7,800 gpd. Pumping 7,800 gpd during off-peak hours require facilities sized for an approximate 22 gpm flow rate. A new 2" waterline approximately 600 feet long could interconnect Mystic Oaks with Creedmoor-Maha WSC. Friction loss in the 600 feet of 2" line at 22 gpm is approximately 2 to 3 psi. A meter assembly could be placed between the two systems which would be activated during emergency conditions. Mystic Oaks has the necessary ground storage capacity to store their projected year 2010 estimated daily threshold water use.

Onion Creek Meadows estimated threshold water demand for year 2010 is 38,150 gpd. Pumping 38,150 gpd during off-peak hours require facilities sized for an approximate 106 gpm flow rate. A new 4" waterline approximately 700 feet long could interconnect Onion

Creek Meadows with Creedmoor-Maha WSC. Friction loss in the 700 feet of 4" line at 106 gpm is approximately 2 to 3 psi. A meter assembly could be placed between the two systems which would be activated during emergency conditions. Onion Creek Meadows has the necessary ground storage capacity to store their projected year 2010 estimated daily threshold water use.

2.8.2 GROUP NO. II UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
II.	3. CenTex Materials
	10. Comal Tackle Company
	34. Texas-Lehigh Company

2.8.2.1 Description Of Facilities Required For Interconnect

Group No. II consists of three (3) industrial water suppliers. For the purpose of the interconnect study, these suppliers were not examined for utility interconnect. The industrial suppliers who comprise this group may wish to consider the possibility of interconnecting for a more dependable source of water supply.

2.8.3 GROUP NO. III UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
III.	4. Chaparral Water Company
	11. Copper Hills Subdivision
	30. Southwest Territory Water Company

2.8.3.1 Description Of Facilities Required For Interconnect

Group No. III represents three (3) water suppliers located along the western edge of the BS/EACD service area. These suppliers could economically interconnect with one another to derive mutual benefit should one of the suppliers experience an emergency condition. Copper Hills Subdivision, the smaller of the three water suppliers in this Group was not considered as a supply source but rather a benefactor of the interconnect.

Chaparral WC estimated threshold water demand for year 2010 is 20,700 gpd. Pumping 20,700 gpd during off-peak hours would require facilities sized for an approximate 58 gpm flow rate. A new 3" waterline approximately 1,700 feet long could interconnect Chaparral with Southwest Territory WC. A crossing of Little Bear Creek would be required. Friction loss in the 1,700 feet of 3" line at 58 gpm is approximately 8 to 9 psi. A meter assembly could be installed between the two suppliers and would be activated during emergency conditions. Likewise, Southwest Territory WC with an estimated year 2010 threshold water demand of 16,950 gpd could use the 3" waterline for an emergency interconnect. The 16,950 gpd pumped during off-peak hours is approximately 47 gpm. A 47 gpm flow through 1,700 feet of 3" line produces friction loses of approximately 5 to 6 psi.

Finally, Copper Hills Subdivision could interconnect through approximately 250 feet of 1 1/2" waterline to the 3" emergency interconnect line proposed above. Copper Hills year 2010 estimated threshold water demand is 4,200 gpd. Pumping 4,200 gpd during off-peak hours would require facilities sized for an approximate 12 gpm demand. Friction loss in the 250 feet of 1 1/2" line at 12 gpm is approximately 1 to 2 psi. A meter assembly would be required on the 1 1/2" line to activate during an emergency condition to measure flow from either Southwest Territory or Chaparral.

All three water suppliers proposed in Group III have sufficient water storage capacity to store their respective estimated year 2010 daily threshold water demand.

2.8.4 GROUP NO. IV UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMEND FOR UTILITY INTERCONNECT
IV.	5. Chatleff Control, Inc.
	8. City of Buda
	16. Goforth Water Supply Corporation
	27. Plum Creek Water Supply Corporation
	35. Tilson Custom Homes

2.8.4.1 Description Of Facilities Required For Interconnect

Group No. IV water suppliers consist of one industrial water supplier, Chatleff Control, one municipal water supplier, City of Buda, two major water supply corporations, Goforth WSC and Plum Creek WSC and Tilson Custom Homes. Four of the five suppliers have wells located in the same vicinity and, therefore, can be economically interconnected. Interconnection of wells located in the same general area would be a bad policy unless the wells have different depths. Table 2.2 presents information on the suppliers' well depths and pumpage rate. The City of Buda has three wells with two being in the depth range of 390' to 450'. The third has a depth of 740'. Goforth WSC and Plum Creek WSC well depths range between 640' to 720' respectively. Chatleff Control Inc.'s well is in the 450' depth range. Goforth WSC has an existing interconnect with Creedmoor- Maha WSC (whose wells are about 450' deep,) it becomes more apparent that interconnection of these four water suppliers is feasible. Should the deeper wells become contaminated, the suppliers with the deep wells could rely on their interconnect to suppliers with shallower wells to provide threshold water demand. Conversely, if shallower wells, like those of the City of Buda, experience problems from point source contamination, the interconnect with Goforth WSC and Plum Creek WSC would provide Buda's estimated threshold water demand.

The City of Buda's year 2010 estimated threshold water demand is 111,400 gpd. Pumping 111,400 gpd, during off-peak hours, would require facilities sized for an approximate 310 gpm flow rate. A new 6" waterline approximately 2000 feet long could interconnect the City of Buda with both Goforth WSC and Plum Creek WSC. Friction loss in the 2000 feet of 6" line at 310 gpm is approximately 7 psi. The 6" waterline could be utilized to provide water to Plum Creek WSC and Goforth WSC from the City of Buda. Practically, Buda can not provide the year 2010 threshold water demand for Goforth WSC (268,650 gpd, off-peak pumping rate 746 gpm) and Plum Creek WSC (163,500 gpd, off-peak pumping rate 454 gpm) should the deeper well systems become contaminated. Buda's two shallow wells (390' - 450' depth) combined pumping capacity per the latest TDH survey report is 600 gpm. (These wells are located some distance from the Buda third well, but the three wells are interconnected.) This pumping rate falls short of the 1,200 gpm combined estimated threshold water demand of Goforth WSC and Plum Creek WSC. But, additional water can be provided through Creedmoor-Maha WSC to Goforth WSC to makeup the difference. Chatleff Controls Inc. could provide some (54 gpm rated capacity) shallow well (500' depth) water supply, if necessary.

The above recommended interconnects provide an emergency system, for minimal capital investment, that allows for water from two very different aquifer depths to flow from one system to another. Also, Creedmoor-Maha WSC, Goforth WSC, Plum Creek WSC and the City of Buda represent the largest residential user class water suppliers in the BS/EACD.

Tilson Custom Homes year 2010 estimated threshold water demand is 750 gpd. Pumping 750 gpd during off-peak hours requires facilities sized for a 2 to 3 gpm flow rate. Tilson Custom Homes is located approximately 2,500 feet from the nearest Plum Creek WSC waterline. new 2" line - 2,500 feet in length could be installed. This line would have a minimal friction loss at the 2 to 3 gpm demand. A meter assembly could be required between Tilson Custom Homes and Plum Creek WSC that would be activated during emergency conditions.

All of the water suppliers in this interconnect group have sufficient existing storage capacity to store their respective year 2010 estimated threshold water demand.

2.8.5 GROUP NO. V UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
V.	6. Cimarron Park Water Company, Inc.
	14. Estates Utilities Water Supply Corporation
	21. Leisurewoods Water Company
	37. Huntington Estates

2.8.5.1 Description Of Facilities Required For Interconnect

Group No. V includes four (4) water suppliers which primarily serve single-family residential customers. These suppliers could interconnect for mutual benefit during emergency water need conditions.

Estates Utilities WSC year 2010 estimated threshold water demand is 23,050 gpd. Pumping 23,050 gpd during off-peak hours would require facilities sized for an approximate 64 gpm flow rate. A new 3" waterline approximately 600 feet long could interconnect Estates Utilities WSC with Leisurewoods WSC. Friction loss in the 600 feet of 3" line at 64 gpm is approximately 3 to 4 psi. Estates Utilities WSC has the necessary storage capacity to store their estimated daily threshold water demand.

Leisurewoods WC and Cimarron Park WC could be interconnected by extending a water line approximately 300 feet. Leisurewoods WC's year 2010 estimated threshold water demand is 57,750 gpd. Pumping

57,750 gpd during off-peak hours would require facilities sized for an approximate 160 gpm flow rate. Cimarron Park WC year 2010 estimated threshold water demand is 82,450 gpd. Pumping 82,450 gpd during off-peak hours would require facilities sized for an approximate 229 gpm flow rate. Using the higher flow rate of 229 gpm for sizing line capacity, a 6" waterline - 300 feet long would have an approximate friction loss of 1 to 3 psi.

Huntington Estates WSC, constructed in 1985, is sized for approximately 150 customers but currently serves only one customer. Huntington Estates WS year 2010 estimated threshold water demand is 5,600 gpd. Pumping 5,600 gpd during off-peak hours would require facilities sized for an approximate 16 gpm flow rate. A new 3" waterline approximately 5,000 feet long could interconnect Huntington Estates with Estates Utilities WSC. Friction loss in the 5,000 feet of 3" line at 16 gpm is approximately 1 to 2 psi. Practically, due to pressure plane differential between Estates Utilities and Huntington Estates Water System, Huntington Estates is considered a water supplier solely with Estates Utilities being considered a benefactor only. Estates Utilities estimated threshold value flow rate is 64 gpm. Friction loss in the 5,000 feet of 3" line at 64 gpm is approximately 29 to 30 psi. This loss is excessive, therefore a 4" line with an approximate friction loss of 6 to 7 psi in the 5,000 feet of line is recommended. Estate Utilities and Huntington Estates could consider an in-line booster pump station facility to provide dual benefits, but, due to the lack of existing customers in Huntington Estates, and for the purpose of this study, this interconnect appears to benefit Estates Utilities only and any consideration of in-line booster pump facilities may be cost excessive and therefore impractical at this time.

All four water suppliers have the necessary ground storage capacity to store their estimated daily threshold water demand.

2.8.6 GROUP NO. VI UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
VI.	7. City of Austin Irrigation Wells

2.8.6.1 Description Of Facilities Required For Interconnect

The City of Austin irrigation wells (three) are all shallow Colorado River Alluvium wells (50' depth range) with capacities ranging from 350 to 500 gpm. These wells are not intended for potable water supply, and therefore, not considered in the utility interconnect study presented in this report.

2.8.7 GROUP NO. VII UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
VII.	9. City of Sunset Valley

2.8.7.1 Description of Facilities Required for Interconnect

The City of Sunset Valley has access to the City of Austin water transmission lines for emergency interconnect. A temporary interconnect was used in 1988 when Sunset Valley's well pump was out of operation.

Year 2010 estimated threshold water demand for Sunset Valley is 17,250 gpd. Pumping 17,250 gpd during off-peak hours would require facilities sized for an approximate 48 gpm flow rate. A new 2" waterline approximately 100 feet long could interconnect Sunset Valley with Austin. Friction loss through the 100 feet of 2" line at 48 gpm is approximately 1 to 2 psi. A meter assembly could be placed between the two systems which would be activated during emergency conditions. Sunset Valley has the necessary ground storage capacity to store their estimated threshold water use.

2.8.8 GROUP NO. VIII UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
VIII.	13. Dellana Hills Subdivision
	15. G&J Water District
	31. Ridgewood Village Water System

2.8.8.1 Description Of Facilities Required For Interconnect

The three (3) Group VIII water suppliers could be interconnected to provide mutual benefit. As presented on Exhibit No. 3 (Section 6 - Facility Planning Maps), it is recommended that Ridgewood interconnect to the City of Rollingwood or the City of Austin water system. Since Rollingwood purchases water from the City of Austin, it makes little difference which entity provides the emergency interconnect.

Ridgewood Village WS is the largest water supplier with an estimated year 2010 threshold water demand of 14,850 gpd. Pumping 14,850 gpd during off-peak hours would require facilities sized for an approximate 41 gpm flow rate. A 2" diameter waterline connected to Rollingwood would provide adequate water flow with no more than a 2 to 3 psi friction loss for 200 feet of connecting line. Consequently, G&J Water District and Dellana Hills could interconnect with 2" diameter lines to each other and Ridgewood to provide for their emergency interconnect needs. This scenario would provide for a dependable surface water source should emergency ground water conditions develop.

A meter assembly could be placed between each system to be activated during emergency conditions. Ridgewood Village WS has adequate storage capacity for their estimated threshold water use. Dellana Hills and G&J Water District do not have any ground storage capacity, only pressurized tank storage. Dellana Hills pressurized storage capacity (900 gallons) is severely limited, therefore, their system should consider acquiring additional storage capacity in the amount of 3,000 gallons for a total storage capacity of 3,900 gallons. Dellana Hills year 2010 estimate threshold water demand is 3,900 gpd. G&J Water District has 6,000 gallons of pressure tank capacity which is about twice their year 2010 estimated threshold water demand of 3,400 gpd.

2.8.9 GROUP NO. IX UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
IX.	17. Harold Hicks & Al Schuster MHP
	23. Mooreland Water System
	26. Oak Forest Highlands
	29. Slaughter Creek Acres WSC
	36. Village of San Leanna

2.8.9.1 Description Of Facilities Required For Interconnect

Group IX water suppliers are uniquely located in relation to City of Austin water lines that can be used for emergency interconnects. The two major water suppliers of this group are Village of San Leanna and Slaughter Creek Acres WSC. As presented on Exhibit No. 3 (Section 6 - Facility Planning Maps), San Leanna could extend a waterline approximately 3,000 feet to connect with an existing 12" Austin water line. The year 2010 estimated threshold water demand for San Leanna is 28,300 gpd. Pumping 28,300 gpd during off-peak hours would require facilities sized for an approximate 79 gpm flow rate. A new 4" waterline approximately 3,000 feet long with a 79 gpm demand would have a friction loss of approximately 5 to 6 psi. A meter assembly could be placed between the two systems which would be activated during emergency conditions. San Leanna has the necessary ground storage capacity to store their estimated threshold water demands.

Oak Forest Highlands could participate in the above interconnect due to their location adjacent to the proposed 4" waterline interconnect between Austin and San Leanna. Oak Forest Highlands could connect to this 4" diameter waterline with 50' of 2" diameter line. Oak Forest Highlands has a year 2010 estimated threshold water demand of 7,700 gpd. Pumping 7,700 gpd during off-peak hours would require facilities sized for a 21 gpm flow rate. Oak Forest Highlands is located approximately 2,200 feet from the existing City of Austin's 12" waterline. Oak Forest Highlands could participate in sharing the cost of the waterline installation with San Leanna, which would create an interconnect between all three water suppliers. It appears that Oak Forest Highlands would require an additional 7,700 gallons in storage capacity to provide estimated year 2010 threshold water demand storage.

Harold Hicks & Al Schuster Mobile Home Park could interconnect with the existing 12" City of Austin waterline located along Manchaca Road. The mobile home park's year 2010 estimated threshold water demand is 10,000 gpd. Pumping 10,000 gpd during off-peak hours would require facilities sized for a 28 gpm flow rate. A 2" waterline approximately 100 feet in length could interconnect the mobile home park with the City of Austin's 12" waterline. Friction loss through a 100-foot long 2"- waterline with a 28 gpm demand is less than 1 psi. A meter assembly could be placed between each system to be activated during emergency conditions. It appears that the mobile home water storage capacity is limited to a 1,500 gallon pressure tank. Additional storage capacity in the amount of 8,500 gallons is recommended in order to accommodate the year 2010 estimated threshold water demand.

Mooreland Water System could interconnect to the existing City of Austin's 12" waterline located on Manchaca Road. Year 2010 estimated threshold water demand for Mooreland is 13,400 gpd. Pumping 13,400 gpd during off-peak pumping hours requires facilities sized for a 37 gpm flow rate. A new 2" waterline approximately 100 feet in length could interconnect Mooreland WS with the City of Austin's 12" line. Friction loss through a 100'-long 2"- line with a 37 gpm demand is approximately 1 to 2 psi. A meter assembly could be placed between each system to be activated during emergency conditions. The Mooreland Water System has 8,000 gallons of combined pressure and ground storage capacity. Additional storage capacity in the amount of 5,400 gallons is recommended in order to accommodate the year 2010 estimated threshold water demand.

Slaughter Creek Acres WSC could interconnect to an existing City of Austin 12" waterline as presented on Exhibit No. 3 (Section 6 - Facility Planning Maps). Slaughter Creek Acres year 2010 estimated threshold water demand is 17,850 gpd. Pumping 17,850 gpd during off-peak hours requires facilities sized for a 50 gpm flow rate. A new 3" waterline approximately 300 feet long could interconnect Slaughter Creek Acres WSC with the City of Austin's line. Friction loss in a 2" line 300 feet long with a 50 gpm demand is approximately 6 to 7 psi. A meter assembly could be placed between the two systems which would be activated during emergency conditions. Slaughter Creek has the necessary ground storage capacity to store their estimated threshold water demand.

2.8.10 GROUP NO. X UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECTS
X.	18. Hays Consolidated Independent School District - Dahlstrom Middle School

2.8.10.1 Description Of Facilities Required For Interconnect

The Dahlstrom Middle School is located adjacent to FM 967, west of Buda, in the far west portion of the BS/EACD. Due to it's location, it would be cost prohibitive to provide an emergency interconnect to another public water supplier. Leisurewoods WSC is approximately 10,000 feet due east and is the closest public water supplier to provide an interconnect. Another alternative the school may investigate is interconnecting with the Dahlstrom Corp. Plant well source. The Dahlstrom Corp. Plant well is 400' deep with a 270' cased section. The well produces 100 gpm and is approximately 4,500 linear feet from the middle school. By interconnecting to an alternatively located source, such as the Dahlstrom Corp. well, the school could provide a means of alternative water supply should an emergency condition occur with their on-site well source.

2.8.11 GROUP NO. XI UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
XI.	19. Hays Consolidated Independent School District, Jack C. Hays High School
	24. Mountain City Oaks WSC

2.8.11.1 Description Of Facilities Required For Interconnect

These two water suppliers are located approximately 2,500 feet from each other. Jack C. Hays High School threshold water demand for year 2010 is an estimated 44,600 gpd. Pumping 44,600 gpd during off- peak hours would require facilities sized for a 124 gpm flow rate. A new 4" waterline 2,500 - feet in length could flow 124 gpm with a friction loss of approximately 11 to 12 psi. This line could interconnect the Jack C. Hays High School with Mountain City WSC providing water to either entity. Mountain City WSC's year 2010 estimated threshold water demand is 30,100 gpd. Pumping 30,100 gpd during off-peak hours results in a flow of 84 gpm. This flow could be accommodated with the 4" interconnect. A meter assembly could be installed between the two suppliers to be activated during emergency conditions. Both the Jack C. Hays High

School and Mountain City WSC have sufficient ground storage capability for their respective threshold water demands.

A point to consider for this interconnect is the depth of each suppliers' wells. Mountain City Oaks WSC's well is 407 feet deep while the High School well depth is 575 feet deep. The above suggests that intrusion of contaminated water to one entity's well source may not adversely affect the other source.

2.8.12 GROUP NO. XII UTILITY INTERCONNECTION

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
XII.	20. J.D. Malone Water System

2.8.12.1 Description Of Facilities Required For Interconnect

The J.D. Malone water system is located in an area close to Slaughter Creek Acres. As presented on Exhibit No. 3 (Section 6 - Facility Planning Maps), the J.D. Malone WS is located near the City of Austin's existing water transmission lines. Although the year 2010 estimated threshold water demand for the J.D. Malone WS is only 9,000 gpd (25 gpm pumped capacity during off-peak hours), it is recommended that the water system extend a 2" water line approximately 500 feet to interconnect with the City of Austin's water line. The interconnect would provide the community with a dependable source of water should an emergency condition occur. A meter assembly could be installed between the two suppliers to be activated during emergency need conditions. The J.D. Malone WS is deficient in the storage capacity required for the threshold water demand. Additional storage capacity in the amount of 5,000 gallons is recommended for the system.

2.8.13 GROUP NO. XIII UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
XIII.	22. Marbridge Foundation
	32. Bear Creek Park

2.8.13.1 Description Of Facilities Required for Interconnect

The Marbridge Foundation and Bear Creek Park have similar year 2010 threshold water demands of 21,500 gpd and 13,600 gpd, respectively. Pumping 21,500 gpd during off-peak hours requires facilities sized for a 60 gpm flow rate. A new 3" - line could interconnect the two suppliers. Approximately 3,500 - feet of 3" - line would be required. Friction loss in this 3" - line with a flow of 46 gpm is approximately 10 to 11 psi. A meter assembly could be installed between the two suppliers to be activated during an emergency condition. Bear Creek Park has sufficient storage capacity for their estimated threshold water demand. The Marbridge Foundation available storage capacity in ground and pressurized storage is sufficient for their year 2010 estimated threshold water demand.

2.8.14 GROUP NO. XIV UTILITY INTERCONNECTION

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
XIV.	28. Shady Hollow Estates WSC

2.8.14.1 Description of Facilities Required for Interconnect

The Shady Hollow Estates Water System has an existing interconnect with the City of Austin.

2.9 DEVELOP FINANCIAL PLAN

In order to develop financial plans, estimated costs of interconnect facilities for each water system were determined. The projected construction and financing costs are presented by Group

Number and system in Table Nos. 2.5 through 2.18. A summary of individual water system construction and financing costs are presented in Tables 2.19 and 2.20, respectively.

2.10 REVIEW INSTITUTIONAL AND REGULATORY CONSTRAINTS

The TDH will review interconnect plans as they are developed. Rule 337.206 (f) Interconnections, of the TDH Rules and Regulations for Public Water Supply Systems addresses interconnect requirements. TDH staff provides further clarification of the rule for the proposed "emergency interconnects" as recommended in this study. Item No. 2 of the previously mentioned rule, requiring 0.35 gpm per connection supply capability for a second source supplier, will not be applicable. TDH recognizes that "emergency interconnects" are a "temporary" source of supply, rather than secondary source of supply. This clarification is critical to implementation of the emergency interconnects. Suppliers of "emergency" water will not have to permanently allocate reserve supplies which could be utilized to serve future customers.

The following items will be required for the TDH review process:

1. Engineer's report detailing design guidelines for facility sizing;
2. Agreement between participating utilities interconnecting;
3. Any necessary easements required; and
4. Miscellaneous "other" data as required by the TDH.

Generic interconnect agreements for water suppliers has been included in Appendix G. These agreements have been used by groundwater suppliers in Harris County for emergency interconnects.

The TWDB has requested that interconnect plans be provided to their Planning Division and Groundwater Units. The TWDB has no review

TABLE 2.5 PROJECTED COST FOR GROUP NO. I UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
I.	1. AquaTex Water Supply
	2. Arroyo Doble Water System
	12. Creedmoor-Maha Water Supply Corp.
	25. Mystic Oaks Water Co-Op
	33. Onion Creek Meadows

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
1. AquaTex WS	2" Waterline, 500 L.F. @ $5.00/L.F.	$ 2,500.00
	1" Meter Assembly (includes piping with gate valves)	400.00
	Two 2" Wet Connections	500.00
	Sub-Total	$ 3,400.00
	Non-Construction Costs & Contingency	850.00
	TOTAL	$ 4,250.00

Financing $4,250 estimated interconnect cost based on 68 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$86.17	$51.56
Approx. monthly per customer cost	$ 1.27	$ 0.76

TABLE 2.5 PROJECTED COST FOR GROUP NO. I UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
2. Arroyo Doble	4" Waterline, 3,200 L.F. @ $8.00/L.F.	$25,600.00
	Onion Creek Crossing 100 L.F. @ $25.00/L.F.	2,500.00
	2" Meter Assembly (includes piping with gate valves)	1,000.00
	Two 4" Wet Connections	1,000.00
	Sub-Total	$30,100.00
	Non-Construction Costs & Contingency	4,500.00
	TOTAL	$34,600.00

Financing $34,600.00 estimated interconnect cost based on 266 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$701.56	$419.79
Approx. monthly per customer cost	$ 2.64	$ 1.58

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
12. Creedmoor-Maha	Creedmoor-Maha WS has existing interconnects with the City of Austin and Goforth W.S. Corporation. These are presented on Exhibit No. 3. In this interconnect study, Creedmoor-Maha is solely considered a supplier of water and derives no direct benefit through interconnecting with Group I water suppliers. Therefore, no direct costs are borne by the corporation.	

TABLE 2.5 PROJECTED COST FOR GROUP NO. I UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
25. Mystic Oaks W.S.	2" Waterline, 600 L.F. @ $5.00/L.F.	$ 3,000.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Sub-total	$ 3,900.00
	Non-Construction Costs & Contingency	1,000.00
	TOTAL	$ 4,900.00

Financing $4,900 estimated interconnect cost based on 39 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$99.35	$59.45
Approx. monthly per customer cost	$ 2.55	$ 1.52

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
33. Onion Creek Meadows	4" Waterline, 700 L.F. @ $8.00/L.F.	$ 5,600.00
	2" Meter Assembly (Includes piping and gate valves)	1,000.00
	Two 4" Wet Connections	1,000.00
	Sub-total	$ 7,600.00
	Non-Construction Costs & Contingency	1,200.00
	TOTAL	$ 8,800.00

Financing $8,800 estimated interconnect cost based on 203 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$178.43	$106.77
Approx. monthly per customer cost	$ 0.88	$ 0.53

TABLE 2.6 PROJECTED COST FOR GROUP NO. II UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
II.	3. CenTex Material 10. Comal Tackle Company 34. Texas-Lehigh Company

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
3. CenTex Material	Not considered for Emergency Interconnect	

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
10. Comal Tackle Company	Not Considered for Emergency Interconnect	

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
34. Texas-Lehigh Cement Company	Not Considered for Emergency Interconnect	

TABLE 2.7 PROJECTED COST FOR GROUP NO. III UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
III.	4. Chaparral Water Company
	11. Copper Hills Subdivision
	30. Southwest Territory Water Company

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
4. Chaparral Water Company	3" Waterline, 1,700 L.F. @ $7.00/L.F.	$11,900.00
	Little Bear Creek Crossing 100 L.F. @ $25.00/L.F.	2,500.00
	1 1/2 Meter Assembly (Includes piping and gate valves)	700.00
	Two 3" Wet Connections	800.00
	Sub-Total	$15,900.00

Proposed interconnect with Southwest Territory derives mutual benefit, therefore, adjusted share of 3" interconnect cost will be 50% of common estimated cost elements. Southwest Territory would pay for the remaining 50% share of this installation.

Adjusted Sub-Total Cost	$ 8,300.00
Non-Construction Costs & Contingency	1,250.00
Total	$ 9,550.00

Financing $9,550 estimated interconnect cost based on 138 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$193.64	$115.87
Approx. monthly per customer cost	$ 1.40	$ 0.84

TABLE 2.7 PROJECTED COST FOR GROUP NO. III UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
11. Copper Hills Subdivision	1 - 1/2" Waterline, 250 L.F. @ $4.00/L.F.	$ 1,000.00
	1 - 1/2" Wet Connection	200.00
	Sub-Total	$ 1,200.00
	Non-Construction Costs & Contingency	300.00
	TOTAL	$ 1,500.00

Copper Hills proposed interconnect would be to the 3" interconnect line proposed between Southwest Territory and Chaparral Water. Copper Hills could utilize the meters installed by either of these two water suppliers. Copper Hills is a primary benefactor of these interconnects, not a primary water supplier.

Financing $1,500 estimated interconnect cost based on 6 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$30.41	$18.20
Approx. monthly per customer cost	$ 5.07	$ 3.03

TABLE 2.7 PROJECTED COST FOR GROUP NO. III UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
30. Southwest Territory	3" Waterline, 1,700 L.F. @ $7.00/L.F.	$11,900.00
	Little Bear Creek Crossing 100 L.F. @ $25.00/L.F.	2,500.00
	1 - 1/2" Meter Assembly	700.00
	Two 3" Wet Connections	800.00
	Sub-total	$15,900.00

Proposed interconnect with Chaparral Water derives mutual benefit between two parties, therefore, adjusted share of 3" interconnect cost will be 50% of common estimated cost elements. Chaparral Water would pay for the remaining 50% share of the installation.

Adjusted Subtotal Cost	$ 8,300.00
Non-Construction Costs & Contingency	1,250.00
TOTAL	$ 9,550.00

Financing $9,550 estimated interconnect cost based on 113 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 193.64	$115.87
Approx. monthly per customer cost	$ 1.71	$ 1.03

TABLE 2.8 PROJECTED COST FOR GROUP NO. IV UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
IV.	5. Chatleff Control, Inc.
	8. City of Buda
	16. Goforth Water Supply Corporation
	27. Plum Creek Water Supply Corporation
	35. Tilson Custom Homes

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
5. Chatleff Controls	Not considered for Emergency Interconnect	

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
8. City of Buda	6" Waterline, 2000 L.F. @ $15.00/L.F.	$30,000.00
	Two 3" Meter Assemblies Includes piping with gate values)	3,000.00
	Three 6" Wet Connections	2,250.00
	Sub-Total	$35,250.00

Proposed interconnect with Goforth and Plum Creek Water Supply Corporations derives mutual benefit between three parties, therefore, adjusted share of 6" interconnect cost will be 33% (1/3) of total estimated installation cost. Goforth and Plum Creek will pay for the remaining share of the installation.

Adjusted Sub-Total Cost	$11,750.00
Non-Construction Costs & Contingency	1,750.00
TOTAL	$13,500.00

Financing $13,500 estimated interconnect cost based on 544 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$273.73	$163.79
Approx. monthly per customer cost	$ 0.50	$ 0.30

TABLE 2.8 PROJECTED COST FOR GROUP NO. IV UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
16. Goforth W.S. Corp.	6" Waterline, 2000 L.F. @ $15.00/L.F.	$30,000.00
	Two 3" Meter Assemblies (Includes piping and gate values)	3,000.00
	Three 6" Wet Connections	2,250.00
	Sub-total	$35,250.00

Proposed interconnect with the City of Buda and Plum Creek W.S. Corporation derives mutual benefit between three parties, therefore, adjusted share of 6" interconnect cost will be 33% (1/3) of total estimated installation cost. City of Buda and Plum Creek will pay for the remaining share of the installation.

Adjusted Subtotal Cost	$11,750.00
Non-Construction Costs & Contingency	1,750.00
TOTAL	$13,500.00

Financing $13,500 estimated interconnect cost based on 1,205 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 273.73	$163.79
Approx. monthly per customer cost	$ .23	$ 0.14

TABLE 2.8 PROJECTED COST FOR GROUP NO. IV UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
27. Plum Creek Water Supply Corp.	6" Waterline, 2000 L.F. @ $15.00/L.F.	$30,000.00
	Two 3" Meter Assembly (Includes piping and gate valves)	3,000.00
	Three 6" Wet Connections	2,250.00
	Sub-total	$35,250.00
	Proposed interconnect with Goforth and City of Buda derives mutual benefit between three parties, therefore, adjusted share of 6" interconnect cost will be 33% (1/3) of total estimated installation cost. City of Buda and Goforth will pay for the remaining share of the installation.	
	Adjusted Subtotal Cost	$11,750.00
	Non-Construction Costs & Contingency	1,750.00
	TOTAL	$13,500.00

Financing $13,500 estimated interconnect cost based on 733 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 273.73	$163.79
Approx. monthly per customer cost	$ 0.37	$ 0.22

TABLE 2.8 PROJECTED COST FOR GROUP NO. IV UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
35. Tilson Custom Homes	2" Waterline, 2,500 L.F. @ $5.00/L.F.	$12,500.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Sub-total	$13,400.00
	Non-Construction Costs & Contingency	2,000.00
	TOTAL	$15,400.00

Financing $15,400 estimated interconnect cost based on 5 commercial customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$312.26	$186.84
Approx. monthly per customer cost	$ 62.45	$ 37.37

TABLE 2.9 PROJECTED COST FOR GROUP NO. V UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
V.	6. Cimarron Park Water Company, Inc.
	14. Estates Utilities WSC
	21. Leisure Woods Water Company
	37. Huntington Estates

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
6. Cimarron Park WC Inc.	6" Waterline, 300 L.F. @ $15.00/L.F.	$ 4,500.00
	3" Meter Assembly (Includes piping with gate valves)	1,500.00
	Two 6" Wet Connections	1,500.00
	Sub-Total	$ 7,500.00

Proposed interconnect with Leisure Woods derives mutual benefit, therefore, adjusted share of 6" interconnect cost will be 50% of total estimated installation cost. Leisure Woods would pay for the remaining 50% share of the installation.

	Adjusted Sub-Total Cost	$ 3,750.00
	Non-Construction Costs & contingency	1,250.00
	TOTAL	$ 5,000.00

Financing $5,000 estimated interconnect cost based on 426 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$101.38	$60.66
Approx. monthly per customer cost	$ 0.24	$ 0.41

TABLE 2.9 PROJECTED COST FOR GROUP NO. V UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
14. Estates Utilities	3" Waterline, 600 L.F. @ $7.00/L.F.	$ 4,200.00
	1 1/2" Meter Assembly (Includes piping and gate valves)	700.00
	Two 3" Wet Connections	800.00
	Sub-total	$ 5,700.00
	Non-Construction Costs & Contingency	1,300.00
	TOTAL	$ 7,000.00

Financing $7,000 estimated interconnect cost based on 82 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$141.93	$84.93
Approx. monthly per customer cost	$ 1.73	$ 1.04

TABLE 2.9 PROJECTED COST FOR GROUP NO. V UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
14. Estates Util. (Interconnect to Huntington Estates)	4" Waterline, 5000 L.F. @ $8.00/L.F.	$40,000.00
	2" Meter Assembly (Includes piping and gate valves)	1,000.00
	Two 4" Wet Connections	1,000.00
	Sub-total	$42,000.00
	Non-Construction Cost & Contingency	6,000.00
	TOTAL	$48,000.00

Financing $48,000.00 estimated interconnect cost based on 82 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$973.27	$582.37
Approx. monthly per customer cost	$ 11.87	$ 7.10

TABLE 2.9 PROJECTED COST FOR GROUP NO. V UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
21. Leisurewoods	6" Waterline, 300 L.F. @ $15.00/L.F.	$ 4,500.00
	3" Meter Assembly (Includes piping and gate valves)	1,500.00
	Two 6" Wet Connections	1,500.00
	Sub-total	$ 7,500.00

Proposed interconnect with Cimarron Park Water Corp. derives mutual benefit, therefore, adjusted share of 6" interconnect cost will be 50% of total estimated installation cost. Cimarron Park would pay for the remaining 50% share of the installation.

Adjusted Subtotal Cost	$ 3,750.00
Non-Construction Costs & Contingency	1,250.00
TOTAL	$ 5,000.00

Financing $5,000 estimated interconnect cost based on 400 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 101.38	$66.60
Approx. monthly per customer cost	$ 0.25	$ 0.15

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
37. Huntington Estates	Considered as source of supply only for Estates Utilities.	

TABLE 2.10 PROJECTED COST FOR GROUP NO. VI UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
VI.	7. City of Austin Irrigation Wells

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
7. City of Austin	Irrigation Wells Only - Not considered for Emergency Interconnection	

TABLE 2.11 PROJECTED COST FOR GROUP NO. VII UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
VII.	9. City of Sunset Valley

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
9. City of Sunset Valley	2" Waterline, 100 L.F. @ $ 5.00/L.F.	$ 500.00
	1 1/2" Meter Assembly (Includes piping with gate valves)	700.00
	Two 2" Wet Connections	500.00
	Sub-Total	$ 1,700.00
	Non-Construction Costs & Contingency	500.00
	Total	$ 2,200.00

Financing $2,200 estimated interconnect cost based on 77 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$44.61	$26.89
Approx. monthly per customer cost	$ 0.58	$ 0.35

TABLE 2.12 PROJECTED COST FOR GROUP NO. VIII UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
VIII.	13. Dellana Hills Subdivision 15. G&J Water District 31. Ridgewood Village Water Systems

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
13. Dellana Hills	1" Waterline, 50 L.F. @ $4.00/L.F.	$ 200.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	1" Wet Connection	200.00
	Additional 3,000 Gallon Pressurized Storage Tank Capacity	5,000.00
	Sub-total	$ 5,800.00
	Non-Construction Costs & Contingency	1,200.00
	TOTAL	$ 7,000.00

Financing $7,000 estimated interconnect cost based on 25 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$141.93	$84.93
Approx. monthly per customer cost	$ 5.68	$ 3.40

TABLE 2.12 PROJECTED COST FOR GROUP NO. VIII UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
15. G&J Water District	1" Waterline, 50 L.F. @ $4.00/L.F.	$ 200.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	1" Wet Connection	200.00
	Sub-total	$ 800.00
	Non-Construction Costs & Contingency	200.00
	TOTAL	$ 1,000.00

Financing $1,000 estimated interconnect cost based on 16 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 20.28	$12.13
Approx. monthly per customer cost	$ 1.27	$ 0.76

TABLE 2.12 PROJECTED COST FOR GROUP NO. VIII UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
31. Ridgewood Village	2" Waterline, 200 L.F. @ $5.00/L.F.	$ 1,000.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Sub-total	$ 1,900.00
	Non-Construction Costs & Contingency	700.00
	TOTAL	$ 2,600.00

Financing $2,600 estimated interconnect cost based on 74 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$52.72	$31.55
Approx. monthly per customer cost	$ 0.71	$ 0.43

TABLE 2.13 PROJECTED COST FOR GROUP NO. IX UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
IX.	17. Harold Hicks & Al Schuster MHP
	23. Mooreland Water Systems
	26. Oak Forest Highlands
	29. Slaughter Creek Acres WSC
	36. Village of San Leanna

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
17. Harold Hicks & Al Schuster	2" Waterline, 100 L.F. @ $5.00/L.F.	$ 500.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Additional 8,500 Gallons Storage Capacity	13,000.00
	Sub-total	$14,400.00
	Non-Construction Costs & Contingency	2,600.00
	TOTAL	$17,000.00

Financing $17,000 estimated interconnect cost based on 50 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$344.70	$206.26
Approx. monthly per customer cost	$ 6.89	$ 4.13

TABLE 2.13 PROJECTED COST FOR GROUP NO. IX UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
23. Mooreland Water Systems	2" Waterline, 100 L.F. @ $5.00/L.F.	$ 500.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Additional 5,400 Gallons Storage Capacity	9,600.00
	Sub-total	$11,000.00
	Non-Construction Costs & Contingency	2,000.00
	TOTAL	$13,000.00

Financing $13,000 estimated interconnect cost based on 33 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$263.59	$157.73
Approx. monthly per customer cost	$ 7.99	$ 4.78

TABLE 2.13 PROJECTED COST FOR GROUP NO. IX UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
26. Oak Forest Highlands	4" Waterline, 2,200 L.F. @ $8.00/L.F.	$17,600.00
	2" Waterline 50 L.F. @ $5.00/L.F.	250.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	One 4" Wet Connection	500.00
	Additional 7,700 Gallons Storage Capacity	$12,250.00
	Sub-total	$31,000.00

Proposed interconnect with City of Austin existing 12" waterline involves cost sharing with Village of San Leanna to route waterline from intersection of Manchaca Road and FM 1626 east to Oak Forest and San Leanna. Based on demand requirements, Oak Forest requires 21 gpm year 2010 threshold water demand and San Leanna has a 79 gpm year 2010 threshold water demand. Therefore, 21% of the items marked with an asterisk will be Oak Forest costs and 79% will be San Leanna's costs.

Adjusted Subtotal Cost	$16,701.00
Non-Construction Costs & Contingency	2,799.00
TOTAL	$19,500.00

Financing $19,500 estimated interconnect cost based on 28 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 395.39	$236.59
Approx. monthly per customer cost	$ 14.12	$ 8.45

TABLE 2.13 PROJECTED COST FOR GROUP NO. IX UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
29. Slaughter Cr. Acres WSC	3" Waterline, 300 L.F. @ $7.00/L.F.	$ 2,100.00
	1 1/2" Meter Assembly (Includes piping and gate valves)	700.00
	Two 3" Wet Connections	800.00
	Sub-total	$ 3,600.00
	Non-Construction Costs & Contingency	900.00
	TOTAL	$ 4,500.00

Financing $4,500 estimated interconnect cost based on 70 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$91.24	$54.60
Approx. monthly per customer cost	$ 1.30	$ 0.78

TABLE 2.13 PROJECTED COST FOR GROUP NO. IX UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
36. Village of San Leanna	4" Waterline, 2,200 L.F. @ $8.00/L.F.	$17,600.00*
	4" Waterline, 800 L.F. @ $8.00/L.F.	6,400.00
	2" Meter Assembly (Includes piping and gate valves)	1,000.00
	4" Wet Connection	500.00*
	4" Wet connection	500.00
	Sub-total	$26,000.00

Proposed interconnect with City of Austin existing 12" waterline involves cost sharing first 2,200 L.F. of 4" waterline with Oak Forest. Based on demand requirements, Oak Forest requires 21 gpm year 2010 threshold water demand and San Leanna requires 79 gpm year 2010 threshold water demand. Therefore, 79% of the items marked with an asterisk will be San Leanna's costs and 21% will be Oak Forest cost.

Adjusted Subtotal Cost	$22,200.00
Non-Construction Costs & Contingency	3,300.00
TOTAL	$25,500.00

Financing $25,500 estimated interconnect cost based on 131 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 517.05	$309.39
Approx. monthly per customer cost	$ 3.95	$ 2.36

TABLE 2.14 PROJECTED COST FOR GROUP NO. X UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
X.	18. Hays Consolidated Independent School District-Dahlstrom Middle School

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
18. Hays CISD - Dahlstrom MS	Interconnect to Leisurewoods	$80,000.00

Financing $80,000.00 estimated interconnect cost to Leisurewoods System produces the following monthly debt service requirements:

Terms of Loan:	8% For 60 months	8% For 120 months	8% For 240 months
App. monthly cost	$1,622.11	$970.62	$669.15

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
18. Hays CISD - Dahlstrom MS	Interconnect to Dahlstrom Corp. Well	$45,000.00

Financing $45,000.00 estimated interconnect cost to Dahlstrom well produces the following monthly debt service requirements:

Terms of Loan:	8% For 60 months	8% For 120 months	8% For 240 months
App. monthly cost	$ 912.44	$545.97	$376.40

TABLE 2.15 PROJECTED COST FOR GROUP NO. XI UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
XI.	19. Hays Cosolidated Independent School District, Jack C. Hays High School 24. Mountain City Oaks Water Supply Corporation

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
19. Hays CISD Jack Hays HS	4" Waterline,2500 L.F. @ $8.00/L.F.	$20,000.00
	3" Meter Assembly (Includes piping and gate valves)	1,500.00
	Two 4" Wet Connections	1,000.00
	Sub-total	$22,500.00

Proposed interconnect with Mountain City Oaks derives mutual benefit, therefore, adjusted share of 4" interconnect cost will be 50% of total estimated installation cost. Mountain City would pay for the remaining 50% share of the installation.

	Adjusted Subtotal Cost	$11,250.00
	Non-Construction Costs Contingency	1,750.00
	TOTAL	$13,000.00

Financing $13,000 estimated interconnect cost to Mountain City System produces the following monthly debt service requirements:

Terms of Loan:	8% For 60 months	8% For 120 months	8% For 240 months
App. monthly cost	$ 263.59	$157.73	$108.74

TABLE 2.15 PROJECTED COST FOR GROUP NO. XI UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
24. Mountain City Oaks	4" Waterline, 2500 L.F. @ $8.00/L.F.	$20,000.00
	One 3" Meter Assembly (Piping and gate valves)	1,500.00
	Two 4" Wet Connections	1,000.00
	Sub-total	$22,500.00

Proposed interconnect with Hays CISD (Jack C. Hays High School) derives mutual benefit, therefore, adjusted share of 4" interconnect cost will be 50% of total estimated installation cost. Hays CISD would pay for the remaining 50% share of the installation.

Adjusted Subtotal Cost	$11,250.00
Non-Construction Costs & Contingency	1,750.00
TOTAL	$13,000.00

Financing $13,000 estimated interconnect cost to Hays CISD system based on 135 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 263.59	$157.73
Approx. monthly per customer cost	$ 1.95	$ 1.17

TABLE 2.16 PROJECTED COST FOR GROUP NO. XII UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
XII.	20. J.D. Malone Water System

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
20. J.D. Malone	2" Waterline, 500 L.F. @ $5.00/L.F.	$ 2,500.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Additional 5,000 Gallons Storage Capacity	$ 9,000.00
	Sub-total	$12,400.00
	Non-Construction Costs & Contingency	2,100.00
	TOTAL	$14,500.00

Financing $14,500 estimated interconnect cost based on 47 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$294.01	$175.93
Approx. monthly per customer cost	$ 6.26	$ 3.74

TABLE 2.17 PROJECTED COST FOR GROUP NO. XIII UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
XIII.	22. Marbridge Foundation 32. Bear Creek Park

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
22. Marbridge Foundation	3" Waterline, 3500 L.F. @ $7.00/L.F.	$24,500.00
	Bear Creek Crossing 100 L.F. @ $25.00/L.F.	2,500.00
	1 - 1/2" Meter Assembly (Piping and gate valves)	700.00
	Two 3" Wet Connections	800.00
	Sub-total	$28,500.00

Proposed interconnect with Bear Creek Park Water System derives mutual benefit, therefore, adjusted share of 3" interconnect cost will be 50% of total estimated installation cost. Bear Creek Park would pay for the remaining 50% share of the installation.

Adjusted Subtotal Cost	$14,250.00
Non-Construction Costs & Contingency	2,000.00
TOTAL	$16,250.00

Financing $16,250 estimated interconnect cost to Bear Creek Park Water system produces the following monthly debt service requirements:

Terms of Loan:	8% For 60 months	8% For 120 months	8% For 240 months
App. monthly cost	$ 329.49	$197.16	$135.92

TABLE 2.17 PROJECTED COST FOR GROUP NO. XIII UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
32. Bear Creek Park	3" Waterline, 3,500 L.F. @ $7.00/L.F.	$24,500.00
	Bear Creek Crossing 100 L.F. @ $25.00/L.F.	2,500.00
	1 - 1/2" Meter Assembly (Piping and gate valves)	700.00
	Two 3" Wet Connections	800.00
	Sub-total	$28,500.00

Proposed interconnect with Marbridge Foundation Water System derives mutual benefit between two parties, therefore, adjusted share of 3" interconnect cost will be 50% of total estimated installation cost. Marbridge Foundation would pay for the remaining 50% share of the installation.

	Adjusted Subtotal Cost	$14,250.00
	Non-Construction Costs & Contingency	$ 2,000.00
	TOTAL	$16,250.00

Financing $16,250 estimated interconnect cost to Marbridge Foundation Water System based on 78 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 329.49	$197.16
Approx. monthly per customer cost	$ 4.22	$ 2.53

TABLE 2.18 PROJECTED COST FOR GROUP NO. XIV UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
XIV.	28. Shady Hollow Estates Water Supply Corporation

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
28. Shady Hollow Estates WSC	Shady Hollow Estates has an existing interconnect with the City of Austin. Exhibit No. 3 presents the location of this interconnect.	

TABLE 2.19 SUMMARY OF RECOMMENDED UTILITY INTERCONNECT FOR WATER SUPPLY SYSTEMS

GROUP NO.	SYS. NO.	SYSTEM NAME	NO. OF PRIMARY SYSTEM CONN.	ESTIMATED COST (1990 $)
I	1.	Aquatex Water Supply	12	$ 4,250
	2.	Arroyo Doble Water System	12	34,600
	12.	Creedmoor-Maha WSC	N.C.	0
	25.	Mystic Oaks Water Co-Op	12	4,900
	33.	Onion Creek Meadows	12	8,800
II	3.	CenTex Material[1]	N.C.	0
	10.	Comal Tackle Company	N.C.	0
	34.	Texas-Lehigh Cement Co.	N.C.	0
III	4.	Chaparral Water Co.	11,30	9,550
	11.	Copper Hills Subdivision	4, 30	1,500
	30.	Southwest Territory WC	4,11	9,550
IV	5.	Chatleff Control Inc.	N.C.	0
	8.	City of Buda	5,16,27	13,500
	16.	Goforth WSC	8,12,27	13,500
	27.	Plum Creek Water	8,12,16	13,500
	35.	Tilson Custom Homes	27	15,400
V	6.	Cimarron Park WC Inc.	21	5,000
	14.	Estate Utilities	21	7,000
	21.	Liesurewoods Water	6	5,000
	37.	Huntington Estates	N.C.	0
VI	7.	City of Austin Wells	N.C.	0
VII	9.	City of Sunset Valley[2]	-	2,200
VIII	13.	Dellana Hills	15,31	7,000
	15.	G&J Water District	15,31	1,000
	31.	Ridgewood Village WS[3]		2,600
IX	17.	Harold Hicks/Al Schuster[2]	-	17,000
	23.	Mooreland Water System[2]	-	13,000
	26.	Oak Forest Highlands[2]	-	19,500
	29.	Slaughter Crk. Acres WSC[2]	-	4,500
	36.	Village of San Leanna[2]	-	25,500

[1]Not considered.

[2]Connect to City of Austin.

[3]Connect to the City of Rollingwood.

TABLE 2.19 SUMMARY OF RECOMMENDED UTILITY INTERCONNECT FOR WATER SUPPLY SYSTEMS (CONTINUED)

GROUP NO.	SYS. NO.	SYSTEM NAME	NO. OF PRIMARY SYSTEM CONN.	ESTIMATED COST (1990 $)
X	18.	Hays CISD-Dahlstrom MS[4]	21	45,000
XI	19.	Hays CISD-Jack C. Hays HS	24	13,000
	24.	Mountain City Oaks WS	19	13,000
XII	20.	J.D. Malone[2]		14,500
XIII	22.	Marbridge Foundation	32	16,250
	32.	Bear Creek Park	22	16,250
XIV	28.	Shady Hollow Estates WSC[5]		

[4]Connect to Leisurewoods WC or drill new well.

[5]Has existing connection with City of Austin.

TABLE 2.20 SUMMARY OF FINANCING COSTS FOR INDIVIDUAL WATER SYSTEMS

WATER SYSTEM	TOTAL EST. COST FOR INTER-CONNECT	EST. COST PER CUSTOMER @ 8% 5 YEARS	EST. COST PER CUSTOMER @ 8% 10 YEARS
1. Aquatex WS	$ 4,250.00	$1.27	0.76
2. Arroyo Doble WS	34,600.00	2.64	1.58
3. CenTex Material[1]			
4. Chaparral WC	9,550.00	1.40	0.84
5. Chatleff Control[1]			
6. Cimarron Park WC	5,000.00	0.24	0.14
7. City of Austin Irrigation Wells[1]			
8. City of Buda	13,500.00	0.50	0.30
9. City of Sunset Valley	2,200.00	0.58	0.35
10. Comal Tackle Co.[1]			
11. Copper Hills S/D	1,500.00	5.07	3.03
12. Creedmoor-Maha WSC	None	-0-	-0-
13. Dellana Hills S/D	7,000.00	5.68	3.40
14. Estates Utilities WSC	7,000.00	1.73	1.04
15. G&JW District	1,000.00	1.27	0.76
16. Goforth WSC	13,500.00	0.23	0.14
17. Harold Hicks & Al Schuster	17,000.00	6.89	4.13
18. Hays Consol. - Dahlstrom MS	45,000.00	912.44	545.97
19. Hays Consol. - Jack C. Hays HS	13,000.00	263.59	157.73
20. J.D. Malone W.S.	14,500.00	6.26	3.74
21. Leisure Woods WSC	5,000.00	0.25	0.15
22. Marbridge Foundation	16,250.00	329.49	197.16
23. Mooreland W.S.	13,000.00	7.99	4.78
24. Mountain City Oaks W.S. Corp.	13,000.00	1.95	1.17
25. Mystic Oaks WC	4,900.00	2.55	1.52
26. Oak Forest Highlands	19,500.00	14.12	8.45
27. Plum Creek WS Corp.	13,500.00	0.37	0.22
28. Shady Hollow Estates WS Corp.	None	-0-	-0-
29. Slaughter Creek Acres WS Corp.	4,500.00	1.30	0.78
30. Southwest Territory	9,550.00	1.71	1.03
31. Ridgewood Village WS	2,600.00	0.71	0.43
32. Bear Creek Park	16,250.00	4.22	2.53
33. Onion Creek Meadows	8,800.00	0.88	0.53
34. Texas-Lehigh Corp.[1]			
35. Tilson Custom Homes	15,400.00	7.10	4.25
36. Village of San Leanna	25,500.00	3.95	2.36
37. Huntington Estates	None	-0-	-0-

[1]Not Considered for Emergency Interconnect

authority over the plans unless they finance the interconnect systems.

The TWC requests that water suppliers inform their District Section of interconnected utilities. Any tariff modifications by supplier's to accommodate the interconnects must be on file with the suppliers Certificate of Convenience and Necessity (CCN) documents. However, amendments to CCN service areas are not anticipated for the emergency interconnect facilities.

2.11 REFERENCES

1. Novotny, V., and Chesters, G. 1981. Handbook of NONPOINT POLLUTION SOURCES AND MANAGEMENT. Van Nostrand Reinhold Environmental Engineering Series.

2. Water Utility Capital Financing, First Edition Manual of Water Supply Practices (M29). 1988. American Water Works Association.

3. Skillern, F.E.. 1988. Texas Water Law, Volume 1. Sterling Press.

4. Texas Department of Health, Rules and Regulations for Public Water Systems. Adopted 1988.

5. Hydrology and Water Quality of the Edwards Aquifer Associated with Barton Springs in the Austin Area, Texas. U.S. Geological Survey. Water-Resources Investigations Report 86-4036. 1986. Prepared in cooperation with the City of Austin.

6. Tillman, D.A. 1989. Barton Springs/Edwards Aquifer Conservation District Statistical Analysis of Water Elevations and Springflow for the Barton Springs/Edwards Aquifer Regions.

7. The Texas Caver, Vol. 32, No. 2, April 1987. Article entitled "Edwards Stratigraphy and Oil Spills in the Austin, Texas Area" by William H. Russell.

8. Optimal Groundwater Management Model for the Barton Springs-Edwards Aquifer, Edwards Aquifer Research and Data Center, March 1989 by Nisai Wanakule, Ph.D. Asst. Director and Hydrogeologist.

9. Effects of Storm-Water Runoff on Water Quality of the Edwards Aquifer Near Austin, Texas, By Freeman L. Andrews, Terry L. Schertz, Raymond M. Slade, Jr. and Jack Rawson, U.S. Geological Survey, Water-Resources Investigations Report 84-4124.

10. Hays County Regional Water and Wastewater Study, By HDR Engineering, Authorization of Hays County Water Development Board, October, 1988.

APPENDIX A

BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT WELL/METER INSPECTION FORM

Barton Springs/Edwards Aquifer Conservation District

Well/Meter Inspection Form

Contact Date: ______________ Inspection Date: ______________

Water Supply Name: ______________ **CCN#** ______________
Mailing Address: ______________
Managers Name: ______________

Operators Name: ______________ **Type License:** ______________
Inspection Contact: ______________ Phone Number: ______________
Well ID#: ______________ Water Supply Company#______________
Well Location: ______________

____

____

Well Depth: __________ft. **Well Bore Size:** __________ in. **Depth to Water:** __________ ft.
Casing Size: __________in. **Pump Size:** __________Hp. **Pumping Rate:** __________ GPM
Meter Type: __________ **Brand:** __________ **ID#**:__________
Current Meter Reading: __________ Annual Pumpage: __________
Date of Installation: __________ **Date of Calibration:** __________
Percent Accuracy: __________ **Verified:** Documents | Testing | Operator | NOT
Elec. meter reading: __________ **Date of Reading:** __________

Amount of Shrinkage: __________ Average Line Loss: __________

____

Operator Calculated: Y or N If not who calculates: __________
Distance between well and meter: __________

Does water supply measure static water levels in well? Y or N
If so, the most current level was: __________ on (date)__________
What is the wells pumping capacity:__________
What is the amount of drawdown/time: __________ Recovery Time: __________ Tested?__________
How Verified?__________

Storage Facilities Type: __________ **Capacity:** __________Gals. **Elevation:** __________
Operating Pressures: __________

Cooling/recirculating water: Yes or No **Metered**: Yes or No **Reported:** Yes or No
Current Meter Reading: __________ **Rate of Flow:** __________

Treatment Facilities: __________ Type: __________ Capacity: __________
Total # of connections: __________; Res. __________; Comm. __________; Indust. __________; Agr. __________

Are maps available of the distribution systems: Y or N
May we have a copy or order one: Y or N Received: Y or N
Surrounding wells, operating, abandoned, location, distance from WSC, types of wells, problems if any:

____

____

Conservation programs: ______________

____

Leak Detection Programs: ______________
Historic water use data available: Yes or No By user group: Yes or No

Form 01Inspect. June 2, 1989

General condition of system: Excellent Good Average Poor

Notes: ____

____

____

____

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____

____

# of Photos ______

Descriptions of each:

(1) ____

(2) ____

(3) ____

(4) ____

(5) ____

(6) ____

Well ID# in photos Y or N

Additional Comments ____

____

____

____

Inspected by: (print) ______________________

Signed: ______________________ Date: ______________________

Note: Items in **Bold print** must be verified by inspection and/or supporting documentation.

APPENDIX B

BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT WATER SUPPLIERS AND FACILITIES

APPENDIX B

Barton Springs / Edwards Aquifer Conservation District
Water Suppliers and Facilities *

	CCN	NAME
1	11341	**AquaTex Water Supply (Twin Creek Water Supply)**
		Well (22 GPM - 480')
		P.Tank (120 Gal.)
		Well (50 GPM - 505')
		G.S.Tank (8x2400)
		P.Tank (1400 Gal.)
		P.Tank (1900 Gal.)
2	11117	**Arroyo Doble Water System**
		Well (130 GPM - 440')
		G.S.Tank (74,000 Gal.)
		P.Tank (2,600 Gal.)
		Well (130 GPM - 385')
		G.S.Tank (70,000 Gal.)
		P.Tank (5,000 Gal.)
3	none	**CenTex Material**
		Well (1200 GPM - 200')
		Well (950 GPM - 200')
4	11247	**Chaparral Water Co.**
		Well (10 GPM - 500')
		Well (7 GPM - 585')
		Well (10 GPM - 720')
		Well (60 GPM - 850')
		G.S.Tank (43,000 Gal.)
		P.Tank (1,800 Gal.)
		P.Tank (2x94 Gal.)
		Well (5 GPM - 420')
		Well (5 GPM - 420')
		Well (25 GPM - 400')
		G.S.Tank (43,000 Gal.)
		P.Tank (3,300 Gal.)
		Well (5 GPM - 420')
		Well (5 GPM - 420')
		Well (25 GPM - 400')
		G.S.Tank (43,000 Gal.)
		P.Tank (3,000 Gal.)
5	none	**Chatleff Control Inc.**
		Well (60 GPM - 450')
		G.S.Tank (6,000 Gal.)
		P.Tank (4x72 Gal.)

Barton Springs / Edwards Aquifer Conservation District
Water Suppliers and Facilities *

	CCN	NAME
6	12140	**Cimarron Park Water Co. Inc.**
		Well (200 GPM - 500')
		G.S.Tank (200,000 Gal.)
		G.S.Tank (65,800 Gal.)
		P.Tank (5,000 Gal.)
		Well (600 GPM - 500')
		E.Tank (100,000 Gal.)
7	none	**City of Austin Wells**
		Well (350 GPM - 52')
		Well (503 GPM - 50')
		Well (465 GPM - 51')
8	11953	**City of Buda**
		Well (250 GPM - 390')
		E.Tank (50,000 Gal.)
		G.S.Tank (126,000 Gal.)
		Well (350 GPM - 450')
		Well (650 GPM - 740')
		S.P.Tank (500,000 Gal.)
9	10300	**City of Sunset Valley**
		Well (? - 360')
		Well (? - 360')
		Well (120 GPM - 30')
		Tank (44,000 Gal.)
		Tank (5,000 Gal.)
		5 Private Wells
10	none	**Comal Tackle Company**
		Well (25 GPM - 240')
		Tank (5,000 Gal.)
11	none	**Copper Hills Subdivision**
		Well (5 GPM - 500')
		Well (22 GPM - 500')
		Well (20 GPM - 500')
		Well (7 GPM - 500')
		G.S.Tank (83,000 Gal.)
		P.Tank (2,500 Gal.)

Barton Springs / Edwards Aquifer Conservation District
Water Suppliers and Facilities *

	CCN	NAME
12	11029	**Creedmoor-Maha WSC**
		Well (500 GPM - 450')
		Well (600 GPM - 450')
		Well (1500 GPM - 450')
13	none	**Dellana Hills**
		Well (15 GPM - 400')
		Well (400')
		P.Tank (900 Gal.)
14	11457	**Estate Utilities**
		Well (150 GPM - 301')
		P.Tank (6,000 Gal.)
		G.S.Tank (125,000 Gal.)
		Well (500 GPM - 325')
15	none	**G&J Water District**
		Well (60 GPM - 400')
		P.Tank (1,000 Gal.)
		P.Tank (5,000 Gal.)
16	11356	**Goforth WSC**
		Well (250 GPM - 640')
		Well (450 GPM - 640')
		Well (1,500 GPM - 740')
		Well (1,500 GPM - 740')
17	none	**Harold Hicks & Al Schuster**
		Well (55 GPM - 415')
		Tank (1,500 Gal.)
18	none	**Hays CISD**
		Well (150 GPM - 260')
		G.S.Tank (75,000 Gal.)
		P.Tank (5,000 Gal.)
19	none	**Hays CISD**
		Well (25 gpm - 575')
		G.S.Tank (75,000 Gal.)
20	none	**J.D.Malone**
		Well (40 GPM - 425')
		Tank (4,000 Gal.)

	CCN	NAME
21	10880	**Liesurewoods Water**
		Well (150 GPM - 400')
		Well (150 GPM - 400')
		G.S.Tank (56,400 Gal.)
		G.S.Tank (56,400 Gal.)
		P.Tank (7,000 Gal.)
		P.Tank (2,500 Gal.)
		Well (150 GPM - 400')
		Well (150 GPM - 400')
		Well (150 GPM - 400')
		G.S.Tank (56,400 Gal.)
		G.S.Tank (56,400 Gal.)
		P.Tank (5,000 Gal.)
22	none	**Marbridge Foundation**
		Well (70 GPM - 475')
		Well (98 GPM - 475')
		Well (90 GPM - 405')
		Well (75 GPM)
23	none	**Mooreland Water System**
		Well (60 GPM - 400')
		P.Tank (1000 Gal.)
		G.S.Tank (7000 Gal.)
24	11427	**Mountain City Oaks WS**
		Well (240 GPM - 407')
		G.S.Tank (68,000 Gal.)
		G.S.Tank (123,000 Gal.)
		P.Tank (5,000 Gal.)
25	none	**Mystic Oaks Water Co-op**
		Well (58 GPM - 400')
		G.S.Tank (5600 Gal.)
		G.S.Tank (5200 Gal.)
		P.Tank x2 (525 Gal.)
		Well (38 GPM)
		G.S.Tank (3100 Gal.)
		G.S.Tank (5200 Gal.)
		P.Tank (1000 Gal.)

Barton Springs / Edwards Aquifer Conservation District
Water Suppliers and Facilities *

	CCN	NAME
26	12086	**Oak Forest Highlands**
		2 Wells (62 GPM ea.)
27	10299	**Plum Creek Water**
		Well (275 GPM - 640')
		Well (650 GPM - 720')
		S.P.Tank (41,000 Gal.)
		P.Tank (5,000 Gal.)
		G.S.Tank (66,400 Gal.)
		S.P.Tank (41,000 Gal.)
		S.P.Tank (41,000 Gal.)
28	11846	**Shady Hollow Estates Water Supply Corp.**
		Well (260 GPM - 600')
		G.S.Tank (100,000 Gal.)
		P.Tank (5,500 Gal.)
29	11725	**Slaughter Creek Acres Water Supply Corp.**
		Well (83 GPM - 420')
		Well (420')
		G.S.Tank (5,000 Gal.)
		G.S.Tank (18,000 Gal.)
		P.Tank (2,500 Gal.)
		G.S.Tank (5,000 Gal.)
		P.Tank (500 Gal.)
30	11813	**Southwest Territory Water Co.**
		Well (40 GPM - 500')
		Well (125 GPM - 820')
		Well (18 GPM - 350')
		G.S.Tank (43,800 Gal.)
		P.Tank (2,500 Gal.)
31	10303	**Ridgewood Village Water System (Stenger & Stenger)**
		Well (200 GPM - 290')
		G.S.Tank (50,000 Gal.)
		P.Tank (5,000 Gal.)
		Pump Sta. (300 GPM)

Barton Springs / Edwards Aquifer Conservation District
Water Suppliers and Facilities *

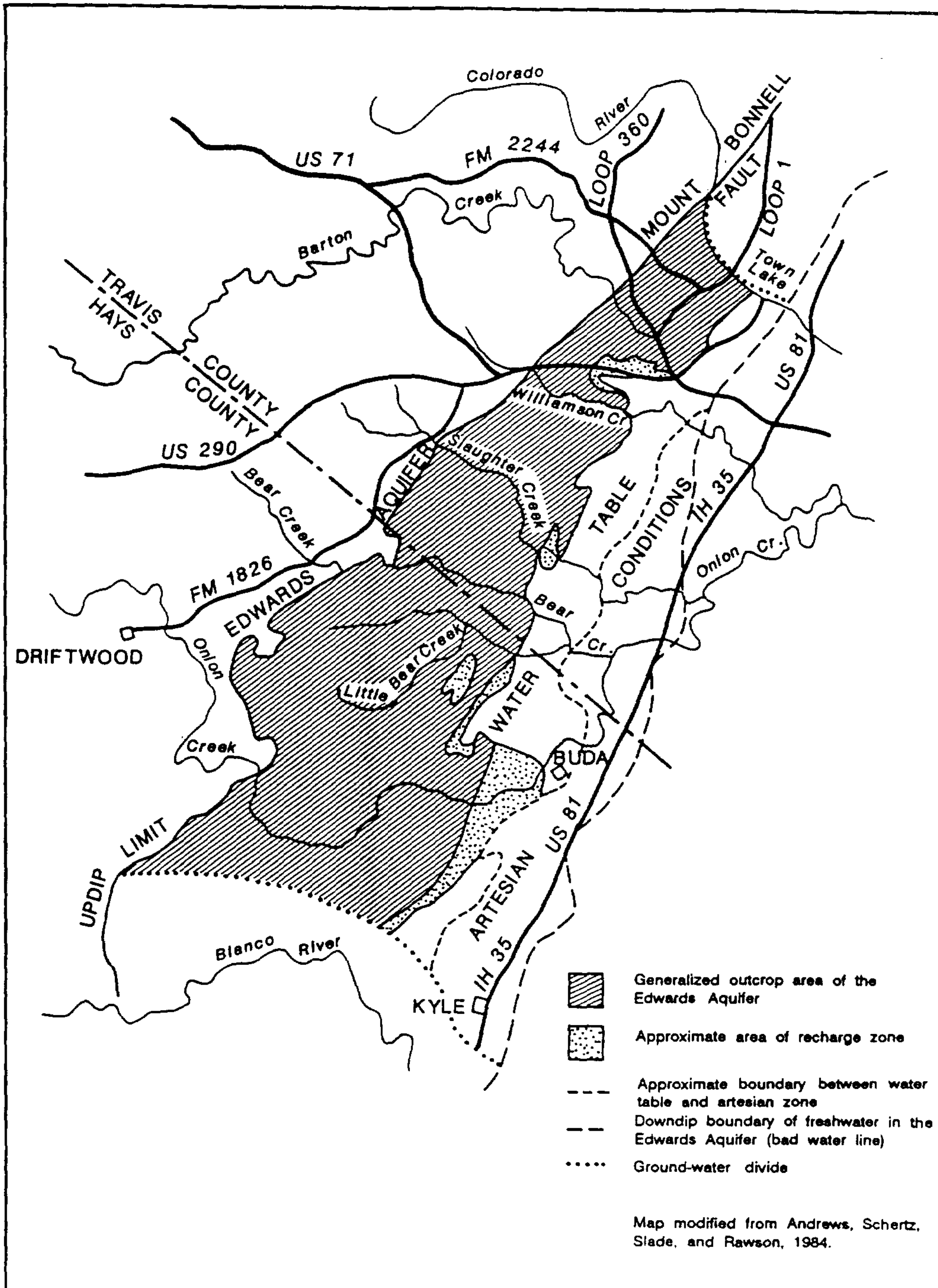
	CCN	NAME
32	none	**Bear Creek Park (by Chaparral Water Co.)**
		Well (100 GPM - 320')
		Well (30 GPM - 240')
		G.S.Tank (5,350 Gal.)
		P.Tank (2x900 Gal.)
		G.S.Tank (11,900 Gal.)
		P.Tank (900 Gal.)
33	none	**Onion Creek Meadows (by Chaparral Water Co.)**
		Well (80 GPM - 402')
		G.S.Tank (5,350 Gal.)
		P.Tank (2x900 Gal.)
		Well (60 GPM - 365')
		G.S.Tank (33,000 Gal.)
		P.Tank (2x525 Gal.)
		Well (60 GPM - 441')
		G.S.Tank (18,400 Gal.)
		P.Tank (2,700 Gal.)
34	none	**Texas-Lehigh Cement Co.**
		Well
		Well
		Well
		E.Tank (100,000 Gal.)
35	none	**Tilson Custom Homes**
		Well (20 GPM - 450')
		Tank (3,500 Gal.)
36	none	**Village of San Leanna**
		Well (110 GPM - 502')
		G.S.Tank (42,000 Gal.)
		G.S.Tank (42,000 Gal.)
		P.Tank (5,000 Gal.)
		Well (75 GPM - 500')
		P.Tank (2,500 Gal.)
		Well (50 GPM - 500')
		P.Tank (525 Gal.)

* Data from Texas Department of Health information and Texas Water Commision information

APPENDIX C

DELINEATION OF BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

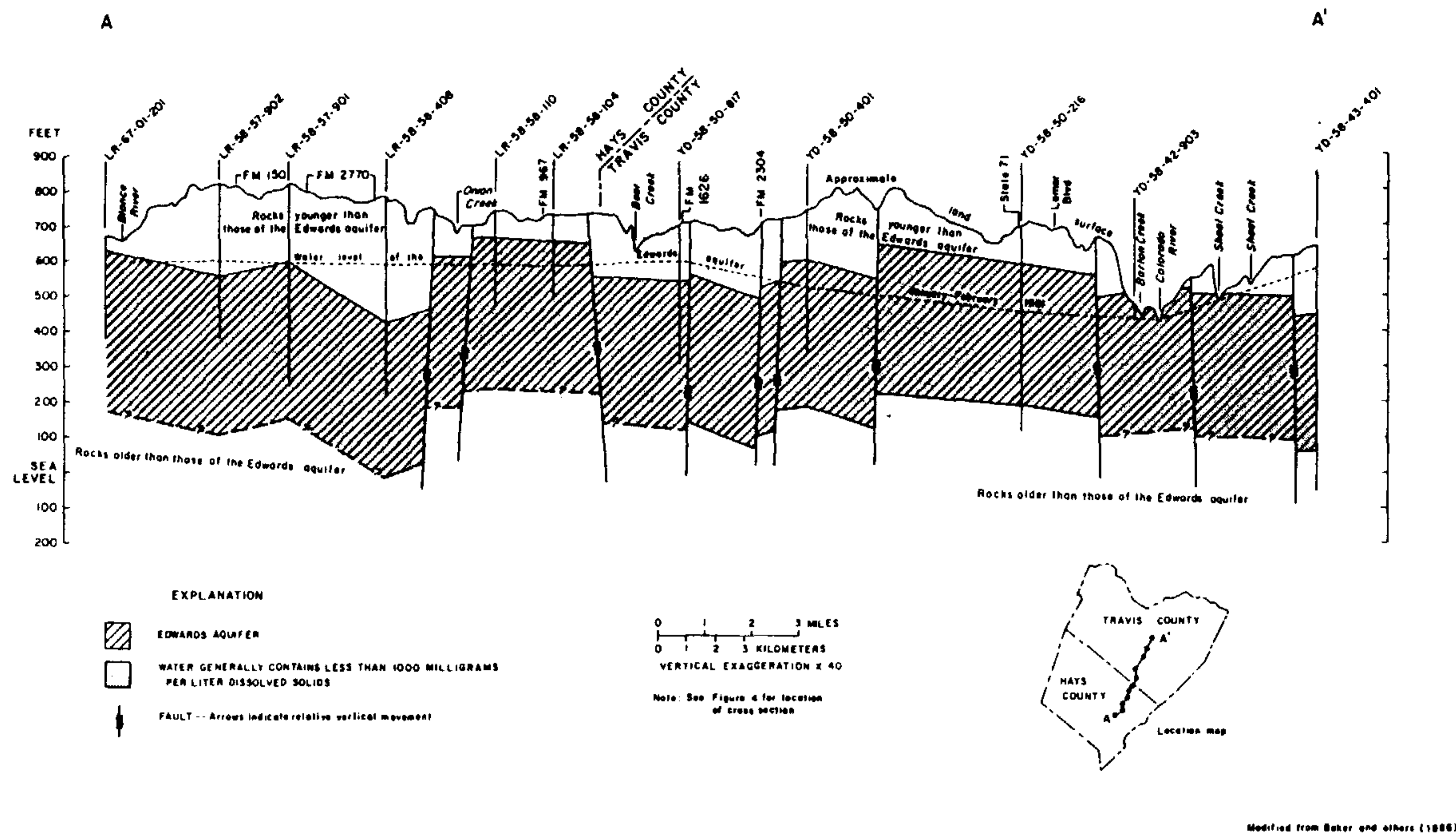
APPENDIX C DELINEATION OF BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER



APPENDIX D

HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG STRIKE, A-A'

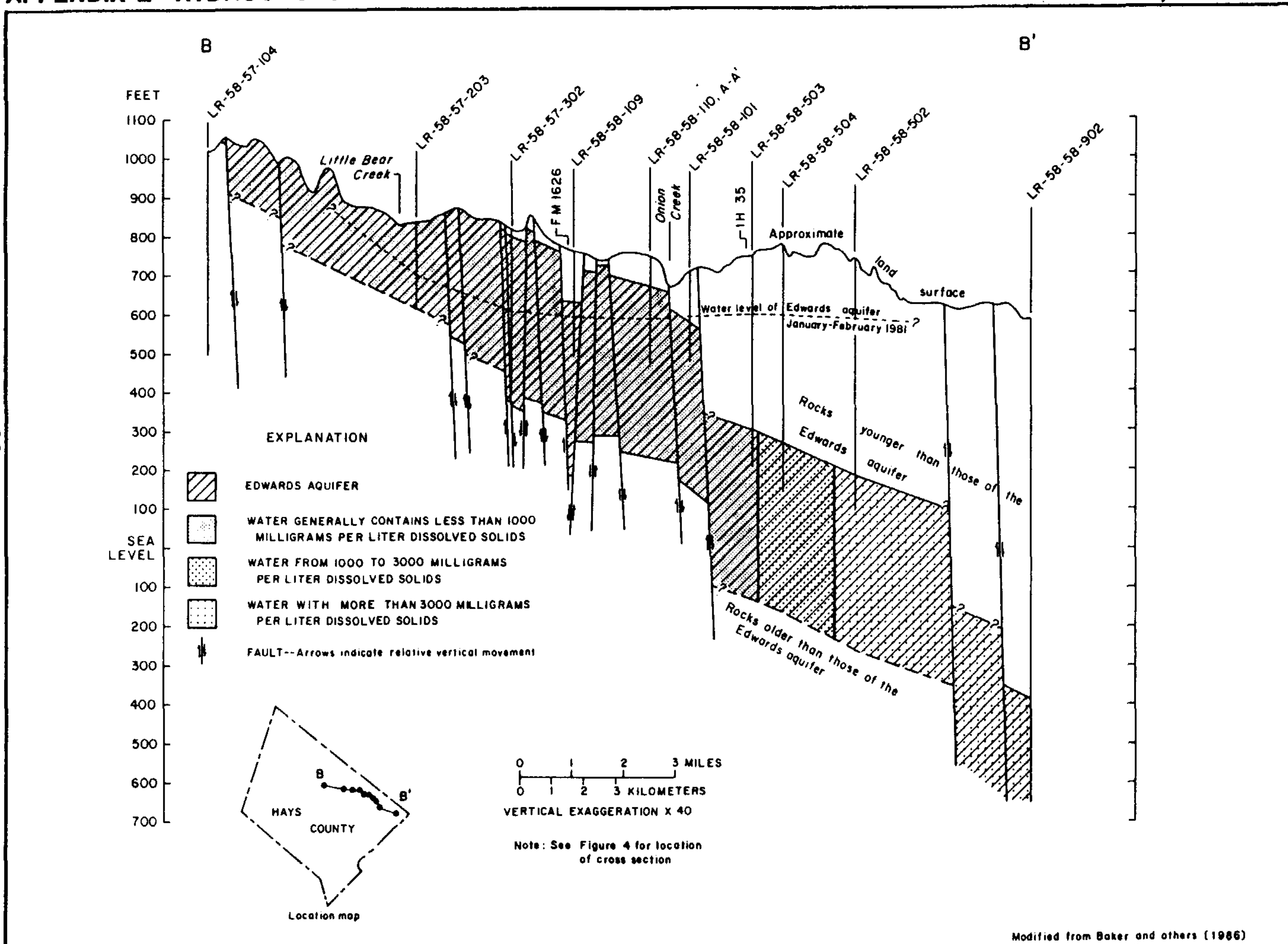
APPENDIX D HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG STRIKE, A-A'



APPENDIX E

HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG DIP IN HAYS COUNTY, B-B'

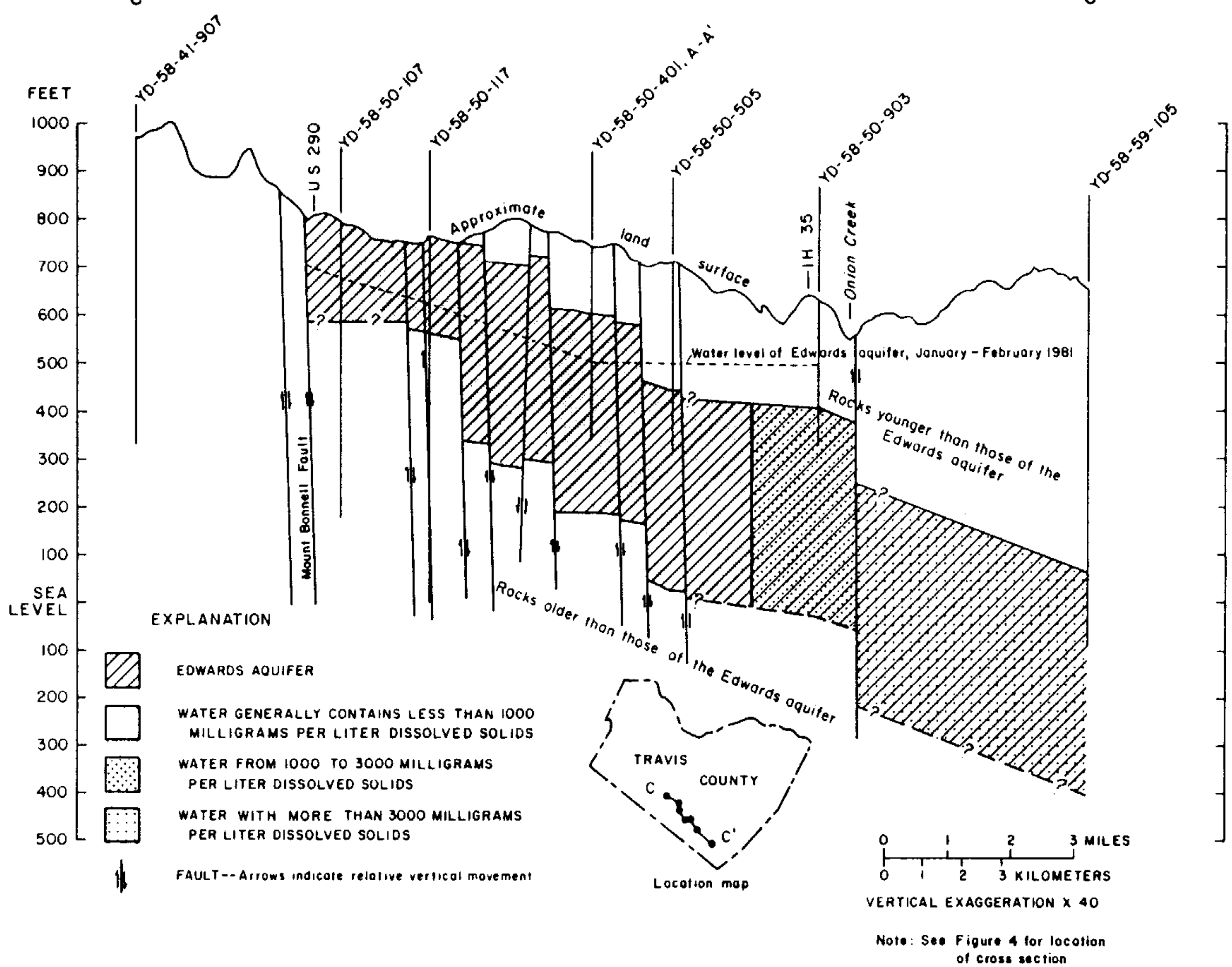
APPENDIX E HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG DIP IN HAYS COUNTY, B-B'



APPENDIX F

HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG DIP IN TRAVIS COUNTY, C-C'

APPENDIX F HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG DIP IN TRAVIS COUNTY, C-C'



Note: See Figure 4 for location of cross section

Modified from Baker and others (1986)

SECTION 3 REPORT

REGIONAL WATER PLAN
for the
BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

WATER CONSERVATION PLAN

prepared for

BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT
Austin, Texas

and

TEXAS WATER DEVELOPMENT BOARD
Planning Grants Assistance Program
Austin, Texas

TWDB CONTRACT NO. 9-483-732

prepared by

DAVID VENHUIZEN, P.E.
Uhland, Texas

SEPTEMBER 1990

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REGIONAL WATER PLAN
FOR THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER
SECTION 3
WATER CONSERVATION PLAN

3.0 BS/EACD WATER CONSERVATION PLAN

The BS/EACD was created to conserve and to protect the quality of the groundwater within its jurisdictional area. This chapter examines options for and formulates a water conservation plan through which the BS/EACD and the water supply entities drawing upon these groundwater resources can advance that general objective. The report begins with a consideration of the goals and objectives of a water conservation plan for the BS/EACD area. A brief description of the nature of the groundwater resources within the BS\EACD's area follows. Arguments are then presented regarding the proper context for evaluating the cost efficiency of conservation measures. Following that, the nature of groundwater demand by users of these resources is examined, providing a general indication of where significant conservation appears achievable. Then the four predominant usage sectors are examined in detail to elucidate the opportunities for conservation in each sector. These include interior (domestic) demand, exterior (mainly irrigation) demand, industrial demand, and unaccounted-for losses. Next, the role of pricing in conservation strategy is reviewed. The conservation study concludes with an examination of mechanisms for implementation of conservation measures.

3.0.1 GOALS AND OBJECTIVES

A subcommittee of the BS/EACD Policy Advisory Committee (PAC) was appointed in early 1989 and charged with formulating proposals for "interim" conservation and drought contingency plans. The draft conservation plan produced by that subcommittee offered the following goal statement:

"The goal is to preserve and protect the waters in the Barton Springs segment of the Edwards Aquifer, including maintaining the quality of Barton Springs."

This goal statement suggests the following definition of "conservation":

"Conservation is the maximum beneficial and efficient use of water, the reduction of waste, and beneficial reuse of water."

The BS/EACD PAC adopted the following objectives for a water conservation plan:

"The objectives of conservation are to reduce per capita demand, reduce peak summer demand usage, and maintain or improve the water quality in the Edwards Aquifer. General methods of obtaining these objectives include:

1. Public education and information;
2. Interior water use efficiency enhancement;
3. Exterior water use efficiency enhancement and demand reduction;
4. Adjustments in water pricing policies;
5. Beneficial reuse or substitution of non-potable water in demands where potable water is not required; and
6. Leak detection and repair."

These goals and objectives form a good overall framework within which to explore the opportunities for water conservation. They also highlight a crucial point about the nature of a "real" conservation effort.

Too often, "conservation" is equated to the types of short term curtailment efforts embodied in drought contingency plans. The plan presented herein does NOT deal with doing without to get by nor with enforcing changes of lifestyle or habit to meet a crisis situation. Rather it focuses on measures which can be taken to AVOID a crisis.

The focus is on "durable" rather than "removable" conservation measures. The plan stresses means of reducing per capita demand which do not depend to any great degree upon conscious daily effort by the water users. Instead, they depend upon changes in the way water-demanding tasks are addressed. Three distinct types of changes can be readily identified:

1. Changes in how water using tasks are "formulated", e.g., Xeriscape to reduce landscape irrigation requirements;
2. Changes in how water using components are designed, e.g., ultra-low volume toilets; and
3. Changes in how water system components are maintained, e.g., leak detection and repair.

These changes can produce permanent, reliable reductions in per capita demand. Given this focus, it can be readily appreciated that the basic underlying questions include:

1. What will it cost to achieve this long-term conservation?
2. How can the changes required to implement these measures best be encouraged and/or enforced?
3. What costs would be incurred if these measures are not pursued?

The remainder of this section attempts to provide some possible answers to the last question, while the rest of this chapter focuses mainly on the first two questions.

3.0.2 HYDROGEOLOGIC FACTORS INDICATING A NEED FOR CONSERVATION

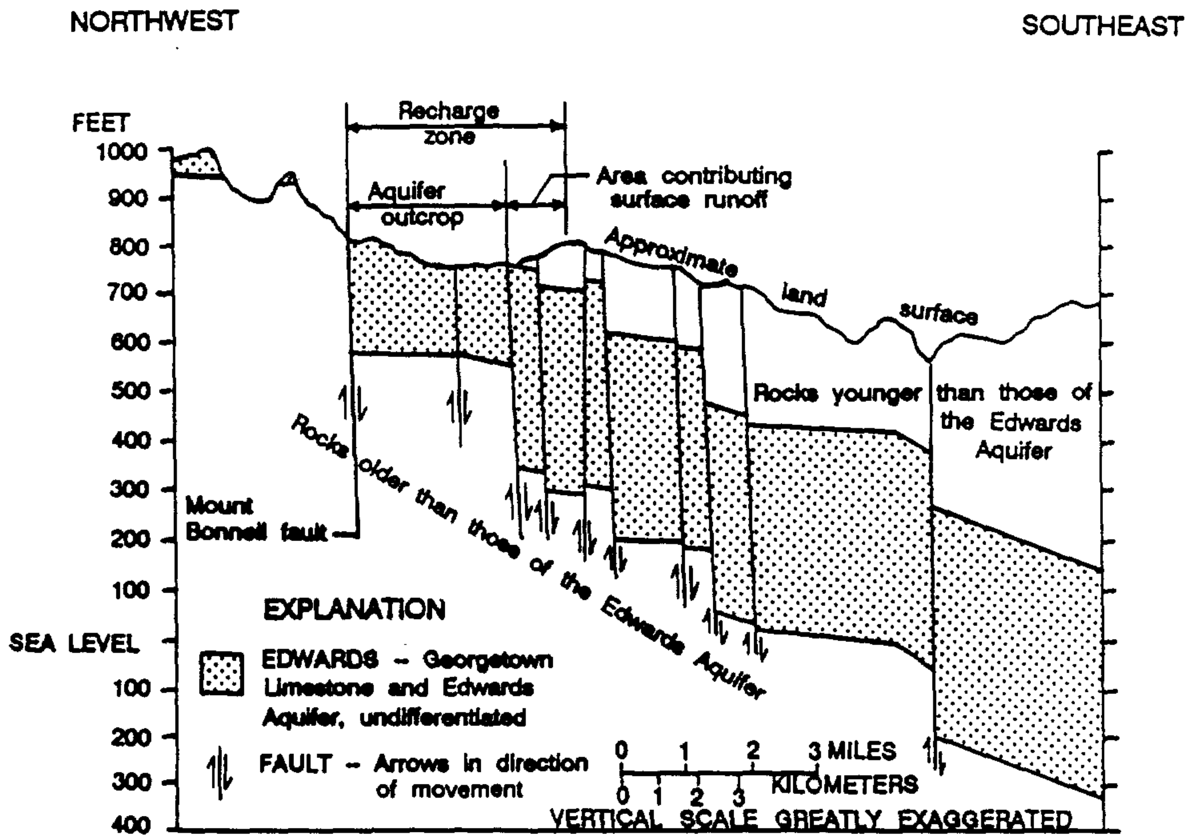
3.0.2.1 A Brief Review of the Hydrogeologic Setting

The Barton Springs segment is a portion of the Edwards aquifer is composed of Edwards and Georgetown limestones. A series of studies conducted by the U.S. Geological Survey (USGS) and the Texas Water Development Board (TWDB) have defined the limits of this segment. It is generally bounded on the north by the Colorado River, where it discharges through Barton, Cold and Deep Eddy Springs. To the south, a groundwater divide near FM 150 defines the southern limit of the Edwards which provides flow to Barton Springs. The western boundary is along the Mount Bonnell and associated faults. To the west of the fault line, strata older than the Edwards Formation. East of this line, formations of the Edwards aquifer are exposed at the surface, forming the "recharge zone". Here and on to the east, the Balcones Fault Zone has created a series of "steps" which dips the Edwards aquifer under younger strata, creating a "confined zone". The generally recognized easterly boundary of the aquifer is the so-called "bad water line", where the total dissolved solids level of Edwards water is 1,000 mg/l or greater. Figure 3.1 shows a generalized hydrogeologic section along the dip.

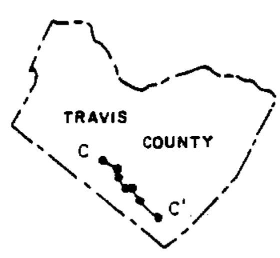
Where the Edwards Formation is exposed at the surface, it is partially eroded. The thickness in this area is determined by faulting and the extent of erosion, ranging from about 100 feet to about 450 feet. Where not exposed and eroded, the thickness varies from about 400 feet in the northern part of the area to about 450 feet in its southern reaches.

As Figure 3.1 shows, the aquifer is under "water table" conditions in the recharge zone; that is, a well drilled in this area would have a free water surface in the well at the same elevation as the

FIGURE 3.1 GENERALIZED HYDROGEOLOGIC SECTION ALONG DIP OF THE EDWARDS AQUIFER



Adopted from Slade and others, in press



top of the saturated zone in the aquifer. For some indeterminant distance into the confined zone, water table conditions continue to exist. This distance would vary spatially with the local pattern of faulting and temporally with the storage level of the aquifer. Going further into the confined zone, a point is reached where the aquifer is under artesian conditions; that is, the free water surface in a well drilled here would rise above the contact with the Edwards aquifer.

The Edwards Formation is underlain by a confining bed known as the Walnut Formation, which ranges in thickness from 15 to 60 feet. Below this lies the Trinity Group, which contains several water bearing strata. The water in these aquifers is generally of lower quality than Edwards water. Trinity Group strata outcrop to the west of the Mount Bonnell fault line. Figure 3.2 summarizes the lithology of the Edwards Formation.

The porosity and permeability of the Edwards aquifer is greatly influenced by irregular dissolution of the limestones. These in turn determine hydraulic properties. Flow in the aquifer is primarily through dissolution cavities and caves associated with faults, fractures and joints, and only secondarily through porous (primary porosity) media within the limestone. Thus the hydraulic properties can vary greatly over the aquifer's area and through its depth at any location.

The only source of fresh water input to the Edwards is from rainfall over and upstream of the recharge zone. Studies by the USGS (1986) have shown that the vast majority of recharge occurs along the six major creeks: Barton, Williamson, Slaughter, Bear, Little Bear, and Onion. Recharge is highly dependent upon the occurrence of runoff-producing storms over the watersheds of these creeks. This makes the amount of storage in the Edwards aquifer very sensitive to conditions of drought.

FIGURE 3.2 GENERALIZED HYDROGEOLOGIC COLUMN SHOWING THE EDWARDS AQUIFER AND ITS CONFINING BEDS AND THE CORRELATIVE FORMATIONS

SYSTEM	FORMATION	HYDROGEOLOGIC UNIT
CRETACEOUS	BUDA LIMESTONE	UPPER CONFINING BED
	DEL RIO CLAY	
	GEORGETOWN LIMESTONE	EDWARDS AQUIFER
	EDWARDS LIMESTONE	
	WALNUT FORMATION	LOWER CONFINING BED
	GLEN ROSE LIMESTONE	AQUIFER

3.0.2.2 Possible Impacts of Increased Pumpage

Historically, pumpage from the Barton Springs segment of the Edwards aquifer has been a fairly small fraction of the total spring discharge. The volume of spring discharge is "self regulated" by the level of water in the aquifer. Discharge decreases as storage drops, which historically has been mainly due to lack of recharging rains rather than to pumped withdrawals. In recent years, however, pumpage from the Edwards aquifer in this area has increased. This higher pumpage is directly related to decreased discharges from Barton Springs and to other potential negative impacts.

An indication that the storage level in the aquifer now responds more quickly than in historical periods comes from water level data evaluation. Generally lower water levels were experienced not in 1956 at the end of the 6-year drought of record, rather in 1984 during about a 10-month "mini-drought".

In 1956, well LR 58-58-101, located near Buda, had an average water level of 561.5 feet MSL over the July-October period, with a minimum water level of 561. In 1984, the minimum level was 553 feet MSL, and, except for one reading, the level was continuously lower than 561 from July through October.

Well YD 58-50-801, located near San Leanna, recorded a minimum level of 505 feet MSL in June of 1956, but this was an "isolated" low point. Readings in May and July were 525 and 519 feet MSL, respectively. In 1984, though the minimum recorded level was just above the all-time minimum, standing at 506 in September, water levels were at 516 or less continuously from June through September.

These data suggest that pumpage is already at a level where its impacts are more noticeable. Thus the "self regulation" of total discharge could be overridden and withdrawal from the Edwards aquifer could enter the realm of groundwater mining, decreasing water levels in the aquifer below those observed historically.

One negative impact of this increased pumpage may be a decline in the quality of water in the Edwards aquifer. Studies by the USGS (1986) indicate that quality degradation might be caused by two sources: (1) leakage from the Trinity aquifer, and (2) encroachment of water high in dissolved solids along the "bad water" line.

Due to faulting, water bearing strata of the Trinity are not "sealed off" from the Edwards at all points by the Walnut Formation, and the Walnut Formation may not form a perfect seal where it does separate the two aquifers. Evidence suggests that local "overpumpage" of the Edwards routinely induces leakage of Trinity water into Edwards wells at some locations under present conditions. The implication of this circumstance is reflected in a USGS report (1986):

"If future development of wells and pumpage is expanded, the areal extent of leakage from adjacent aquifers may greatly increase. Under such circumstances, the chemical character of the water pumped from wells that penetrate the Edwards aquifer and from Barton Springs may be similar to a mixture of waters from the Edwards and Trinity aquifers. . . . If leakage into the Edwards aquifer became significant under future conditions, the resultant quality of water in the Edwards aquifer may deteriorate and even require treatment."

"Bad water" encroachment is another potential threat to quality if increased pumpage reduces aquifer storage below historic levels.

Evidence suggests that this may have already occurred in the northeast portion of the aquifer when storage levels were low. This circumstance appears to dictate that keeping Barton Springs flowing is an unavoidable consequence of assuring that the quality of Edwards water--at least in this area--does not degrade.

Further south, it is speculated that local faulting patterns might block significant "bad water" movement into the freshwater zone. Due to this situation, USGS (1986) states that "[i]f, in the future, increased pumping significantly lowers potentiometric surfaces in this area, the faults may restrict bad-water encroachment into well fields." [Emphasis added.] The implication is that this is one of many aspects of aquifer "behavior" about which there is little knowledge on what would happen once well levels in the area were drawn down below the limit of historical records.

The USGS analysis also does not deal with the potential for "bad water" encroachment between the northeastern area and the faulted area to the south. USGS (1986) provides data showing that well levels to the east of the "bad water" line are higher than those just inside the freshwater zone even during times of average spring discharge. This implies that increased pumpage might produce an adequate gradient for movement of "bad water" into the freshwater zone. The numerous sizable wells now pumping from Buda northward to about Slaughter Creek would appear to be particularly vulnerable.

Another potential negative impact of increasing the level of pumpage from the aquifer is an inability of many wells to continue to produce Edwards water. USGS (1985) outlined studies of the impact of increased pumpage which concluded that a large portion of the Edwards would be "dewatered" under future growth scenarios. While the exact assumptions upon which that model was based may be open to question, the general indication is clearly one of decreasing storage levels with increased pumpage. In reviewing that study, USGS (1986) states:

"The water demand for this growth may exceed the resources of the Edwards aquifer particularly in site specific areas. [sic] The effect of this growth on ground-water levels and on Barton Springs discharge depends upon the extent that the Edwards aquifer is used to provide the water demand."

However, it is not necessary to hypothesize huge area-wide increases in pumpage in order to foresee possible problems with abstraction. Recall the variable nature of hydraulic properties within the aquifer. According to USGS researchers, it is well established that much of the available capacity of the aquifer is near the top, in the zone of historic water level fluctuation. It is entirely possible that even a small decrease in the water level of any given well, due to increased pumpage demand, could significantly alter the drawdown curve. Historically that well may have been withdrawing at a level with high permeability, but a decreased static level and/or an increased demand could result in withdrawal from levels having less well developed permeability, creating a drawdown much greater than previously experienced. Even though such conditions may have no effect on the quality or the reliability of the supply, it may still result in a costly deepening of the well and increased pumping costs for the supply entity.

3.0.2.3 Conservation: An Ongoing Drought Contingency Plan

The foregoing outlined how the nature of the Barton Springs segment of the Edwards aquifer dictates that increased pumpage may lead to problems with the quality and quantity of supplies, at least in parts of the area. Note, however, that these problems are mainly predicated upon conditions of low recharge. As long as recharge continues to be "adequate", the impact of increased abstraction would mainly be a (presumably minor) reduction of flow from Barton Springs. Localized drawdown problems could still occur at any storage level with a sufficiently high level of local demand, but, of course, they would be more severe at lower storage levels. In sum, the resource is very drought-sensitive, and it is likely to become more so as pumpage levels increase, both locally and over the aquifer as a whole.

In effect, then, a conservation program for the BS/EACD and the users of this resource can be viewed as an on-going drought contingency plan. Any long-term reductions in groundwater pumpage resulting from program implementation would decrease the severity of the impacts from any given period of drought.

Historically, reductions in aquifer storage reflect a reaction to long-term conditions of low recharge rather than to the seasonal variations in pumpage. While this is an artifact of the seasonal patterns of recharging storms in this area--and also due no doubt to springflows having dominated the rate of discharge--it is an indication that any conservation program should attempt to reduce the "base" demand as well as the peak demands of aquifer users. The potential for negative impacts--except perhaps for local drawdown problems--appears related more to the total level of withdrawal than to the peaking pattern or peak rate of withdrawal.

In closing this discussion, it is noted that most models attempting to predict the impacts of the "greenhouse" effect show the future climate of Central Texas as becoming somewhat drier on average. Since recharge of the Edwards aquifer depends upon the occurrence of recharging storms (those of sufficient volume and intensity to produce significant runoff), even a change in rainfall patterns--without any reductions in average annual levels--could greatly reduce the storage level in the aquifer. This provides yet another reason to favor the maximum level of water conservation which can be cost efficiently obtained.

3.0.3 COST EFFICIENCY OF CONSERVATION--A RESOURCE ECONOMICS VIEWPOINT

3.0.3.1 Marginal costs of alternative supplies

As discussed above, under favorable climatic conditions, the Edwards aquifer may in fact be a renewable resource, even in the face of increasing demand (if one neglects the reduction in springflow implied by increased pumpage). But prudent public policy does not favor gambling upon the continual existence of favorable conditions. Nor does it favor gambling that any impacts of storage level reductions upon the availability and quality of Edwards water would be minimal. Therefore, Edwards water ought to be considered as a potentially scarce and exhaustible resource, and plans for its management should be based upon that view.

In a market economy, scarce resources are generally allocated by the law of supply and demand: as scarcity increases, price goes up, serving to allocate the resource to those uses which produce the best return on the investment. Neglecting for the moment the question of whether strict market principles ought to be applied to "social goods" like water supply, it is still useful to consider the role of market forces in the allocation of Edwards water.

Under Texas law, groundwater is subject to a "right of capture", so that any user is generally free to take all it can pump, regardless of the impact upon other users of the same resource. One result of this situation is that users of Edwards water have tended to view the water supply as being "free", subject only to the cost of abstraction and distribution. As noted, if climatic conditions (and probably local pumping intensity as well) do not become too unfavorable, this could indeed continue to be a realistic viewpoint.

If one proceeds upon the assumption that Edwards water is a potentially scarce and exhaustible resource, however, then it is no longer rational to view the supply source as being free. Natural resource depletion costs should be considered when attempting to place a value on the water delivered to a user. Thus, present prices--which do not take the depletion cost into account--offer a poor guide for how much and when to invest in measures to ensure the availability and quality of this water, both to an individual user and to the group of users as a whole. A failure to adequately ensure the availability or protect the quality of Edwards water may eventually lead to a need to access alternative sources of supply --or even just to deepen existing wells, install larger pumps and/or pump longer to obtain the same volume. The costs of these actions represents the "long-run marginal cost" of water supply.

Since present prices for water do not accurately reflect this long-run marginal cost, fiscal analysis of conservation measures may result in "undervaluing" those measures; that is, at present prices, the rate of return on the investment in a conservation measure would appear to be too low to justify implementation. However, it may be the very failure to institute these measures which eventually requires users to incur the costs of alternative supplies. It may have been far less expensive in the long run to pursue those "unjustifiable" conservation measures, since this would have obviated, downscaled, or shoved further into the future the costs of alternative supply projects.

Individuals, businesses and supply entities should somehow take this long-run marginal cost of water supply into account when evaluating the "cost efficiency" of conservation measures. But such costs would not actually be incurred until the water user was forced to begin implementing the alternative supply project. This dictates that a long-term economic analysis rather than a short-term fiscal analysis is called for. As an aid to evaluating conservation measures in that manner, some indications of the apparent long-run marginal cost of water supply in the BS/EACD's jurisdictional area are provided here.

The recent Hays County Water Development Board study offers cost estimates for alternative water supplies to parts of this area. Of those, the option with the lowest marginal cost was a project to supply water to Hays and Buda from the City of Austin. Examining the project cost and the estimated amount of water to be supplied by it (as detailed in Table 3.3-2 of the Hays County WDB final report), an estimate of the long-run marginal cost of an alternative water supply in this case is $20.09 per 1000 gallons for the period of 1995 to 2005.

Tempering this, it should be noted that this study assumed Hays and Buda would continue to use the same average day amount of groundwater demanded in 1984, while the alternative supply would provide only for demand beyond that level. This assumption dictates that the project would mainly serve peaking demands. It appears that about 10% of the total supply would be derived from this project. (This scenario assumes, of course, that Hays and Buda can indeed continue to obtain high quality Edwards water at the 1984 pumping rates.) The Hays County WDB report represented the net fiscal impact of this project as an increase in the monthly charge per connection of $12 in Hays and of $19 in Buda. If Hays and Buda were to take all of their supplies through this project, the cost would drop to "only" $7.72 per 1000 gallons. This is over 5 times Buda's current top rate and over 2.5 times Hays' current top rate.

At the other end of the scale, the project recommended to serve Mountain City would entail an increase in the monthly charge per connection to finance it of $67 in the period of 1995-2005. (See Table 3.3-3 of the Hays County WDB final report.) Insufficient detail was provided in the report to break out the costs for Mountain City from the entire project, so an estimate of water cost per 1000 gallons is not derived. Comparing the cost per connection with that for Hays and Buda, however, indicates that the cost is probably far in excess of $20 per 1000 gallons. (The average daily demand from the alternative supply projected for Mountain City in 2000 is the same as that projected for Hays and Buda). Since many of the smaller water supply systems in the BS/EACD jurisdictional area are situated similarly to Mountain City, it is likely that their alternative supply costs would be similar, assuming the range of alternatives is limited to those considered in the Hays County WDB study.

These estimates of long-run marginal costs graphically illustrate how fiscal analysis may not be a "proper" guide for investment in conservation. Some consideration of the probable long-run marginal costs of alternative supplies should be injected into the analysis. Adjustments of rate structures in concert with the principles of marginal cost pricing will naturally make fiscal analysis of conservation measures more realistic. This is discussed later in Section 7 of this report.

If the Hays County WDB estimates of long-run marginal costs are even roughly accurate, however, prices high enough to reflect these costs could not be fiscally justified by a supplier until it actually committed resources to a supply project. This is not likely to occur until more thorough analyses of the aquifer's vulnerability and a more complete analysis of all options for alternative water supply are conducted. In the meantime, conservation opportunities will continually be confronted. Therefore, it will be useful to employ a "best guess" of long-run marginal cost as a guide to the economic efficiency of conservation measures. Based upon the best information available at this point, a marginal price of at least $5 per 1000 gallons appears readily justifiable for this purpose.

3.0.3.2 Marginal costs of system infrastructure

Even if it does not require alternative supply projects, increased water demand may still incur high marginal costs. The water supply system may require larger storage volumes, new wells or larger pumps in existing wells, larger transmission mains, etc. In short, the incremental cost of increased water service capacity is largely determined by the incremental costs of increasing capacities of system components.

While these fiscal "penalties" of expanding water service have little direct bearing upon the main focus of this plan--which is conserving and protecting the availability and quality of Edwards water--they can have a great impact upon the economic feasibility of various conservation measures. If per capita demand were reduced, more customers could be served with existing capacity. So forestalling--through conservation--the need for the next increment of capacity expansion would decrease the marginal cost of providing the expanded water service. Reduction of system peak demands is particularly beneficial in this regard.

Conservation measures which do not appear to be attractive based upon short-term fiscal analysis may in fact be less expensive than the long-run marginal cost of system expansion. Just as in the case of marginal costs associated with accessing alternative supplies, these "avoided" costs of system capacity expansion should be taken into account when evaluating the cost efficiency of pursuing conservation measures.

3.1 WATER USE IN THE BS/EACD AREA

A major focus of this study was to detail the types and patterns of water demand among Edwards aquifer users. This information is essential if one is to intelligently determine how best to cost efficiently conserve water. The information received from water suppliers and other sources was used to characterize water demands.

3.1.1 WATER SUPPLIER DATA

3.1.1.1 Data Provided by Water Suppliers

Each water supply entity was requested to provide the following information:

1. Water produced in each month of the years 1983 through 1988;
2. Water sold in each month of the years 1983 through 1988 to each of the following classes of customers; and
   - A. Residential
   - B. Commercial
   - C. Industrial
   - D. Agricultural
3. The number of active accounts in each of the above classes of customers in each month of the years 1983 through 1988.

Goforth WSC, Estates WSC, and Ridgewood Village Water Company provided a fairly complete set of the requested data. Complete pumpage and accounts data was also provided for the City of Sunset Valley, but sales data was only available back to mid-1986. Data was also provided for Chaparral Water Company beginning in late 1987. Based upon these data, residential demand profiles for these systems are displayed in Tables 3.1 through 3.5.

TABLE 3.1 GOFORTH WSC RESIDENTIAL DEMAND PROFILES, 1983-1988

YEAR OF RECORD = 1983 ESTIMATED PERSONS PER CONNECTION = 2.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	2912	2961	2738	2942	4797	4590	5086	5452	6328	5534	4069	3946
CONNECTIONS	525	526	527	533	533	530	527	526	561	554	558	570
GAL/CONN	5546	5629	5252	5519	9000	8661	9651	10365	11280	9990	7292	6923
GPD/CONN	179	201	169	184	290	289	311	334	376	322	243	223
GPCD	78	87	74	80	126	126	135	145	163	140	106	97

YEAR OF RECORD = 1984 ESTIMATED PERSONS PER CONNECTION = 2.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	5445	3956	3961	4354	6791	6782	7698	7650	8661	8050	6351	6125
CONNECTIONS	583	591	587	624	650	641	659	679	693	719	743	740
GAL/CONN	9340	6694	6748	6977	10448	10580	11631	11266	12497	11196	8547	8277
GPD/CONN	301	239	218	233	337	353	377	363	417	361	285	267
GPCD	131	104	95	101	147	153	164	158	181	157	124	116

TABLE 3.1 GOFORTH WSC RESIDENTIAL DEMAND PROFILES, 1983-1988 (CONTINUED)

YEAR OF RECORD = 1985 ESTIMATED PERSONS PER CONNECTION = 2.3												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
WATER SOLD (1,000 GAL)	5047	6416	5024	5028	6166	7504	7209	12887	11040	7085	5612	5598
CONNECTIONS	743	758	757	755	817	816	818	840	937	939	925	927
GAL/CONN	6792	8464	6637	6660	7547	9196	8813	15341	11783	7545	6067	6039
GPD/CONN	219	302	214	222	243	307	284	495	393	243	202	195
GPCD	95	131	93	97	106	133	124	215	171	106	88	85

YEAR OF RECORD = 1986 ESTIMATED PERSONS PER CONNECTION = 2.3												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
WATER SOLD (1,000 GAL)	5649	5727	5376	7422	7472	7010	10706	14284	8255	6622	6068	5659
CONNECTIONS	968	963	952	977	984	1003	1005	1008	1015	1019	1019	1017
GAL/CONN	5836	5947	5647	7596	7594	6989	10653	14170	8133	6499	5954	5565
GPD/CONN	188	212	182	253	245	233	344	457	271	210	198	180
GPCD	82	92	79	110	107	101	149	199	118	91	86	78

TABLE 3.1 GOFORTH WSC RESIDENTIAL DEMAND PROFILES, 1983-1988 (CONTINUED)

YEAR OF RECORD = 1987 ESTIMATED PERSONS PER CONNECTION = 2.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	6969	5431	5385	7457	9614	6160	8974	12764	10166	8518	7957	6092
CONNECTIONS	995	988	992	984	988	990	1002	1009	1010	1009	1012	1012
GAL/CONN	7004	5497	5429	7578	9731	6222	8956	12650	10066	8442	7862	6020
GPD/CONN	226	196	175	253	314	207	289	408	336	272	262	194
GPCD	98	85	76	110	136	90	126	177	146	118	114	84

YEAR OF RECORD = 1988 ESTIMATED PERSONS PER CONNECTION = 2.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	6765	6278	6206	7544	8745	8798	10693	10457	12232	9780	7728	7404
CONNECTIONS	1013	1010	1008	1014	1022	1021	1023	1015	1026	1037	1034	1030
GAL/CONN	6678	6216	6157	7440	8557	8617	10452	10303	11922	9431	7474	7188
GPD/CONN	215	222	199	248	276	287	337	332	397	304	249	232
GPCD	94	97	86	108	120	125	147	145	173	132	108	101

TABLE 3.2 ESTATES WSC RESIDENTIAL DEMAND PROFILES, 1985-1988

YEAR OF RECORD = 1985 ESTIMATED PERSONS PER CONNECTION = 3.3												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
WATER SOLD (1,000 GAL)	555	566	558	808	801	999	1025	1807	1186	691	486	590
CONNECTIONS	78	78	79	79	79	78	80	79	79	78	78	78
GAL/CONN	7120	7260	7066	10224	10142	12802	12813	22867	15015	8857	6228	7559
GPD/CONN	230	259	228	341	327	427	413	738	501	286	208	244
GPCD	70	79	69	103	99	129	125	224	152	87	63	74

YEAR OF RECORD = 1986 ESTIMATED PERSONS PER CONNECTION = 3.3												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
WATER SOLD (1,000 GAL)	619	555	692	787	660	695	1773	1832	619	569	575	621
CONNECTIONS	78	78	78	78	76	76	75	78	79	79	79	79
GAL/CONN	7933	7120	8869	10096	8688	9142	23639	23489	7831	7197	7282	7857
GPD/CONN	256	254	286	337	280	305	763	758	261	232	243	253
GPCD	78	77	87	102	85	92	231	230	79	70	74	77

TABLE 3.2 ESTATES WSC RESIDENTIAL DEMAND PROFILES, 1985-1988 (CONTINUED)

YEAR OF RECORD = 1987 ESTIMATED PERSONS PER CONNECTION = 3.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	575	416	569	999	624	748	1886	1743	628	623	690	557
CONNECTIONS	78	79	78	78	79	79	79	79	79	80	80	79
GAL/CONN	7366	5267	7293	12804	7903	9472	23879	22066	7945	7782	8623	7054
GPD/CONN	238	188	235	427	255	316	770	712	265	251	287	228
GPCD	72	57	71	129	77	96	223	216	80	76	87	69

YEAR OF RECORD = 1988 ESTIMATED PERSONS PER CONNECTION = 3.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	448	578	739	765	883	1391	917	1072	1123	777	675	545
CONNECTIONS	76	77	78	77	77	78	78	78	78	80	81	79
GAL/CONN	5893	7508	9475	9937	11473	17827	11762	13748	14396	9718	8333	6897
GPD/CONN	190	268	306	331	370	594	379	443	480	313	278	222
GPCD	58	81	93	100	112	180	115	134	145	95	84	67

TABLE 3.3 RIDGEWOOD VILLAGE RESIDENTIAL DEMAND PROFILES, 1983-1988

YEAR OF RECORD = 1983												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	519	464	542	786	879	711	1146	1268	1103	640	740	717
CONNECTIONS	72	72	72	72	72	72	72	72	72	72	72	72
GAL/CONN	7208	6444	7528	10917	12208	9875	15917	17611	15319	8889	10278	9958
GPD/CONN	223	230	243	364	394	329	513	568	511	287	343	321

YEAR OF RECORD = 1984												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	650	911	635	1248	1650	1573	2002	1697	1119	812	827	597
CONNECTIONS	72	72	72	73	73	73	73	73	73	73	73	74
GAL/CONN	9028	12653	8819	17096	22603	21548	27425	23247	15329	11123	11329	8068
GPD/CONN	291	452	284	570	729	718	885	750	511	359	378	260

TABLE 3.3 RIDGEWOOD VILLAGE RESIDENTIAL DEMAND PROFILES, 1983-1988 (CONTINUED)

YEAR OF RECORD = 1985												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	542	686	643	779	1133	1211	1494	2139	1133	825	616	615
CONNECTIONS	74	74	74	74	74	74	74	74	74	74	74	74
GAL/CONN	7324	9270	8689	10527	15311	16365	20189	28905	15311	11149	8324	8311
GPD/CONN	236	331	280	351	494	545	651	932	510	360	277	268

YEAR OF RECORD = 1986												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	558	589	875	1238	466	871	2221	1599	839	676	605	472
CONNECTIONS	74	74	75	75	75	75	75	75	75	75	75	75
GAL/CONN	7541	7959	11667	16507	6213	11613	29613	21320	11187	9013	8067	6293
GPD/CONN	243	284	376	550	200	387	955	688	373	291	269	203

TABLE 3.3 RIDGEWOOD VILLAGE RESIDENTIAL DEMAND PROFILES, 1983-1988 (CONTINUED)

YEAR OF RECORD = 1987												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
WATER SOLD (1,000 GAL)	521	528	654	861	897	718	848	1809	1071	963	785	518
CONNECTIONS	75	75	75	75	75	75	75	75	75	75	75	75
GAL/CONN	6947	7040	8720	11480	11960	9573	11307	24120	14280	13107	10467	6970
GPD/CONN	224	251	281	383	386	319	365	778	476	423	349	223

YEAR OF RECORD = 1988												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
WATER SOLD (1,000 GAL)	546	798	687	830	1125	1244	1105	1625	1441	1165	916	582
CONNECTIONS	76	76	76	76	76	76	76	76	76	76	76	76
GAL/CONN	232	375	292	364	478	546	469	690	632	494	402	247
GPD/CONN	215	222	199	248	276	287	337	332	397	304	249	232

2.8.13 GROUP NO. XIII UTILITY INTERCONNECTIONS

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
XIII.	22. Marbridge Foundation
	32. Bear Creek Park

2.8.13.1 Description Of Facilities Required for Interconnect

The Marbridge Foundation and Bear Creek Park have similar year 2010 threshold water demands of 21,500 gpd and 13,600 gpd, respectively. Pumping 21,500 gpd during off-peak hours requires facilities sized for a 60 gpm flow rate. A new 3" - line could interconnect the two suppliers. Approximately 3,500 - feet of 3" - line would be required. Friction loss in this 3" - line with a flow of 46 gpm is approximately 10 to 11 psi. A meter assembly could be installed between the two suppliers to be activated during an emergency condition. Bear Creek Park has sufficient storage capacity for their estimated threshold water demand. The Marbridge Foundation available storage capacity in ground and pressurized storage is sufficient for their year 2010 estimated threshold water demand.

2.8.14 GROUP NO. XIV UTILITY INTERCONNECTION

GROUP NO.	WATER SYSTEMS RECOMMENDED FOR UTILITY INTERCONNECT
XIV.	28. Shady Hollow Estates WSC

2.8.14.1 Description of Facilities Required for Interconnect

The Shady Hollow Estates Water System has an existing interconnect with the City of Austin.

2.9 DEVELOP FINANCIAL PLAN

In order to develop financial plans, estimated costs of interconnect facilities for each water system were determined. The projected construction and financing costs are presented by Group

Number and system in Table Nos. 2.5 through 2.18. A summary of individual water system construction and financing costs are presented in Tables 2.19 and 2.20, respectively.

2.10 REVIEW INSTITUTIONAL AND REGULATORY CONSTRAINTS

The TDH will review interconnect plans as they are developed. Rule 337.206 (f) Interconnections, of the TDH Rules and Regulations for Public Water Supply Systems addresses interconnect requirements. TDH staff provides further clarification of the rule for the proposed "emergency interconnects" as recommended in this study. Item No. 2 of the previously mentioned rule, requiring 0.35 gpm per connection supply capability for a second source supplier, will not be applicable. TDH recognizes that "emergency interconnects" are a "temporary" source of supply, rather than secondary source of supply. This clarification is critical to implementation of the emergency interconnects. Suppliers of "emergency" water will not have to permanently allocate reserve supplies which could be utilized to serve future customers.

The following items will be required for the TDH review process:

1. Engineer's report detailing design guidelines for facility sizing;
2. Agreement between participating utilities interconnecting;
3. Any necessary easements required; and
4. Miscellaneous "other" data as required by the TDH.

Generic interconnect agreements for water suppliers has been included in Appendix G. These agreements have been used by groundwater suppliers in Harris County for emergency interconnects.

The TWDB has requested that interconnect plans be provided to their Planning Division and Groundwater Units. The TWDB has no review

TABLE 2.5 PROJECTED COST FOR GROUP NO. I UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
I.	1. AquaTex Water Supply
	2. Arroyo Doble Water System
	12. Creedmoor-Maha Water Supply Corp.
	25. Mystic Oaks Water Co-Op
	33. Onion Creek Meadows

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
1. AquaTex WS	2" Waterline, 500 L.F. @ $5.00/L.F.	$ 2,500.00
	1" Meter Assembly (includes piping with gate valves)	400.00
	Two 2" Wet Connections	500.00
	Sub-Total	$ 3,400.00
	Non-Construction Costs & Contingency	850.00
	TOTAL	$ 4,250.00

Financing $4,250 estimated interconnect cost based on 68 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$86.17	$51.56
Approx. monthly per customer cost	$ 1.27	$ 0.76

TABLE 2.5 PROJECTED COST FOR GROUP NO. I UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
2. Arroyo Doble	4" Waterline, 3,200 L.F. @ $8.00/L.F.	$25,600.00
	Onion Creek Crossing 100 L.F. @ $25.00/L.F.	2,500.00
	2" Meter Assembly (includes piping with gate valves)	1,000.00
	Two 4" Wet Connections	1,000.00
	Sub-Total	$30,100.00
	Non-Construction Costs & Contingency	4,500.00
	TOTAL	$34,600.00

Financing $34,600.00 estimated interconnect cost based on 266 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$701.56	$419.79
Approx. monthly per customer cost	$ 2.64	$ 1.58

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
12. Creedmoor-Maha	Creedmoor-Maha WS has existing interconnects with the City of Austin and Goforth W.S. Corporation. These are presented on Exhibit No. 3. In this interconnect study, Creedmoor-Maha is solely considered a supplier of water and derives no direct benefit through interconnecting with Group I water suppliers. Therefore, no direct costs are borne by the corporation.	

TABLE 2.5 PROJECTED COST FOR GROUP NO. I UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
25. Mystic Oaks W.S.	2" Waterline, 600 L.F. @ $5.00/L.F.	$ 3,000.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Sub-total	$ 3,900.00
	Non-Construction Costs & Contingency	1,000.00
	TOTAL	$ 4,900.00

Financing $4,900 estimated interconnect cost based on 39 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$99.35	$59.45
Approx. monthly per customer cost	$ 2.55	$ 1.52

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
33. Onion Creek Meadows	4" Waterline, 700 L.F. @ $8.00/L.F.	$ 5,600.00
	2" Meter Assembly (Includes piping and gate valves)	1,000.00
	Two 4" Wet Connections	1,000.00
	Sub-total	$ 7,600.00
	Non-Construction Costs & Contingency	1,200.00
	TOTAL	$ 8,800.00

Financing $8,800 estimated interconnect cost based on 203 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$178.43	$106.77
Approx. monthly per customer cost	$ 0.88	$ 0.53

TABLE 2.6 PROJECTED COST FOR GROUP NO. II UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
II.	3. CenTex Material 10. Comal Tackle Company 34. Texas-Lehigh Company

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
3. CenTex Material	Not considered for Emergency Interconnect	

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
10. Comal Tackle Company	Not Considered for Emergency Interconnect	

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
34. Texas-Lehigh Cement Company	Not Considered for Emergency Interconnect	

TABLE 2.7 PROJECTED COST FOR GROUP NO. III UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
III.	4. Chaparral Water Company
	11. Copper Hills Subdivision
	30. Southwest Territory Water Company

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
4. Chaparral Water Company	3" Waterline, 1,700 L.F. @ $7.00/L.F.	$11,900.00
	Little Bear Creek Crossing 100 L.F. @ $25.00/L.F.	2,500.00
	1 1/2 Meter Assembly (Includes piping and gate valves)	700.00
	Two 3" Wet Connections	800.00
	Sub-Total	$15,900.00

Proposed interconnect with Southwest Territory derives mutual benefit, therefore, adjusted share of 3" interconnect cost will be 50% of common estimated cost elements. Southwest Territory would pay for the remaining 50% share of this installation.

Adjusted Sub-Total Cost	$ 8,300.00
Non-Construction Costs & Contingency	1,250.00
Total	$ 9,550.00

Financing $9,550 estimated interconnect cost based on 138 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$193.64	$115.87
Approx. monthly per customer cost	$ 1.40	$ 0.84

TABLE 2.7 PROJECTED COST FOR GROUP NO. III UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
11. Copper Hills Subdivision	1 - 1/2" Waterline, 250 L.F. @ $4.00/L.F.	$ 1,000.00
	1 - 1/2" Wet Connection	200.00
	Sub-Total	$ 1,200.00
	Non-Construction Costs & Contingency	300.00
	TOTAL	$ 1,500.00

Copper Hills proposed interconnect would be to the 3" interconnect line proposed between Southwest Territory and Chaparral Water. Copper Hills could utilize the meters installed by either of these two water suppliers. Copper Hills is a primary benefactor of these interconnects, not a primary water supplier.

Financing $1,500 estimated interconnect cost based on 6 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$30.41	$18.20
Approx. monthly per customer cost	$ 5.07	$ 3.03

TABLE 2.7 PROJECTED COST FOR GROUP NO. III UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
30. Southwest Territory	3" Waterline, 1,700 L.F. @ $7.00/L.F.	$11,900.00
	Little Bear Creek Crossing 100 L.F. @ $25.00/L.F.	2,500.00
	1 - 1/2" Meter Assembly	700.00
	Two 3" Wet Connections	800.00
	Sub-total	$15,900.00

Proposed interconnect with Chaparral Water derives mutual benefit between two parties, therefore, adjusted share of 3" interconnect cost will be 50% of common estimated cost elements. Chaparral Water would pay for the remaining 50% share of the installation.

Adjusted Subtotal Cost	$ 8,300.00
Non-Construction Costs & Contingency	1,250.00
TOTAL	$ 9,550.00

Financing $9,550 estimated interconnect cost based on 113 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 193.64	$115.87
Approx. monthly per customer cost	$ 1.71	$ 1.03

TABLE 2.8 PROJECTED COST FOR GROUP NO. IV UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
IV.	5. Chatleff Control, Inc.
	8. City of Buda
	16. Goforth Water Supply Corporation
	27. Plum Creek Water Supply Corporation
	35. Tilson Custom Homes

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
5. Chatleff Controls	Not considered for Emergency Interconnect	

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
8. City of Buda	6" Waterline, 2000 L.F. @ $15.00/L.F.	$30,000.00
	Two 3" Meter Assemblies Includes piping with gate values)	3,000.00
	Three 6" Wet Connections	2,250.00
	Sub-Total	$35,250.00

Proposed interconnect with Goforth and Plum Creek Water Supply Corporations derives mutual benefit between three parties, therefore, adjusted share of 6" interconnect cost will be 33% (1/3) of total estimated installation cost. Goforth and Plum Creek will pay for the remaining share of the installation.

Adjusted Sub-Total Cost	$11,750.00
Non-Construction Costs & Contingency	1,750.00
TOTAL	$13,500.00

Financing $13,500 estimated interconnect cost based on 544 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$273.73	$163.79
Approx. monthly per customer cost	$ 0.50	$ 0.30

TABLE 2.8 PROJECTED COST FOR GROUP NO. IV UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
16. Goforth W.S. Corp.	6" Waterline, 2000 L.F. @ $15.00/L.F.	$30,000.00
	Two 3" Meter Assemblies (Includes piping and gate values)	3,000.00
	Three 6" Wet Connections	2,250.00
	Sub-total	$35,250.00

Proposed interconnect with the City of Buda and Plum Creek W.S. Corporation derives mutual benefit between three parties, therefore, adjusted share of 6" interconnect cost will be 33% (1/3) of total estimated installation cost. City of Buda and Plum Creek will pay for the remaining share of the installation.

	Adjusted Subtotal Cost	$11,750.00
	Non-Construction Costs & Contingency	1,750.00
	TOTAL	$13,500.00

Financing $13,500 estimated interconnect cost based on 1,205 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 273.73	$163.79
Approx. monthly per customer cost	$ .23	$ 0.14

TABLE 2.8 PROJECTED COST FOR GROUP NO. IV UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
27. Plum Creek Water Supply Corp.	6" Waterline, 2000 L.F. @ $15.00/L.F.	$30,000.00
	Two 3" Meter Assembly (Includes piping and gate valves)	3,000.00
	Three 6" Wet Connections	2,250.00
	Sub-total	$35,250.00
Proposed interconnect with Goforth and City of Buda derives mutual benefit between three parties, therefore, adjusted share of 6" interconnect cost will be 33% (1/3) of total estimated installation cost. City of Buda and Goforth will pay for the remaining share of the installation.		
	Adjusted Subtotal Cost	$11,750.00
	Non-Construction Costs & Contingency	1,750.00
	TOTAL	$13,500.00

Financing $13,500 estimated interconnect cost based on 733 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 273.73	$163.79
Approx. monthly per customer cost	$ 0.37	$ 0.22

TABLE 2.8 PROJECTED COST FOR GROUP NO. IV UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
35. Tilson Custom Homes	2" Waterline, 2,500 L.F. @ $5.00/L.F.	$12,500.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Sub-total	$13,400.00
	Non-Construction Costs & Contingency	2,000.00
	TOTAL	$15,400.00

Financing $15,400 estimated interconnect cost based on 5 commercial customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$312.26	$186.84
Approx. monthly per customer cost	$ 62.45	$ 37.37

TABLE 2.9 PROJECTED COST FOR GROUP NO. V UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
V.	6. Cimarron Park Water Company, Inc.
	14. Estates Utilities WSC
	21. Leisure Woods Water Company
	37. Huntington Estates

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
6. Cimarron Park WC Inc.	6" Waterline, 300 L.F. @ $15.00/L.F.	$ 4,500.00
	3" Meter Assembly (Includes piping with gate valves)	1,500.00
	Two 6" Wet Connections	1,500.00
	Sub-Total	$ 7,500.00

Proposed interconnect with Leisure Woods derives mutual benefit, therefore, adjusted share of 6" interconnect cost will be 50% of total estimated installation cost. Leisure Woods would pay for the remaining 50% share of the installation.

	Adjusted Sub-Total Cost	$ 3,750.00
	Non-Construction Costs & contingency	1,250.00
	TOTAL	$ 5,000.00

Financing $5,000 estimated interconnect cost based on 426 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$101.38	$60.66
Approx. monthly per customer cost	$ 0.24	$ 0.41

TABLE 2.9 PROJECTED COST FOR GROUP NO. V UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
14. Estates Utilities	3" Waterline, 600 L.F. @ $7.00/L.F.	$ 4,200.00
	1 1/2" Meter Assembly (Includes piping and gate valves)	700.00
	Two 3" Wet Connections	800.00
	Sub-total	$ 5,700.00
	Non-Construction Costs & Contingency	1,300.00
	TOTAL	$ 7,000.00

Financing $7,000 estimated interconnect cost based on 82 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$141.93	$84.93
Approx. monthly per customer cost	$ 1.73	$ 1.04

TABLE 2.9 PROJECTED COST FOR GROUP NO. V UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
14. Estates Util. (Interconnect to Huntington Estates)	4" Waterline, 5000 L.F. @ $8.00/L.F.	$40,000.00
	2" Meter Assembly (Includes piping and gate valves)	1,000.00
	Two 4" Wet Connections	1,000.00
	Sub-total	$42,000.00
	Non-Construction Cost & Contingency	6,000.00
	TOTAL	$48,000.00

Financing $48,000.00 estimated interconnect cost based on 82 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$973.27	$582.37
Approx. monthly per customer cost	$ 11.87	$ 7.10

TABLE 2.9 PROJECTED COST FOR GROUP NO. V UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
21. Leisurewoods	6" Waterline, 300 L.F. @ $15.00/L.F.	$ 4,500.00
	3" Meter Assembly (Includes piping and gate valves)	1,500.00
	Two 6" Wet Connections	1,500.00
	Sub-total	$ 7,500.00

Proposed interconnect with Cimarron Park Water Corp. derives mutual benefit, therefore, adjusted share of 6" interconnect cost will be 50% of total estimated installation cost. Cimarron Park would pay for the remaining 50% share of the installation.

Adjusted Subtotal Cost	$ 3,750.00
Non-Construction Costs & Contingency	1,250.00
TOTAL	$ 5,000.00

Financing $5,000 estimated interconnect cost based on 400 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 101.38	$66.60
Approx. monthly per customer cost	$ 0.25	$ 0.15

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
37. Huntington Estates	Considered as source of supply only for Estates Utilities.	

TABLE 2.10 PROJECTED COST FOR GROUP NO. VI UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
VI.	7. City of Austin Irrigation Wells

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
7. City of Austin	Irrigation Wells Only - Not considered for Emergency Interconnection	

TABLE 2.11 PROJECTED COST FOR GROUP NO. VII UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
VII.	9. City of Sunset Valley

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
9. City of Sunset Valley	2" Waterline, 100 L.F. @ $ 5.00/L.F.	$ 500.00
	1 1/2" Meter Assembly (Includes piping with gate valves)	700.00
	Two 2" Wet Connections	500.00
	Sub-Total	$ 1,700.00
	Non-Construction Costs & Contingency	500.00
	Total	$ 2,200.00

Financing $2,200 estimated interconnect cost based on 77 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$44.61	$26.89
Approx. monthly per customer cost	$ 0.58	$ 0.35

TABLE 2.12 PROJECTED COST FOR GROUP NO. VIII UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
VIII.	13. Dellana Hills Subdivision
	15. G&J Water District
	31. Ridgewood Village Water Systems

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
13. Dellana Hills	1" Waterline, 50 L.F. @ $4.00/L.F.	$ 200.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	1" Wet Connection	200.00
	Additional 3,000 Gallon Pressurized Storage Tank Capacity	5,000.00
	Sub-total	$ 5,800.00
	Non-Construction Costs & Contingency	1,200.00
	TOTAL	$ 7,000.00

Financing $7,000 estimated interconnect cost based on 25 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$141.93	$84.93
Approx. monthly per customer cost	$ 5.68	$ 3.40

TABLE 2.12 PROJECTED COST FOR GROUP NO. VIII UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
15. G&J Water District	1" Waterline, 50 L.F. @ $4.00/L.F.	$ 200.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	1" Wet Connection	200.00
	Sub-total	$ 800.00
	Non-Construction Costs & Contingency	200.00
	TOTAL	$ 1,000.00

Financing $1,000 estimated interconnect cost based on 16 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 20.28	$12.13
Approx. monthly per customer cost	$ 1.27	$ 0.76

TABLE 2.12 PROJECTED COST FOR GROUP NO. VIII UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
31. Ridgewood Village	2" Waterline, 200 L.F. @ $5.00/L.F.	$ 1,000.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Sub-total	$ 1,900.00
	Non-Construction Costs & Contingency	700.00
	TOTAL	$ 2,600.00

Financing $2,600 estimated interconnect cost based on 74 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$52.72	$31.55
Approx. monthly per customer cost	$ 0.71	$ 0.43

TABLE 2.13 PROJECTED COST FOR GROUP NO. IX UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
IX.	17. Harold Hicks & Al Schuster MHP
	23. Mooreland Water Systems
	26. Oak Forest Highlands
	29. Slaughter Creek Acres WSC
	36. Village of San Leanna

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
17. Harold Hicks & Al Schuster	2" Waterline, 100 L.F. @ $5.00/L.F.	$ 500.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Additional 8,500 Gallons Storage Capacity	13,000.00
	Sub-total	$14,400.00
	Non-Construction Costs & Contingency	2,600.00
	TOTAL	$17,000.00

Financing $17,000 estimated interconnect cost based on 50 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$344.70	$206.26
Approx. monthly per customer cost	$ 6.89	$ 4.13

TABLE 2.13 PROJECTED COST FOR GROUP NO. IX UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
23. Mooreland Water Systems	2" Waterline, 100 L.F. @ $5.00/L.F.	$ 500.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Additional 5,400 Gallons Storage Capacity	9,600.00
	Sub-total	$11,000.00
	Non-Construction Costs & Contingency	2,000.00
	TOTAL	$13,000.00

Financing $13,000 estimated interconnect cost based on 33 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$263.59	$157.73
Approx. monthly per customer cost	$ 7.99	$ 4.78

TABLE 2.13 PROJECTED COST FOR GROUP NO. IX UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
26. Oak Forest Highlands	4" Waterline, 2,200 L.F. @ $8.00/L.F.	$17,600.00
	2" Waterline 50 L.F. @ $5.00/L.F.	250.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	One 4" Wet Connection	500.00
	Additional 7,700 Gallons Storage Capacity	$12,250.00
	Sub-total	$31,000.00

Proposed interconnect with City of Austin existing 12" waterline involves cost sharing with Village of San Leanna to route waterline from intersection of Manchaca Road and FM 1626 east to Oak Forest and San Leanna. Based on demand requirements, Oak Forest requires 21 gpm year 2010 threshold water demand and San Leanna has a 79 gpm year 2010 threshold water demand. Therefore, 21% of the items marked with an asterisk will be Oak Forest costs and 79% will be San Leanna's costs.

Adjusted Subtotal Cost	$16,701.00
Non-Construction Costs & Contingency	2,799.00
TOTAL	$19,500.00

Financing $19,500 estimated interconnect cost based on 28 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 395.39	$236.59
Approx. monthly per customer cost	$ 14.12	$ 8.45

TABLE 2.13 PROJECTED COST FOR GROUP NO. IX UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
29. Slaughter Cr. Acres WSC	3" Waterline, 300 L.F. @ $7.00/L.F.	$ 2,100.00
	1 1/2" Meter Assembly (Includes piping and gate valves)	700.00
	Two 3" Wet Connections	800.00
	Sub-total	$ 3,600.00
	Non-Construction Costs & Contingency	900.00
	TOTAL	$ 4,500.00

Financing $4,500 estimated interconnect cost based on 70 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$91.24	$54.60
Approx. monthly per customer cost	$ 1.30	$ 0.78

TABLE 2.13 PROJECTED COST FOR GROUP NO. IX UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
36. Village of San Leanna	4" Waterline, 2,200 L.F. @ $8.00/L.F.	$17,600.00*
	4" Waterline, 800 L.F. @ $8.00/L.F.	6,400.00
	2" Meter Assembly (Includes piping and gate valves)	1,000.00
	4" Wet Connection	500.00*
	4" Wet connection	500.00
	Sub-total	$26,000.00

Proposed interconnect with City of Austin existing 12" waterline involves cost sharing first 2,200 L.F. of 4" waterline with Oak Forest. Based on demand requirements, Oak Forest requires 21 gpm year 2010 threshold water demand and San Leanna requires 79 gpm year 2010 threshold water demand. Therefore, 79% of the items marked with an asterisk will be San Leanna's costs and 21% will be Oak Forest cost.

Adjusted Subtotal Cost	$22,200.00
Non-Construction Costs & Contingency	3,300.00
TOTAL	$25,500.00

Financing $25,500 estimated interconnect cost based on 131 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 517.05	$309.39
Approx. monthly per customer cost	$ 3.95	$ 2.36

TABLE 2.14 PROJECTED COST FOR GROUP NO. X UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
X.	18. Hays Consolidated Independent School District-Dahlstrom Middle School

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
18. Hays CISD - Dahlstrom MS	Interconnect to Leisurewoods	$80,000.00

Financing $80,000.00 estimated interconnect cost to Leisurewoods System produces the following monthly debt service requirements:

Terms of Loan:	8% For 60 months	8% For 120 months	8% For 240 months
App. monthly cost	$1,622.11	$970.62	$669.15

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
18. Hays CISD - Dahlstrom MS	Interconnect to Dahlstrom Corp. Well	$45,000.00

Financing $45,000.00 estimated interconnect cost to Dahlstrom well produces the following monthly debt service requirements:

Terms of Loan:	8% For 60 months	8% For 120 months	8% For 240 months
App. monthly cost	$ 912.44	$545.97	$376.40

TABLE 2.15 PROJECTED COST FOR GROUP NO. XI UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
XI.	19. Hays Cosolidated Independent School District, Jack C. Hays High School 24. Mountain City Oaks Water Supply Corporation

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
19. Hays CISD Jack Hays HS	4" Waterline,2500 L.F. @ $8.00/L.F.	$20,000.00
	3" Meter Assembly (Includes piping and gate valves)	1,500.00
	Two 4" Wet Connections	1,000.00
	Sub-total	$22,500.00

Proposed interconnect with Mountain City Oaks derives mutual benefit, therefore, adjusted share of 4" interconnect cost will be 50% of total estimated installation cost. Mountain City would pay for the remaining 50% share of the installation.

	Adjusted Subtotal Cost	$11,250.00
	Non-Construction Costs Contingency	1,750.00
	TOTAL	$13,000.00

Financing $13,000 estimated interconnect cost to Mountain City System produces the following monthly debt service requirements:

Terms of Loan:	8% For 60 months	8% For 120 months	8% For 240 months
App. monthly cost	$ 263.59	$157.73	$108.74

TABLE 2.15 PROJECTED COST FOR GROUP NO. XI UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
24. Mountain City Oaks	4" Waterline, 2500 L.F. @ $8.00/L.F.	$20,000.00
	One 3" Meter Assembly (Piping and gate valves)	1,500.00
	Two 4" Wet Connections	1,000.00
	Sub-total	$22,500.00

Proposed interconnect with Hays CISD (Jack C. Hays High School) derives mutual benefit, therefore, adjusted share of 4" interconnect cost will be 50% of total estimated installation cost. Hays CISD would pay for the remaining 50% share of the installation.

Adjusted Subtotal Cost	$11,250.00
Non-Construction Costs & Contingency	1,750.00
TOTAL	$13,000.00

Financing $13,000 estimated interconnect cost to Hays CISD system based on 135 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 263.59	$157.73
Approx. monthly per customer cost	$ 1.95	$ 1.17

TABLE 2.16 PROJECTED COST FOR GROUP NO. XII UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
XII.	20. J.D. Malone Water System

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
20. J.D. Malone	2" Waterline, 500 L.F. @ $5.00/L.F.	$ 2,500.00
	1" Meter Assembly (Includes piping and gate valves)	400.00
	Two 2" Wet Connections	500.00
	Additional 5,000 Gallons Storage Capacity	$ 9,000.00
	Sub-total	$12,400.00
	Non-Construction Costs & Contingency	2,100.00
	TOTAL	$14,500.00

Financing $14,500 estimated interconnect cost based on 47 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$294.01	$175.93
Approx. monthly per customer cost	$ 6.26	$ 3.74

TABLE 2.17 PROJECTED COST FOR GROUP NO. XIII UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
XIII.	22. Marbridge Foundation 32. Bear Creek Park

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
22. Marbridge Foundation	3" Waterline, 3500 L.F. @ $7.00/L.F.	$24,500.00
	Bear Creek Crossing 100 L.F. @ $25.00/L.F.	2,500.00
	1 - 1/2" Meter Assembly (Piping and gate valves)	700.00
	Two 3" Wet Connections	800.00
	Sub-total	$28,500.00

Proposed interconnect with Bear Creek Park Water System derives mutual benefit, therefore, adjusted share of 3" interconnect cost will be 50% of total estimated installation cost. Bear Creek Park would pay for the remaining 50% share of the installation.

Adjusted Subtotal Cost	$14,250.00
Non-Construction Costs & Contingency	2,000.00
TOTAL	$16,250.00

Financing $16,250 estimated interconnect cost to Bear Creek Park Water system produces the following monthly debt service requirements:

Terms of Loan:	8% For 60 months	8% For 120 months	8% For 240 months
App. monthly cost	$ 329.49	$197.16	$135.92

TABLE 2.17 PROJECTED COST FOR GROUP NO. XIII UTILITY INTERCONNECT (CONTINUED)

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
32. Bear Creek Park	3" Waterline, 3,500 L.F. @ $7.00/L.F.	$24,500.00
	Bear Creek Crossing 100 L.F. @ $25.00/L.F.	2,500.00
	1 - 1/2" Meter Assembly (Piping and gate valves)	700.00
	Two 3" Wet Connections	800.00
	Sub-total	$28,500.00

Proposed interconnect with Marbridge Foundation Water System derives mutual benefit between two parties, therefore, adjusted share of 3" interconnect cost will be 50% of total estimated installation cost. Marbridge Foundation would pay for the remaining 50% share of the installation.

	Adjusted Subtotal Cost	$14,250.00
	Non-Construction Costs & Contingency	$ 2,000.00
	TOTAL	$16,250.00

Financing $16,250 estimated interconnect cost to Marbridge Foundation Water System based on 78 existing customers produces the following monthly debt service requirements:

Terms of Loan:	8% @ 60 months	8% @ 120 months
Approx. monthly cost	$ 329.49	$197.16
Approx. monthly per customer cost	$ 4.22	$ 2.53

TABLE 2.18 PROJECTED COST FOR GROUP NO. XIV UTILITY INTERCONNECT

GROUP NO.	WATER SYSTEM NAME
XIV.	28. Shady Hollow Estates Water Supply Corporation

WATER SUPPLIER	DESCRIPTION OF INTERCONNECT FACILITY IMPROVEMENTS	ESTIMATED COSTS
28. Shady Hollow Estates WSC	Shady Hollow Estates has an existing interconnect with the City of Austin. Exhibit No. 3 presents the location of this interconnect.	

TABLE 2.19 SUMMARY OF RECOMMENDED UTILITY INTERCONNECT FOR WATER SUPPLY SYSTEMS

GROUP NO.	SYS. NO.	SYSTEM NAME	NO. OF PRIMARY SYSTEM CONN.	ESTIMATED COST (1990 $)
I	1.	Aquatex Water Supply	12	$ 4,250
	2.	Arroyo Doble Water System	12	34,600
	12.	Creedmoor-Maha WSC	N.C.	0
	25.	Mystic Oaks Water Co-Op	12	4,900
	33.	Onion Creek Meadows	12	8,800
II	3.	CenTex Material[1]	N.C.	0
	10.	Comal Tackle Company	N.C.	0
	34.	Texas-Lehigh Cement Co.	N.C.	0
III	4.	Chaparral Water Co.	11,30	9,550
	11.	Copper Hills Subdivision	4, 30	1,500
	30.	Southwest Territory WC	4,11	9,550
IV	5.	Chatleff Control Inc.	N.C.	0
	8.	City of Buda	5,16,27	13,500
	16.	Goforth WSC	8,12,27	13,500
	27.	Plum Creek Water	8,12,16	13,500
	35.	Tilson Custom Homes	27	15,400
V	6.	Cimarron Park WC Inc.	21	5,000
	14.	Estate Utilities	21	7,000
	21.	Liesurewoods Water	6	5,000
	37.	Huntington Estates	N.C.	0
VI	7.	City of Austin Wells	N.C.	0
VII	9.	City of Sunset Valley[2]	-	2,200
VIII	13.	Dellana Hills	15,31	7,000
	15.	G&J Water District	15,31	1,000
	31.	Ridgewood Village WS[3]		2,600
IX	17.	Harold Hicks/Al Schuster[2]	-	17,000
	23.	Mooreland Water System[2]	-	13,000
	26.	Oak Forest Highlands[2]	-	19,500
	29.	Slaughter Crk. Acres WSC[2]	-	4,500
	36.	Village of San Leanna[2]	-	25,500

[1]Not considered.

[2]Connect to City of Austin.

[3]Connect to the City of Rollingwood.

TABLE 2.19 SUMMARY OF RECOMMENDED UTILITY INTERCONNECT FOR WATER SUPPLY SYSTEMS (CONTINUED)

GROUP NO.	SYS. NO.	SYSTEM NAME	NO. OF PRIMARY SYSTEM CONN.	ESTIMATED COST (1990 $)
X	18.	Hays CISD-Dahlstrom MS[4]	21	45,000
XI	19.	Hays CISD-Jack C. Hays HS	24	13,000
	24.	Mountain City Oaks WS	19	13,000
XII	20.	J.D. Malone[2]		14,500
XIII	22.	Marbridge Foundation	32	16,250
	32.	Bear Creek Park	22	16,250
XIV	28.	Shady Hollow Estates WSC[5]		

[4]Connect to Leisurewoods WC or drill new well.

[5]Has existing connection with City of Austin.

TABLE 2.20 SUMMARY OF FINANCING COSTS FOR INDIVIDUAL WATER SYSTEMS

WATER SYSTEM	TOTAL EST. COST FOR INTER-CONNECT	EST. COST PER CUSTOMER @ 8% 5 YEARS	EST. COST PER CUSTOMER @ 8% 10 YEARS
1. Aquatex WS	$ 4,250.00	$1.27	0.76
2. Arroyo Doble WS	34,600.00	2.64	1.58
3. CenTex Material[1]			
4. Chaparral WC	9,550.00	1.40	0.84
5. Chatleff Control[1]			
6. Cimarron Park WC	5,000.00	0.24	0.14
7. City of Austin Irrigation Wells[1]			
8. City of Buda	13,500.00	0.50	0.30
9. City of Sunset Valley	2,200.00	0.58	0.35
10. Comal Tackle Co.[1]			
11. Copper Hills S/D	1,500.00	5.07	3.03
12. Creedmoor-Maha WSC	None	-0-	-0-
13. Dellana Hills S/D	7,000.00	5.68	3.40
14. Estates Utilities WSC	7,000.00	1.73	1.04
15. G&JW District	1,000.00	1.27	0.76
16. Goforth WSC	13,500.00	0.23	0.14
17. Harold Hicks & Al Schuster	17,000.00	6.89	4.13
18. Hays Consol. - Dahlstrom MS	45,000.00	912.44	545.97
19. Hays Consol. - Jack C. Hays HS	13,000.00	263.59	157.73
20. J.D. Malone W.S.	14,500.00	6.26	3.74
21. Leisure Woods WSC	5,000.00	0.25	0.15
22. Marbridge Foundation	16,250.00	329.49	197.16
23. Mooreland W.S.	13,000.00	7.99	4.78
24. Mountain City Oaks W.S. Corp.	13,000.00	1.95	1.17
25. Mystic Oaks WC	4,900.00	2.55	1.52
26. Oak Forest Highlands	19,500.00	14.12	8.45
27. Plum Creek WS Corp.	13,500.00	0.37	0.22
28. Shady Hollow Estates WS Corp.	None	-0-	-0-
29. Slaughter Creek Acres WS Corp.	4,500.00	1.30	0.78
30. Southwest Territory	9,550.00	1.71	1.03
31. Ridgewood Village WS	2,600.00	0.71	0.43
32. Bear Creek Park	16,250.00	4.22	2.53
33. Onion Creek Meadows	8,800.00	0.88	0.53
34. Texas-Lehigh Corp.[1]			
35. Tilson Custom Homes	15,400.00	7.10	4.25
36. Village of San Leanna	25,500.00	3.95	2.36
37. Huntington Estates	None	-0-	-0-

[1]Not Considered for Emergency Interconnect

authority over the plans unless they finance the interconnect systems.

The TWC requests that water suppliers inform their District Section of interconnected utilities. Any tariff modifications by supplier's to accommodate the interconnects must be on file with the suppliers Certificate of Convenience and Necessity (CCN) documents. However, amendments to CCN service areas are not anticipated for the emergency interconnect facilities.

2.11 REFERENCES

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2. Water Utility Capital Financing, First Edition Manual of Water Supply Practices (M29). 1988. American Water Works Association.

3. Skillern, F.E.. 1988. Texas Water Law, Volume 1. Sterling Press.

4. Texas Department of Health, Rules and Regulations for Public Water Systems. Adopted 1988.

5. Hydrology and Water Quality of the Edwards Aquifer Associated with Barton Springs in the Austin Area, Texas. U.S. Geological Survey. Water-Resources Investigations Report 86-4036. 1986. Prepared in cooperation with the City of Austin.

6. Tillman, D.A. 1989. Barton Springs/Edwards Aquifer Conservation District Statistical Analysis of Water Elevations and Springflow for the Barton Springs/Edwards Aquifer Regions.

7. The Texas Caver, Vol. 32, No. 2, April 1987. Article entitled "Edwards Stratigraphy and Oil Spills in the Austin, Texas Area" by William H. Russell.

8. Optimal Groundwater Management Model for the Barton Springs-Edwards Aquifer, Edwards Aquifer Research and Data Center, March 1989 by Nisai Wanakule, Ph.D. Asst. Director and Hydrogeologist.

9. Effects of Storm-Water Runoff on Water Quality of the Edwards Aquifer Near Austin, Texas, By Freeman L. Andrews, Terry L. Schertz, Raymond M. Slade, Jr. and Jack Rawson, U.S. Geological Survey, Water-Resources Investigations Report 84-4124.

10. Hays County Regional Water and Wastewater Study, By HDR Engineering, Authorization of Hays County Water Development Board, October, 1988.

APPENDIX A

BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT WELL/METER INSPECTION FORM

Barton Springs/Edwards Aquifer Conservation District
Well/Meter Inspection Form

Contact Date: ____________ Inspection Date: ____________

Water Supply Name: ____________ **CCN#** ____________
Mailing Address: ____________
Managers Name: ____________

Operators Name: ____________ **Type License:** ____________
Inspection Contact: ____________ Phone Number: ____________
Well ID#: ____________ Water Supply Company#____________
Well Location: ____________

Well Depth: ________ft. **Well Bore Size:** ________ in. **Depth to Water:** ________ ft.
Casing Size: ________in. **Pump Size:** ________Hp. **Pumping Rate:** ________ GPM
Meter Type: ________ **Brand:** ________ **ID#:**________
Current Meter Reading: ________ Annual Pumpage: ________
Date of Installation: ________ **Date of Calibration:** ________
Percent Accuracy: ________ **Verified:** Documents | Testing | Operator | NOT
Elec. meter reading: ________ **Date of Reading:** ________

Amount of Shrinkage: ________ Average Line Loss: ________

Operator Calculated: Y or N If not who calculates: ________
Distance between well and meter: ________

Does water supply measure static water levels in well? Y or N
If so, the most current level was: ________ on (date)________
What is the wells pumping capacity:________
What is the amount of drawdown/time: ________ Recovery Time: ________ Tested?________
How Verified?________

Storage Facilities Type: ________ **Capacity:** ________ Gals. **Elevation:** ________
Operating Pressures: ________

Cooling/recirculating water: Yes or No **Metered**: Yes or No **Reported:** Yes or No
Current Meter Reading: ________ **Rate of Flow:** ________

Treatment Facilities: ________ Type: ________ Capacity: ________
Total # of connections: ________; Res. ________; Comm. ________; Indust. ________; Agr. ________

Are maps available of the distribution systems: Y or N
May we have a copy or order one: Y or N Received: Y or N
Surrounding wells, operating, abandoned, location, distance from WSC, types of wells, problems if any:

Conservation programs: ________

Leak Detection Programs: ________
Historic water use data available: Yes or No By user group: Yes or No

Form 01Inspect. June 2, 1989

General condition of system: Excellent Good Average Poor

Notes: ____

\# of Photos ______

Descriptions of each:

(1) ____________________

(2) ____________________

(3) ____________________

(4) ____________________

(5) ____________________

(6) ____________________

Well ID# in photos Y or N

Additional Comments ____________________

Inspected by: (print) ____________________

Signed: ____________________ Date: ____________________

Note: Items in **Bold print** must be verified by inspection and/or supporting documentation.

APPENDIX B

BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT WATER SUPPLIERS AND FACILITIES

APPENDIX B

Barton Springs / Edwards Aquifer Conservation District
Water Suppliers and Facilities *

	CCN	NAME
1	11341	**AquaTex Water Supply (Twin Creek Water Supply)**
		Well (22 GPM - 480')
		P.Tank (120 Gal.)
		Well (50 GPM - 505')
		G.S.Tank (8x2400)
		P.Tank (1400 Gal.)
		P.Tank (1900 Gal.)
2	11117	**Arroyo Doble Water System**
		Well (130 GPM - 440')
		G.S.Tank (74,000 Gal.)
		P.Tank (2,600 Gal.)
		Well (130 GPM - 385')
		G.S.Tank (70,000 Gal.)
		P.Tank (5,000 Gal.)
3	none	**CenTex Material**
		Well (1200 GPM - 200')
		Well (950 GPM - 200')
4	11247	**Chaparral Water Co.**
		Well (10 GPM - 500')
		Well (7 GPM - 585')
		Well (10 GPM - 720')
		Well (60 GPM - 850')
		G.S.Tank (43,000 Gal.)
		P.Tank (1,800 Gal.)
		P.Tank (2x94 Gal.)
		Well (5 GPM - 420')
		Well (5 GPM - 420')
		Well (25 GPM - 400')
		G.S.Tank (43,000 Gal.)
		P.Tank (3,300 Gal.)
		Well (5 GPM - 420')
		Well (5 GPM - 420')
		Well (25 GPM - 400')
		G.S.Tank (43,000 Gal.)
		P.Tank (3,000 Gal.)
5	none	**Chatleff Control Inc.**
		Well (60 GPM - 450')
		G.S.Tank (6,000 Gal.)
		P.Tank (4x72 Gal.)

Barton Springs / Edwards Aquifer Conservation District
Water Suppliers and Facilities *

	CCN	NAME
6	12140	**Cimarron Park Water Co. Inc.**
		Well (200 GPM - 500')
		G.S.Tank (200,000 Gal.)
		G.S.Tank (65,800 Gal.)
		P.Tank (5,000 Gal.)
		Well (600 GPM - 500')
		E.Tank (100,000 Gal.)
7	none	**City of Austin Wells**
		Well (350 GPM - 52')
		Well (503 GPM - 50')
		Well (465 GPM - 51')
8	11953	**City of Buda**
		Well (250 GPM - 390')
		E.Tank (50,000 Gal.)
		G.S.Tank (126,000 Gal.)
		Well (350 GPM - 450')
		Well (650 GPM - 740')
		S.P.Tank (500,000 Gal.)
9	10300	**City of Sunset Valley**
		Well (? - 360')
		Well (? - 360')
		Well (120 GPM - 30')
		Tank (44,000 Gal.)
		Tank (5,000 Gal.)
		5 Private Wells
10	none	**Comal Tackle Company**
		Well (25 GPM - 240')
		Tank (5,000 Gal.)
11	none	**Copper Hills Subdivision**
		Well (5 GPM - 500')
		Well (22 GPM - 500')
		Well (20 GPM - 500')
		Well (7 GPM - 500')
		G.S.Tank (83,000 Gal.)
		P.Tank (2,500 Gal.)

Barton Springs / Edwards Aquifer Conservation District
Water Suppliers and Facilities *

	CCN	NAME
12	11029	**Creedmoor-Maha WSC**
		Well (500 GPM - 450')
		Well (600 GPM - 450')
		Well (1500 GPM - 450')
13	none	**Dellana Hills**
		Well (15 GPM - 400')
		Well (400')
		P.Tank (900 Gal.)
14	11457	**Estate Utilities**
		Well (150 GPM - 301')
		P.Tank (6,000 Gal.)
		G.S.Tank (125,000 Gal.)
		Well (500 GPM - 325')
15	none	**G&J Water District**
		Well (60 GPM - 400')
		P.Tank (1,000 Gal.)
		P.Tank (5,000 Gal.)
16	11356	**Goforth WSC**
		Well (250 GPM - 640')
		Well (450 GPM - 640')
		Well (1,500 GPM - 740')
		Well (1,500 GPM - 740')
17	none	**Harold Hicks & Al Schuster**
		Well (55 GPM - 415')
		Tank (1,500 Gal.)
18	none	**Hays CISD**
		Well (150 GPM - 260')
		G.S.Tank (75,000 Gal.)
		P.Tank (5,000 Gal.)
19	none	**Hays CISD**
		Well (25 gpm - 575')
		G.S.Tank (75,000 Gal.)
20	none	**J.D.Malone**
		Well (40 GPM - 425')
		Tank (4,000 Gal.)

Barton Springs / Edwards Aquifer Conservation District
Water Suppliers and Facilities *

	CCN	NAME
21	10880	**Liesurewoods Water**
		Well (150 GPM - 400')
		Well (150 GPM - 400')
		G.S.Tank (56,400 Gal.)
		G.S.Tank (56,400 Gal.)
		P.Tank (7,000 Gal.)
		P.Tank (2,500 Gal.)
		Well (150 GPM - 400')
		Well (150 GPM - 400')
		Well (150 GPM - 400')
		G.S.Tank (56,400 Gal.)
		G.S.Tank (56,400 Gal.)
		P.Tank (5,000 Gal.)
22	none	**Marbridge Foundation**
		Well (70 GPM - 475')
		Well (98 GPM - 475')
		Well (90 GPM - 405')
		Well (75 GPM)
23	none	**Mooreland Water System**
		Well (60 GPM - 400')
		P.Tank (1000 Gal.)
		G.S.Tank (7000 Gal.)
24	11427	**Mountain City Oaks WS**
		Well (240 GPM - 407')
		G.S.Tank (68,000 Gal.)
		G.S.Tank (123,000 Gal.)
		P.Tank (5,000 Gal.)
25	none	**Mystic Oaks Water Co-op**
		Well (58 GPM - 400')
		G.S.Tank (5600 Gal.)
		G.S.Tank (5200 Gal.)
		P.Tank x2 (525 Gal.)
		Well (38 GPM)
		G.S.Tank (3100 Gal.)
		G.S.Tank (5200 Gal.)
		P.Tank (1000 Gal.)

Barton Springs / Edwards Aquifer Conservation District
Water Suppliers and Facilities *

	CCN	NAME
26	12086	**Oak Forest Highlands**
		2 Wells (62 GPM ea.)
27	10299	**Plum Creek Water**
		Well (275 GPM - 640')
		Well (650 GPM - 720')
		S.P.Tank (41,000 Gal.)
		P.Tank (5,000 Gal.)
		G.S.Tank (66,400 Gal.)
		S.P.Tank (41,000 Gal.)
		S.P.Tank (41,000 Gal.)
28	11846	**Shady Hollow Estates Water Supply Corp.**
		Well (260 GPM - 600')
		G.S.Tank (100,000 Gal.)
		P.Tank (5,500 Gal.)
29	11725	**Slaughter Creek Acres Water Supply Corp.**
		Well (83 GPM - 420')
		Well (420')
		G.S.Tank (5,000 Gal.)
		G.S.Tank (18,000 Gal.)
		P.Tank (2,500 Gal.)
		G.S.Tank (5,000 Gal.)
		P.Tank (500 Gal.)
30	11813	**Southwest Territory Water Co.**
		Well (40 GPM - 500')
		Well (125 GPM - 820')
		Well (18 GPM - 350')
		G.S.Tank (43,800 Gal.)
		P.Tank (2,500 Gal.)
31	10303	**Ridgewood Village Water System (Stenger & Stenger)**
		Well (200 GPM - 290')
		G.S.Tank (50,000 Gal.)
		P.Tank (5,000 Gal.)
		Pump Sta. (300 GPM)

Barton Springs / Edwards Aquifer Conservation District
Water Suppliers and Facilities *

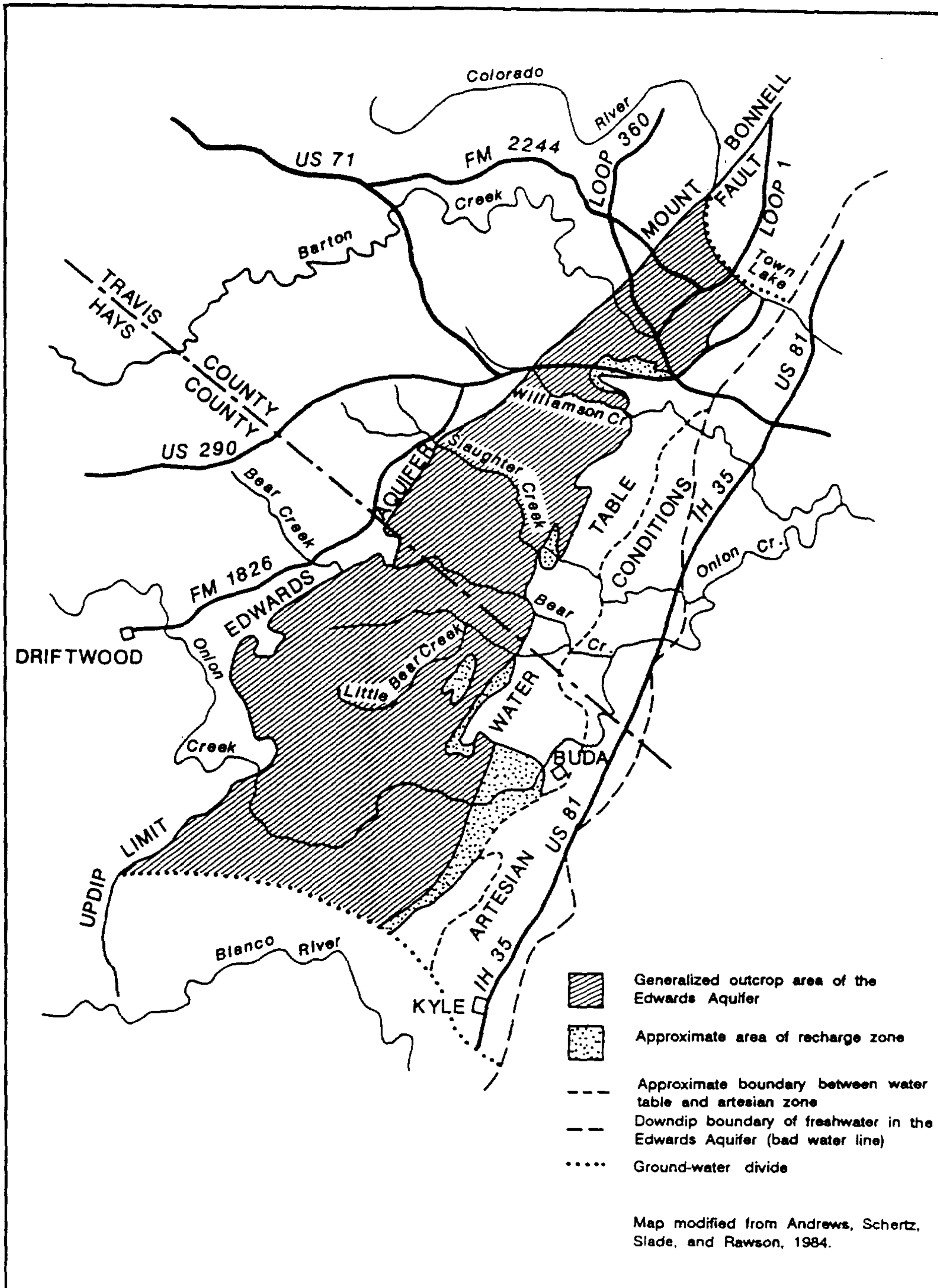
	CCN	NAME
32	none	**Bear Creek Park (by Chaparral Water Co.)**
		Well (100 GPM - 320')
		Well (30 GPM - 240')
		G.S.Tank (5,350 Gal.)
		P.Tank (2x900 Gal.)
		G.S.Tank (11,900 Gal.)
		P.Tank (900 Gal.)
33	none	**Onion Creek Meadows (by Chaparral Water Co.)**
		Well (80 GPM - 402')
		G.S.Tank (5,350 Gal.)
		P.Tank (2x900 Gal.)
		Well (60 GPM - 365')
		G.S.Tank (33,000 Gal.)
		P.Tank (2x525 Gal.)
		Well (60 GPM - 441')
		G.S.Tank (18,400 Gal.)
		P.Tank (2,700 Gal.)
34	none	**Texas-Lehigh Cement Co.**
		Well
		Well
		Well
		E.Tank (100,000 Gal.)
35	none	**Tilson Custom Homes**
		Well (20 GPM - 450')
		Tank (3,500 Gal.)
36	none	**Village of San Leanna**
		Well (110 GPM - 502')
		G.S.Tank (42,000 Gal.)
		G.S.Tank (42,000 Gal.)
		P.Tank (5,000 Gal.)
		Well (75 GPM - 500')
		P.Tank (2,500 Gal.)
		Well (50 GPM - 500')
		P.Tank (525 Gal.)

* Data from Texas Department of Health information
and Texas Water Commision information

APPENDIX C

DELINEATION OF BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

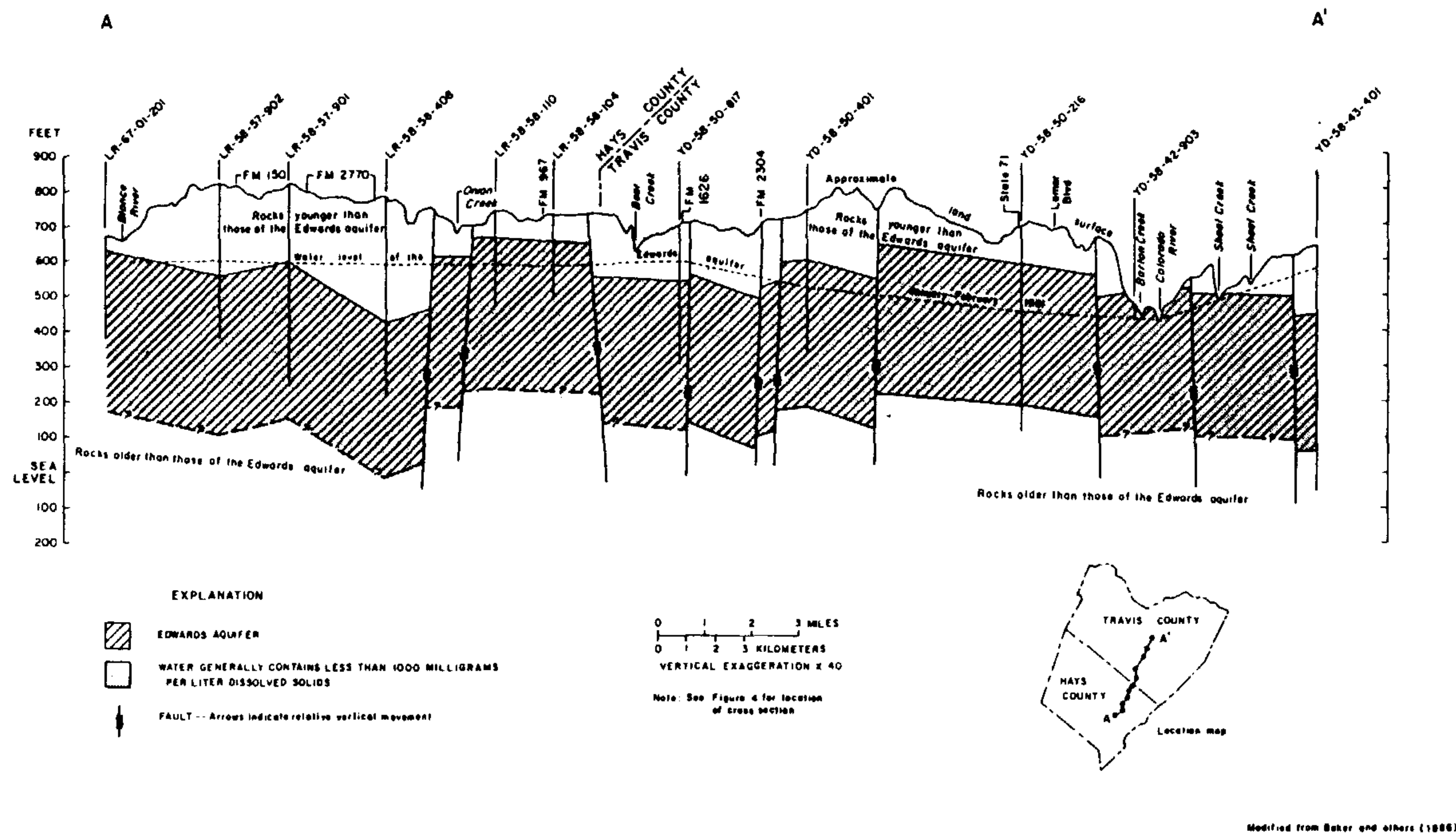
APPENDIX C DELINEATION OF BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER



APPENDIX D

HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG STRIKE, A-A'

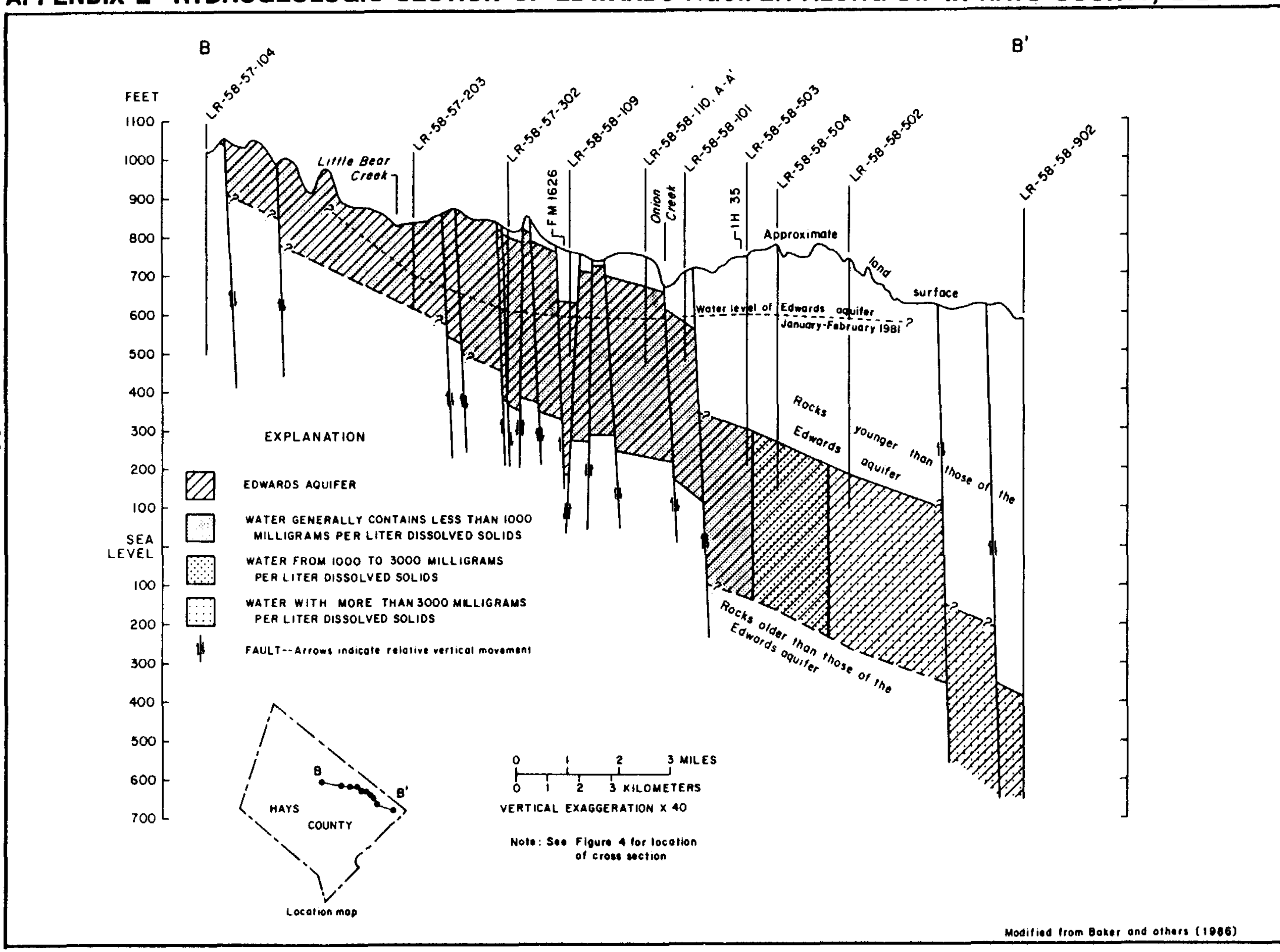
APPENDIX D HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG STRIKE, A-A'



APPENDIX E

HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG DIP IN HAYS COUNTY, B-B'

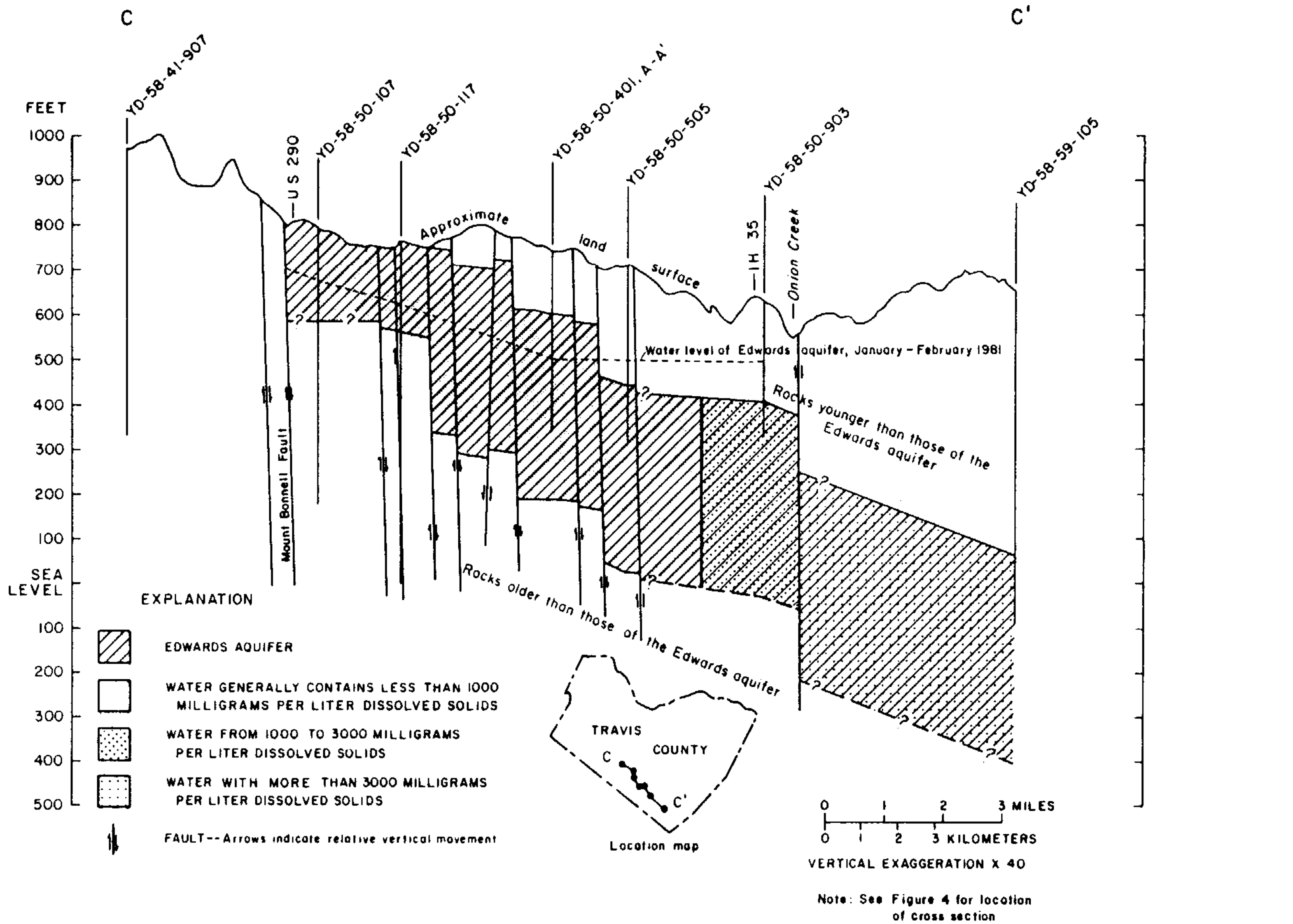
APPENDIX E HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG DIP IN HAYS COUNTY, B-B'



APPENDIX F

HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG DIP IN TRAVIS COUNTY, C-C'

APPENDIX F HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG DIP IN TRAVIS COUNTY, C-C'



Modified from Baker and others (1986)

SECTION 3 REPORT

REGIONAL WATER PLAN
for the
BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

WATER CONSERVATION PLAN

prepared for

BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT
Austin, Texas

and

TEXAS WATER DEVELOPMENT BOARD
Planning Grants Assistance Program
Austin, Texas

TWDB CONTRACT NO. 9-483-732

prepared by

DAVID VENHUIZEN, P.E.
Uhland, Texas

SEPTEMBER 1990

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REGIONAL WATER PLAN
FOR THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER
SECTION 3
WATER CONSERVATION PLAN

3.0 BS/EACD WATER CONSERVATION PLAN

The BS/EACD was created to conserve and to protect the quality of the groundwater within its jurisdictional area. This chapter examines options for and formulates a water conservation plan through which the BS/EACD and the water supply entities drawing upon these groundwater resources can advance that general objective. The report begins with a consideration of the goals and objectives of a water conservation plan for the BS/EACD area. A brief description of the nature of the groundwater resources within the BS\EACD's area follows. Arguments are then presented regarding the proper context for evaluating the cost efficiency of conservation measures. Following that, the nature of groundwater demand by users of these resources is examined, providing a general indication of where significant conservation appears achievable. Then the four predominant usage sectors are examined in detail to elucidate the opportunities for conservation in each sector. These include interior (domestic) demand, exterior (mainly irrigation) demand, industrial demand, and unaccounted-for losses. Next, the role of pricing in conservation strategy is reviewed. The conservation study concludes with an examination of mechanisms for implementation of conservation measures.

3.0.1 GOALS AND OBJECTIVES

A subcommittee of the BS/EACD Policy Advisory Committee (PAC) was appointed in early 1989 and charged with formulating proposals for "interim" conservation and drought contingency plans. The draft conservation plan produced by that subcommittee offered the following goal statement:

"The goal is to preserve and protect the waters in the Barton Springs segment of the Edwards Aquifer, including maintaining the quality of Barton Springs."

This goal statement suggests the following definition of "conservation":

"Conservation is the maximum beneficial and efficient use of water, the reduction of waste, and beneficial reuse of water."

The BS/EACD PAC adopted the following objectives for a water conservation plan:

"The objectives of conservation are to reduce per capita demand, reduce peak summer demand usage, and maintain or improve the water quality in the Edwards Aquifer. General methods of obtaining these objectives include:

1. Public education and information;
2. Interior water use efficiency enhancement;
3. Exterior water use efficiency enhancement and demand reduction;
4. Adjustments in water pricing policies;
5. Beneficial reuse or substitution of non-potable water in demands where potable water is not required; and
6. Leak detection and repair."

These goals and objectives form a good overall framework within which to explore the opportunities for water conservation. They also highlight a crucial point about the nature of a "real" conservation effort.

Too often, "conservation" is equated to the types of short term curtailment efforts embodied in drought contingency plans. The plan presented herein does NOT deal with doing without to get by nor with enforcing changes of lifestyle or habit to meet a crisis situation. Rather it focuses on measures which can be taken to AVOID a crisis.

The focus is on "durable" rather than "removable" conservation measures. The plan stresses means of reducing per capita demand which do not depend to any great degree upon conscious daily effort by the water users. Instead, they depend upon changes in the way water-demanding tasks are addressed. Three distinct types of changes can be readily identified:

1. Changes in how water using tasks are "formulated", e.g., Xeriscape to reduce landscape irrigation requirements;
2. Changes in how water using components are designed, e.g., ultra-low volume toilets; and
3. Changes in how water system components are maintained, e.g., leak detection and repair.

These changes can produce permanent, reliable reductions in per capita demand. Given this focus, it can be readily appreciated that the basic underlying questions include:

1. What will it cost to achieve this long-term conservation?
2. How can the changes required to implement these measures best be encouraged and/or enforced?
3. What costs would be incurred if these measures are not pursued?

The remainder of this section attempts to provide some possible answers to the last question, while the rest of this chapter focuses mainly on the first two questions.

3.0.2 HYDROGEOLOGIC FACTORS INDICATING A NEED FOR CONSERVATION

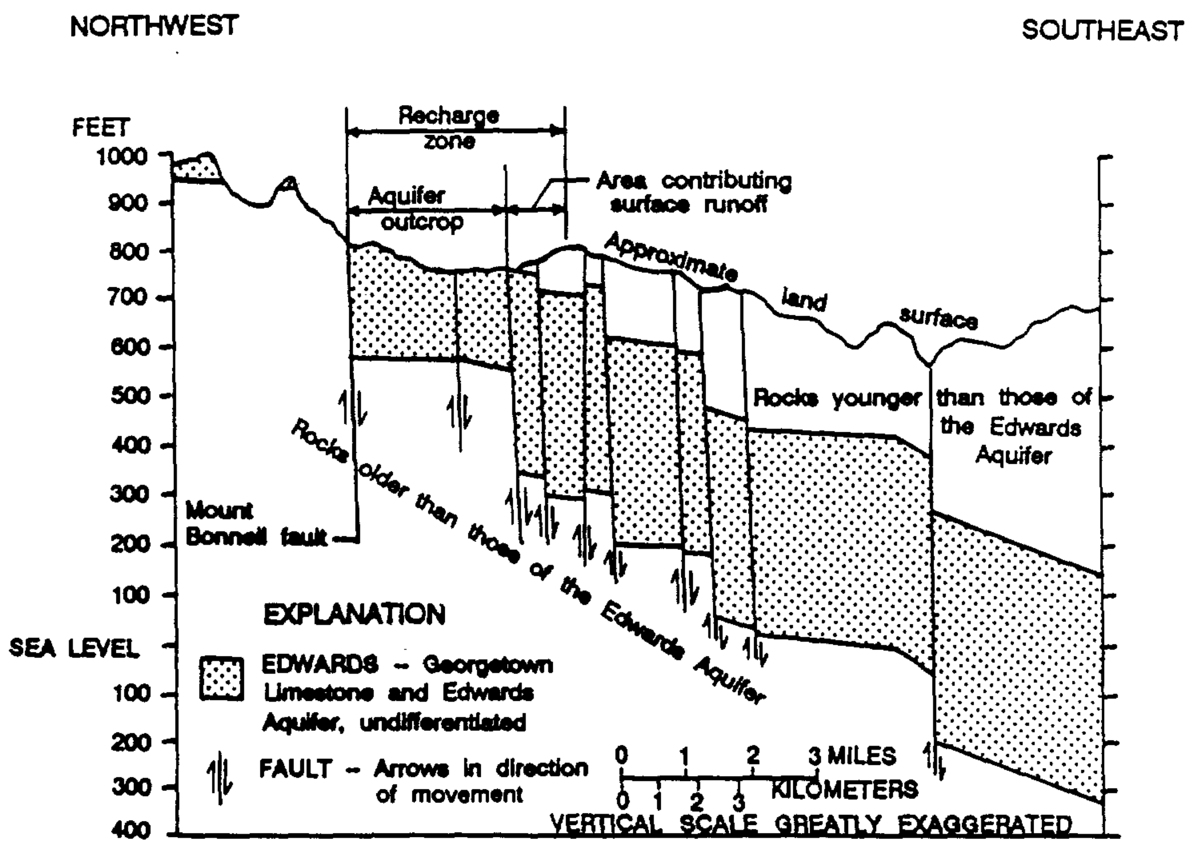
3.0.2.1 A Brief Review of the Hydrogeologic Setting

The Barton Springs segment is a portion of the Edwards aquifer is composed of Edwards and Georgetown limestones. A series of studies conducted by the U.S. Geological Survey (USGS) and the Texas Water Development Board (TWDB) have defined the limits of this segment. It is generally bounded on the north by the Colorado River, where it discharges through Barton, Cold and Deep Eddy Springs. To the south, a groundwater divide near FM 150 defines the southern limit of the Edwards which provides flow to Barton Springs. The western boundary is along the Mount Bonnell and associated faults. To the west of the fault line, strata older than the Edwards Formation. East of this line, formations of the Edwards aquifer are exposed at the surface, forming the "recharge zone". Here and on to the east, the Balcones Fault Zone has created a series of "steps" which dips the Edwards aquifer under younger strata, creating a "confined zone". The generally recognized easterly boundary of the aquifer is the so-called "bad water line", where the total dissolved solids level of Edwards water is 1,000 mg/l or greater. Figure 3.1 shows a generalized hydrogeologic section along the dip.

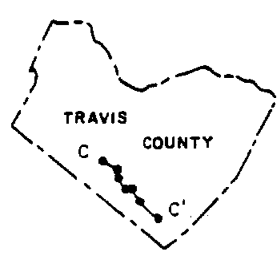
Where the Edwards Formation is exposed at the surface, it is partially eroded. The thickness in this area is determined by faulting and the extent of erosion, ranging from about 100 feet to about 450 feet. Where not exposed and eroded, the thickness varies from about 400 feet in the northern part of the area to about 450 feet in its southern reaches.

As Figure 3.1 shows, the aquifer is under "water table" conditions in the recharge zone; that is, a well drilled in this area would have a free water surface in the well at the same elevation as the

FIGURE 3.1 GENERALIZED HYDROGEOLOGIC SECTION ALONG DIP OF THE EDWARDS AQUIFER



Adopted from Slade and others, in press



Location map

top of the saturated zone in the aquifer. For some indeterminant distance into the confined zone, water table conditions continue to exist. This distance would vary spatially with the local pattern of faulting and temporally with the storage level of the aquifer. Going further into the confined zone, a point is reached where the aquifer is under artesian conditions; that is, the free water surface in a well drilled here would rise above the contact with the Edwards aquifer.

The Edwards Formation is underlain by a confining bed known as the Walnut Formation, which ranges in thickness from 15 to 60 feet. Below this lies the Trinity Group, which contains several water bearing strata. The water in these aquifers is generally of lower quality than Edwards water. Trinity Group strata outcrop to the west of the Mount Bonnell fault line. Figure 3.2 summarizes the lithology of the Edwards Formation.

The porosity and permeability of the Edwards aquifer is greatly influenced by irregular dissolution of the limestones. These in turn determine hydraulic properties. Flow in the aquifer is primarily through dissolution cavities and caves associated with faults, fractures and joints, and only secondarily through porous (primary porosity) media within the limestone. Thus the hydraulic properties can vary greatly over the aquifer's area and through its depth at any location.

The only source of fresh water input to the Edwards is from rainfall over and upstream of the recharge zone. Studies by the USGS (1986) have shown that the vast majority of recharge occurs along the six major creeks: Barton, Williamson, Slaughter, Bear, Little Bear, and Onion. Recharge is highly dependent upon the occurrence of runoff-producing storms over the watersheds of these creeks. This makes the amount of storage in the Edwards aquifer very sensitive to conditions of drought.

FIGURE 3.2 GENERALIZED HYDROGEOLOGIC COLUMN SHOWING THE EDWARDS AQUIFER AND ITS CONFINING BEDS AND THE CORRELATIVE FORMATIONS

SYSTEM	FORMATION	HYDROGEOLOGIC UNIT
CRETACEOUS	BUDA LIMESTONE	UPPER CONFINING BED
	DEL RIO CLAY	
	GEORGETOWN LIMESTONE	EDWARDS AQUIFER
	EDWARDS LIMESTONE	
	WALNUT FORMATION	LOWER CONFINING BED
	GLEN ROSE LIMESTONE	AQUIFER

3.0.2.2 Possible Impacts of Increased Pumpage

Historically, pumpage from the Barton Springs segment of the Edwards aquifer has been a fairly small fraction of the total spring discharge. The volume of spring discharge is "self regulated" by the level of water in the aquifer. Discharge decreases as storage drops, which historically has been mainly due to lack of recharging rains rather than to pumped withdrawals. In recent years, however, pumpage from the Edwards aquifer in this area has increased. This higher pumpage is directly related to decreased discharges from Barton Springs and to other potential negative impacts.

An indication that the storage level in the aquifer now responds more quickly than in historical periods comes from water level data evaluation. Generally lower water levels were experienced not in 1956 at the end of the 6-year drought of record, rather in 1984 during about a 10-month "mini-drought".

In 1956, well LR 58-58-101, located near Buda, had an average water level of 561.5 feet MSL over the July-October period, with a minimum water level of 561. In 1984, the minimum level was 553 feet MSL, and, except for one reading, the level was continuously lower than 561 from July through October.

Well YD 58-50-801, located near San Leanna, recorded a minimum level of 505 feet MSL in June of 1956, but this was an "isolated" low point. Readings in May and July were 525 and 519 feet MSL, respectively. In 1984, though the minimum recorded level was just above the all-time minimum, standing at 506 in September, water levels were at 516 or less continuously from June through September.

These data suggest that pumpage is already at a level where its impacts are more noticeable. Thus the "self regulation" of total discharge could be overridden and withdrawal from the Edwards aquifer could enter the realm of groundwater mining, decreasing water levels in the aquifer below those observed historically.

One negative impact of this increased pumpage may be a decline in the quality of water in the Edwards aquifer. Studies by the USGS (1986) indicate that quality degradation might be caused by two sources: (1) leakage from the Trinity aquifer, and (2) encroachment of water high in dissolved solids along the "bad water" line.

Due to faulting, water bearing strata of the Trinity are not "sealed off" from the Edwards at all points by the Walnut Formation, and the Walnut Formation may not form a perfect seal where it does separate the two aquifers. Evidence suggests that local "overpumpage" of the Edwards routinely induces leakage of Trinity water into Edwards wells at some locations under present conditions. The implication of this circumstance is reflected in a USGS report (1986):

"If future development of wells and pumpage is expanded, the areal extent of leakage from adjacent aquifers may greatly increase. Under such circumstances, the chemical character of the water pumped from wells that penetrate the Edwards aquifer and from Barton Springs may be similar to a mixture of waters from the Edwards and Trinity aquifers. . . . If leakage into the Edwards aquifer became significant under future conditions, the resultant quality of water in the Edwards aquifer may deteriorate and even require treatment."

"Bad water" encroachment is another potential threat to quality if increased pumpage reduces aquifer storage below historic levels.

Evidence suggests that this may have already occurred in the northeast portion of the aquifer when storage levels were low. This circumstance appears to dictate that keeping Barton Springs flowing is an unavoidable consequence of assuring that the quality of Edwards water--at least in this area--does not degrade.

Further south, it is speculated that local faulting patterns might block significant "bad water" movement into the freshwater zone. Due to this situation, USGS (1986) states that "[i]f, in the future, increased pumping significantly lowers potentiometric surfaces in this area, the faults <u>may</u> restrict bad-water encroachment into well fields." [Emphasis added.] The implication is that this is one of many aspects of aquifer "behavior" about which there is little knowledge on what would happen once well levels in the area were drawn down below the limit of historical records.

The USGS analysis also does not deal with the potential for "bad water" encroachment between the northeastern area and the faulted area to the south. USGS (1986) provides data showing that well levels to the east of the "bad water" line are higher than those just inside the freshwater zone even during times of average spring discharge. This implies that increased pumpage might produce an adequate gradient for movement of "bad water" into the freshwater zone. The numerous sizable wells now pumping from Buda northward to about Slaughter Creek would appear to be particularly vulnerable.

Another potential negative impact of increasing the level of pumpage from the aquifer is an inability of many wells to continue to produce Edwards water. USGS (1985) outlined studies of the impact of increased pumpage which concluded that a large portion of the Edwards would be "dewatered" under future growth scenarios. While the exact assumptions upon which that model was based may be open to question, the general indication is clearly one of decreasing storage levels with increased pumpage. In reviewing that study, USGS (1986) states:

"The water demand for this growth may exceed the resources of the Edwards aquifer particularly in site specific areas. [sic] The effect of this growth on ground-water levels and on Barton Springs discharge depends upon the extent that the Edwards aquifer is used to provide the water demand."

However, it is not necessary to hypothesize huge area-wide increases in pumpage in order to foresee possible problems with abstraction. Recall the variable nature of hydraulic properties within the aquifer. According to USGS researchers, it is well established that much of the available capacity of the aquifer is near the top, in the zone of historic water level fluctuation. It is entirely possible that even a small decrease in the water level of any given well, due to increased pumpage demand, could significantly alter the drawdown curve. Historically that well may have been withdrawing at a level with high permeability, but a decreased static level and/or an increased demand could result in withdrawal from levels having less well developed permeability, creating a drawdown much greater than previously experienced. Even though such conditions may have no effect on the quality or the reliability of the supply, it may still result in a costly deepening of the well and increased pumping costs for the supply entity.

3.0.2.3 Conservation: An Ongoing Drought Contingency Plan

The foregoing outlined how the nature of the Barton Springs segment of the Edwards aquifer dictates that increased pumpage may lead to problems with the quality and quantity of supplies, at least in parts of the area. Note, however, that these problems are mainly predicated upon conditions of low recharge. As long as recharge continues to be "adequate", the impact of increased abstraction would mainly be a (presumably minor) reduction of flow from Barton Springs. Localized drawdown problems could still occur at any storage level with a sufficiently high level of local demand, but, of course, they would be more severe at lower storage levels. In sum, the resource is very drought-sensitive, and it is likely to become more so as pumpage levels increase, both locally and over the aquifer as a whole.

In effect, then, a conservation program for the BS/EACD and the users of this resource can be viewed as an on-going drought contingency plan. Any long-term reductions in groundwater pumpage resulting from program implementation would decrease the severity of the impacts from any given period of drought.

Historically, reductions in aquifer storage reflect a reaction to long-term conditions of low recharge rather than to the seasonal variations in pumpage. While this is an artifact of the seasonal patterns of recharging storms in this area--and also due no doubt to springflows having dominated the rate of discharge--it is an indication that any conservation program should attempt to reduce the "base" demand as well as the peak demands of aquifer users. The potential for negative impacts--except perhaps for local drawdown problems--appears related more to the total level of withdrawal than to the peaking pattern or peak rate of withdrawal.

In closing this discussion, it is noted that most models attempting to predict the impacts of the "greenhouse" effect show the future climate of Central Texas as becoming somewhat drier on average. Since recharge of the Edwards aquifer depends upon the occurrence of recharging storms (those of sufficient volume and intensity to produce significant runoff), even a change in rainfall patterns--without any reductions in average annual levels--could greatly reduce the storage level in the aquifer. This provides yet another reason to favor the maximum level of water conservation which can be cost efficiently obtained.

3.0.3 COST EFFICIENCY OF CONSERVATION--A RESOURCE ECONOMICS VIEWPOINT

3.0.3.1 Marginal costs of alternative supplies

As discussed above, under favorable climatic conditions, the Edwards aquifer may in fact be a renewable resource, even in the face of increasing demand (if one neglects the reduction in springflow implied by increased pumpage). But prudent public policy does not favor gambling upon the continual existence of favorable conditions. Nor does it favor gambling that any impacts of storage level reductions upon the availability and quality of Edwards water would be minimal. Therefore, Edwards water ought to be considered as a potentially scarce and exhaustible resource, and plans for its management should be based upon that view.

In a market economy, scarce resources are generally allocated by the law of supply and demand: as scarcity increases, price goes up, serving to allocate the resource to those uses which produce the best return on the investment. Neglecting for the moment the question of whether strict market principles ought to be applied to "social goods" like water supply, it is still useful to consider the role of market forces in the allocation of Edwards water.

Under Texas law, groundwater is subject to a "right of capture", so that any user is generally free to take all it can pump, regardless of the impact upon other users of the same resource. One result of this situation is that users of Edwards water have tended to view the water supply as being "free", subject only to the cost of abstraction and distribution. As noted, if climatic conditions (and probably local pumping intensity as well) do not become too unfavorable, this could indeed continue to be a realistic viewpoint.

If one proceeds upon the assumption that Edwards water is a potentially scarce and exhaustible resource, however, then it is no longer rational to view the supply source as being free. Natural resource depletion costs should be considered when attempting to place a value on the water delivered to a user. Thus, present prices--which do not take the depletion cost into account--offer a poor guide for how much and when to invest in measures to ensure the availability and quality of this water, both to an individual user and to the group of users as a whole. A failure to adequately ensure the availability or protect the quality of Edwards water may eventually lead to a need to access alternative sources of supply --or even just to deepen existing wells, install larger pumps and/or pump longer to obtain the same volume. The costs of these actions represents the "long-run marginal cost" of water supply.

Since present prices for water do not accurately reflect this long-run marginal cost, fiscal analysis of conservation measures may result in "undervaluing" those measures; that is, at present prices, the rate of return on the investment in a conservation measure would appear to be too low to justify implementation. However, it may be the very failure to institute these measures which eventually requires users to incur the costs of alternative supplies. It may have been far less expensive in the long run to pursue those "unjustifiable" conservation measures, since this would have obviated, downscaled, or shoved further into the future the costs of alternative supply projects.

Individuals, businesses and supply entities should somehow take this long-run marginal cost of water supply into account when evaluating the "cost efficiency" of conservation measures. But such costs would not actually be incurred until the water user was forced to begin implementing the alternative supply project. This dictates that a long-term economic analysis rather than a short-term fiscal analysis is called for. As an aid to evaluating conservation measures in that manner, some indications of the apparent long-run marginal cost of water supply in the BS/EACD's jurisdictional area are provided here.

The recent Hays County Water Development Board study offers cost estimates for alternative water supplies to parts of this area. Of those, the option with the lowest marginal cost was a project to supply water to Hays and Buda from the City of Austin. Examining the project cost and the estimated amount of water to be supplied by it (as detailed in Table 3.3-2 of the Hays County WDB final report), an estimate of the long-run marginal cost of an alternative water supply in this case is $20.09 per 1000 gallons for the period of 1995 to 2005.

Tempering this, it should be noted that this study assumed Hays and Buda would continue to use the same average day amount of groundwater demanded in 1984, while the alternative supply would provide only for demand beyond that level. This assumption dictates that the project would mainly serve peaking demands. It appears that about 10% of the total supply would be derived from this project. (This scenario assumes, of course, that Hays and Buda can indeed continue to obtain high quality Edwards water at the 1984 pumping rates.) The Hays County WDB report represented the net fiscal impact of this project as an increase in the monthly charge per connection of $12 in Hays and of $19 in Buda. If Hays and Buda were to take all of their supplies through this project, the cost would drop to "only" $7.72 per 1000 gallons. This is over 5 times Buda's current top rate and over 2.5 times Hays' current top rate.

At the other end of the scale, the project recommended to serve Mountain City would entail an increase in the monthly charge per connection to finance it of $67 in the period of 1995-2005. (See Table 3.3-3 of the Hays County WDB final report.) Insufficient detail was provided in the report to break out the costs for Mountain City from the entire project, so an estimate of water cost per 1000 gallons is not derived. Comparing the cost per connection with that for Hays and Buda, however, indicates that the cost is probably far in excess of $20 per 1000 gallons. (The average daily demand from the alternative supply projected for Mountain City in 2000 is the same as that projected for Hays and Buda). Since many of the smaller water supply systems in the BS/EACD jurisdictional area are situated similarly to Mountain City, it is likely that their alternative supply costs would be similar, assuming the range of alternatives is limited to those considered in the Hays County WDB study.

These estimates of long-run marginal costs graphically illustrate how fiscal analysis may not be a "proper" guide for investment in conservation. Some consideration of the probable long-run marginal costs of alternative supplies should be injected into the analysis. Adjustments of rate structures in concert with the principles of marginal cost pricing will naturally make fiscal analysis of conservation measures more realistic. This is discussed later in Section 7 of this report.

If the Hays County WDB estimates of long-run marginal costs are even roughly accurate, however, prices high enough to reflect these costs could not be fiscally justified by a supplier until it actually committed resources to a supply project. This is not likely to occur until more thorough analyses of the aquifer's vulnerability and a more complete analysis of all options for alternative water supply are conducted. In the meantime, conservation opportunities will continually be confronted. Therefore, it will be useful to employ a "best guess" of long-run marginal cost as a guide to the economic efficiency of conservation measures. Based upon the best information available at this point, a marginal price of at least $5 per 1000 gallons appears readily justifiable for this purpose.

3.0.3.2 Marginal costs of system infrastructure

Even if it does not require alternative supply projects, increased water demand may still incur high marginal costs. The water supply system may require larger storage volumes, new wells or larger pumps in existing wells, larger transmission mains, etc. In short, the incremental cost of increased water service capacity is largely determined by the incremental costs of increasing capacities of system components.

While these fiscal "penalties" of expanding water service have little direct bearing upon the main focus of this plan--which is conserving and protecting the availability and quality of Edwards water--they can have a great impact upon the economic feasibility of various conservation measures. If per capita demand were reduced, more customers could be served with existing capacity. So forestalling--through conservation--the need for the next increment of capacity expansion would decrease the marginal cost of providing the expanded water service. Reduction of system peak demands is particularly beneficial in this regard.

Conservation measures which do not appear to be attractive based upon short-term fiscal analysis may in fact be less expensive than the long-run marginal cost of system expansion. Just as in the case of marginal costs associated with accessing alternative supplies, these "avoided" costs of system capacity expansion should be taken into account when evaluating the cost efficiency of pursuing conservation measures.

3.1 WATER USE IN THE BS/EACD AREA

A major focus of this study was to detail the types and patterns of water demand among Edwards aquifer users. This information is essential if one is to intelligently determine how best to cost efficiently conserve water. The information received from water suppliers and other sources was used to characterize water demands.

3.1.1 WATER SUPPLIER DATA

3.1.1.1 Data Provided by Water Suppliers

Each water supply entity was requested to provide the following information:

1. Water produced in each month of the years 1983 through 1988;
2. Water sold in each month of the years 1983 through 1988 to each of the following classes of customers; and
   A. Residential
   B. Commercial
   C. Industrial
   D. Agricultural
3. The number of active accounts in each of the above classes of customers in each month of the years 1983 through 1988.

Goforth WSC, Estates WSC, and Ridgewood Village Water Company provided a fairly complete set of the requested data. Complete pumpage and accounts data was also provided for the City of Sunset Valley, but sales data was only available back to mid-1986. Data was also provided for Chaparral Water Company beginning in late 1987. Based upon these data, residential demand profiles for these systems are displayed in Tables 3.1 through 3.5.

TABLE 3.1 GOFORTH WSC RESIDENTIAL DEMAND PROFILES, 1983-1988

YEAR OF RECORD = 1983 ESTIMATED PERSONS PER CONNECTION = 2.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	2912	2961	2738	2942	4797	4590	5086	5452	6328	5534	4069	3946
CONNECTIONS	525	526	527	533	533	530	527	526	561	554	558	570
GAL/CONN	5546	5629	5252	5519	9000	8661	9651	10365	11280	9990	7292	6923
GPD/CONN	179	201	169	184	290	289	311	334	376	322	243	223
GPCD	78	87	74	80	126	126	135	145	163	140	106	97

YEAR OF RECORD = 1984 ESTIMATED PERSONS PER CONNECTION = 2.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	5445	3956	3961	4354	6791	6782	7698	7650	8661	8050	6351	6125
CONNECTIONS	583	591	587	624	650	641	659	679	693	719	743	740
GAL/CONN	9340	6694	6748	6977	10448	10580	11631	11266	12497	11196	8547	8277
GPD/CONN	301	239	218	233	337	353	377	363	417	361	285	267
GPCD	131	104	95	101	147	153	164	158	181	157	124	116

TABLE 3.1 GOFORTH WSC RESIDENTIAL DEMAND PROFILES, 1983-1988 (CONTINUED)

YEAR OF RECORD = 1985
ESTIMATED PERSONS PER CONNECTION = 2.3

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	5047	6416	5024	5028	6166	7504	7209	12887	11040	7085	5612	5598
CONNECTIONS	743	758	757	755	817	816	818	840	937	939	925	927
GAL/CONN	6792	8464	6637	6660	7547	9196	8813	15341	11783	7545	6067	6039
GPD/CONN	219	302	214	222	243	307	284	495	393	243	202	195
GPCD	95	131	93	97	106	133	124	215	171	106	88	85

YEAR OF RECORD = 1986
ESTIMATED PERSONS PER CONNECTION = 2.3

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	5649	5727	5376	7422	7472	7010	10706	14284	8255	6622	6068	5659
CONNECTIONS	968	963	952	977	984	1003	1005	1008	1015	1019	1019	1017
GAL/CONN	5836	5947	5647	7596	7594	6989	10653	14170	8133	6499	5954	5565
GPD/CONN	188	212	182	253	245	233	344	457	271	210	198	180
GPCD	82	92	79	110	107	101	149	199	118	91	86	78

TABLE 3.1 GOFORTH WSC RESIDENTIAL DEMAND PROFILES, 1983-1988 (CONTINUED)

YEAR OF RECORD = 1987 ESTIMATED PERSONS PER CONNECTION = 2.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	6969	5431	5385	7457	9614	6160	8974	12764	10166	8518	7957	6092
CONNECTIONS	995	988	992	984	988	990	1002	1009	1010	1009	1012	1012
GAL/CONN	7004	5497	5429	7578	9731	6222	8956	12650	10066	8442	7862	6020
GPD/CONN	226	196	175	253	314	207	289	408	336	272	262	194
GPCD	98	85	76	110	136	90	126	177	146	118	114	84

YEAR OF RECORD = 1988 ESTIMATED PERSONS PER CONNECTION = 2.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	6765	6278	6206	7544	8745	8798	10693	10457	12232	9780	7728	7404
CONNECTIONS	1013	1010	1008	1014	1022	1021	1023	1015	1026	1037	1034	1030
GAL/CONN	6678	6216	6157	7440	8557	8617	10452	10303	11922	9431	7474	7188
GPD/CONN	215	222	199	248	276	287	337	332	397	304	249	232
GPCD	94	97	86	108	120	125	147	145	173	132	108	101

TABLE 3.2 ESTATES WSC RESIDENTIAL DEMAND PROFILES, 1985-1988

YEAR OF RECORD = 1985 ESTIMATED PERSONS PER CONNECTION = 3.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	555	566	558	808	801	999	1025	1807	1186	691	486	590
CONNECTIONS	78	78	79	79	79	78	80	79	79	78	78	78
GAL/CONN	7120	7260	7066	10224	10142	12802	12813	22867	15015	8857	6228	7559
GPD/CONN	230	259	228	341	327	427	413	738	501	286	208	244
GPCD	70	79	69	103	99	129	125	224	152	87	63	74

YEAR OF RECORD = 1986 ESTIMATED PERSONS PER CONNECTION = 3.3												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	619	555	692	787	660	695	1773	1832	619	569	575	621
CONNECTIONS	78	78	78	78	76	76	75	78	79	79	79	79
GAL/CONN	7933	7120	8869	10096	8688	9142	23639	23489	7831	7197	7282	7857
GPD/CONN	256	254	286	337	280	305	763	758	261	232	243	253
GPCD	78	77	87	102	85	92	231	230	79	70	74	77

TABLE 3.2 ESTATES WSC RESIDENTIAL DEMAND PROFILES, 1985-1988 (CONTINUED)

YEAR OF RECORD = 1987
ESTIMATED PERSONS PER CONNECTION = 3.3

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	575	416	569	999	624	748	1886	1743	628	623	690	557
CONNECTIONS	78	79	78	78	79	79	79	79	79	80	80	79
GAL/CONN	7366	5267	7293	12804	7903	9472	23879	22066	7945	7782	8623	7054
GPD/CONN	238	188	235	427	255	316	770	712	265	251	287	228
GPCD	72	57	71	129	77	96	223	216	80	76	87	69

YEAR OF RECORD = 1988
ESTIMATED PERSONS PER CONNECTION = 3.3

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	448	578	739	765	883	1391	917	1072	1123	777	675	545
CONNECTIONS	76	77	78	77	77	78	78	78	78	80	81	79
GAL/CONN	5893	7508	9475	9937	11473	17827	11762	13748	14396	9718	8333	6897
GPD/CONN	190	268	306	331	370	594	379	443	480	313	278	222
GPCD	58	81	93	100	112	180	115	134	145	95	84	67

TABLE 3.3 RIDGEWOOD VILLAGE RESIDENTIAL DEMAND PROFILES, 1983-1988

YEAR OF RECORD = 1983												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
WATER SOLD (1,000 GAL)	519	464	542	786	879	711	1146	1268	1103	640	740	717
CONNECTIONS	72	72	72	72	72	72	72	72	72	72	72	72
GAL/CONN	7208	6444	7528	10917	12208	9875	15917	17611	15319	8889	10278	9958
GPD/CONN	223	230	243	364	394	329	513	568	511	287	343	321

YEAR OF RECORD = 1984												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
WATER SOLD (1,000 GAL)	650	911	635	1248	1650	1573	2002	1697	1119	812	827	597
CONNECTIONS	72	72	72	73	73	73	73	73	73	73	73	74
GAL/CONN	9028	12653	8819	17096	22603	21548	27425	23247	15329	11123	11329	8068
GPD/CONN	291	452	284	570	729	718	885	750	511	359	378	260

TABLE 3.3 RIDGEWOOD VILLAGE RESIDENTIAL DEMAND PROFILES, 1983-1988 (CONTINUED)

YEAR OF RECORD = 1985												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
WATER SOLD (1,000 GAL)	542	686	643	779	1133	1211	1494	2139	1133	825	616	615
CONNECTIONS	74	74	74	74	74	74	74	74	74	74	74	74
GAL/CONN	7324	9270	8689	10527	15311	16365	20189	28905	15311	11149	8324	8311
GPD/CONN	236	331	280	351	494	545	651	932	510	360	277	268

YEAR OF RECORD = 1986												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
WATER SOLD (1,000 GAL)	558	589	875	1238	466	871	2221	1599	839	676	605	472
CONNECTIONS	74	74	75	75	75	75	75	75	75	75	75	75
GAL/CONN	7541	7959	11667	16507	6213	11613	29613	21320	11187	9013	8067	6293
GPD/CONN	243	284	376	550	200	387	955	688	373	291	269	203

TABLE 3.3 RIDGEWOOD VILLAGE RESIDENTIAL DEMAND PROFILES, 1983-1988 (CONTINUED)

YEAR OF RECORD = 1987												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	521	528	654	861	897	718	848	1809	1071	963	785	518
CONNECTIONS	75	75	75	75	75	75	75	75	75	75	75	75
GAL/CONN	6947	7040	8720	11480	11960	9573	11307	24120	14280	13107	10467	6970
GPD/CONN	224	251	281	383	386	319	365	778	476	423	349	223

YEAR OF RECORD = 1988												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	546	798	687	830	1125	1244	1105	1625	1441	1165	916	582
CONNECTIONS	76	76	76	76	76	76	76	76	76	76	76	76
GAL/CONN	232	375	292	364	478	546	469	690	632	494	402	247
GPD/CONN	215	222	199	248	276	287	337	332	397	304	249	232

TABLE 3.4 SUNSET VALLEY RESIDENTIAL DEMAND PROFILES, 1987-1988

YEAR OF RECORD = 1987 ESTIMATED PERSONS PER CONNECTION = 2.8												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	431	424	495	1015	651	642	1105	1902	749	784	573	407
CONNECTIONS	74	75	77	78	77	76	76	76	76	75	74	74
GAL/CONN	5824	5653	6429	13013	8455	8447	14539	25026	9855	10453	7743	5500
GPD/CONN	188	202	207	434	273	282	469	807	329	337	258	177
GPCD	67	72	74	155	97	101	168	288	117	120	92	63

YEAR OF RECORD = 1988 ESTIMATED PERSONS PER CONNECTION = 2.8												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
WATER SOLD (1,000 GAL)	430	579	630	854	978	1183	1036	1434	1571	1204	743	594
CONNECTIONS	74	74	75	76	77	77	77	77	77	77	75	77
GAL/CONN	5811	7824	8400	11237	12698	15358	13454	18623	20408	15633	9905	7715
GPD/CONN	187	279	271	375	410	512	434	601	680	504	330	249
GPCD	67	100	97	134	146	183	155	215	243	180	118	89

TABLE 3.5 CHAPARREL WATER CO. RESIDENTIAL DEMAND PROFILE, 1988

YEAR OF RECORD = 1988 ESTIMATED PERSONS PER CONNECTION = 2.3												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
WATER SOLD (1,000 GAL)	811	922	1224	1307	1384	2043	1134	1782	1668	1441	1166	1004
CONNECTIONS	133	133	132	132	132	129	127	129	129	128	131	130
GAL/CONN	6094	6931	9272	9901	10484	15839	8926	13811	12933	11259	8898	7726
GPD/CONN	197	239	299	330	338	528	288	446	431	363	297	249
GPCD	86	104	130	143	147	230	99	194	187	158	129	108

Of these suppliers, only Goforth served appreciable non-residential demands. Goforth fully broke out its non-residential accounts only for 1987 and 1988. This explains the decrease in number of accounts between December 1986 and January 1987 shown in Table 3.1. Analysis of data for 1987 and 1988 indicates that average monthly demand by commercial accounts did not vary greatly from average residential demand, so it is expected that the average residential demands for 1983-1986 shown in Table 3.1 are valid.

Tables 3.1 through 3.5 show that each system exhibits a fairly stable "base" winter demand, and that demand profiles follow a seasonal pattern. Water use peaking generally occurs in the warm season in months of low rainfall, showing that peaking of demand in these systems is driven by seasonal demands. In the cases of Estates WSC, Sunset Valley, Ridgewood Village WC, and Chaparral WC, summer peaking is expected to be largely due to landscape irrigation. For Goforth WSC, anecdotal evidence indicates that landscape irrigation is not widely practiced. The somewhat more subdued peaking pattern in this system appears to be due to gardening, livestock watering and other demands related to farming and ranching operations.

The average winter demand is a good indication of the level of indoor use being experienced in each system. Winter demands vary somewhat from month to month, year to year, and system to system. Possible sources of this variation include changing occupancy, alterations in water using habits and in customer-side leakage losses, meter reading and recording errors, variations in the length of time between readings, and meter accuracy. For the systems which provided an estimate of average persons per household, average gallons/capita/day (gpcd) is also shown in Tables 3.1 through 3.5. As will be discussed later, the apparent levels of demand indicate considerable potential for conservation of water used for interior uses.

Estates WSC and Sunset Valley provided some data on metered usage and estimated household size for each customer. Data for winter months (an estimate of base demand) and for summer months (an estimate of peak demand) by each account in these systems are displayed in Tables 3.6 through 3.9. A comparison of winter and summer demands is shown in Table 3.10, which indicates the severity of peaking in these systems. These tables illustrate that there is quite a large variation in base demand, and that intensive irrigation is by no means universal in these systems. Implications from these data for the level of conservation attainable are discussed in Sections 3.2 and 3.3.

3.1.1.2 Data Obtained from TWDB

For those systems from which data was not available, an attempt was made to analyze the nature of their demands by using data filed with the Texas Water Development Board. Data for some or all of the years 1983 through 1988 was obtained from TWDB for 16 water supply systems.

There are three limitations imposed by using these data to determine the water demand profiles of these suppliers. First, only pumpage was reported. To translate pumpage to customer usage, information about the system loss rates is required. Unless information indicating otherwise was available, a value of 15% was assumed. However, data supplied by Goforth WSC, Sunset Valley and Ridgewood Village show that loss rates can vary greatly from month to month. So applying an annual average loss rate to each month's production may result in large errors in demand estimates.

TABLE 3.6 ESTATES UTILITIES WINTER MONTH DEMANDS

CONN. NO.	DECEMBER 1987		JANUARY 1988		FEBRUARY 1988	
	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD
1	5180	84	4960	80	5120	88
2	0	0	0	0	3180	55
3	9430	76	7110	57	12560	108
4	4020	43	3830	41	3820	44
5	4140	134	2450	79	2020	70
6	8700	94	6560	71	4860	56
7	8050	130	10010	161	7390	127
8	10870	70	8790	57	10770	74
9	4840	39	7490	60	10490	90
10	5700	46	5330	43	6640	57
11	11870	96	9770	79	11120	96
12	5550	90	4600	74	5460	94
13	5130	33	3590	23	3480	24
14	4010	65	3260	53	3930	68
15	8230	88	8100	87	7470	86
16	9150	148	8230	133	14520	250
17	5450	35	2570	17	5220	36
18	4280	69	3760	61	4150	72
19	12830	138	11280	121	12640	145
20	3540	38	2900	31	3840	44
21	8100	131	5990	97	6640	114
22	7680	62	3900	31	5630	49
23	5350	43	4730	38	4950	43
24	5710	46	4780	39	5040	43
25	5900	95	4440	72	4020	69
26	6280	68	4910	53	6670	77
27	5960	96	6520	105	7200	124
28	17290	62	17490	63	19270	74
29	8450	68	4570	37	6200	53
30	7020	113	5050	81	8130	140
31	9520	154	5500	89	10940	189
32	7360	59	5440	44	6610	57
33	6770	109	5430	88	7140	123
34	6000	48	5350	43	6150	53
35	9250	75	8170	66	8380	72
36	15560	100	10930	71	10480	72
37	7520	121	5910	95	7610	131
38	5850	47	3980	32	6280	54
39	9980	80	8700	70	13890	120
40	3450	56	3590	58	0	0
41	3240	52	3370	54	2980	51
42	5490	89	5100	82	5870	101
43	7280	59	6710	54	8160	70
44	8540	46	6520	35	7700	44
45	4120	33	3840	31	7520	65
46	9870	55	5500	44	7810	67

TABLE 3.6 ESTATES UTILITIES WINTER MONTH DEMANDS (CONTINUED)

CONN. NO.	DECEMBER 1987		JANUARY 1988		FEBRUARY 1988	
	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD
47	8570	92	5990	64	7570	87
48	7860	85	9630	104	20420	235
49	9790	53	7390	40	10940	63
50	4520	73	4040	65	4330	75
51	4400	47	3780	41	5170	59
52	5400	44	4230	34	5750	50
53	3850	62	2950	48	3760	65
54	10560	114	10190	110	7250	83
55	2180	35	1670	27	1720	30
56	11040	119	6760	73	8830	101
57	29920	193	16630	107	17740	122
58	6380	41	4780	31	6510	45
59	0	0	0	0	0	0
60	6300	51	4630	37	6600	57
61	4650	30	3660	24	4680	32
62	10460	84	9820	79	11700	101
63	2380	19	2460	20	2800	24
64	7430	240	4950	160	6650	229
65	7760	63	6140	50	7740	67
66	5050	54	3520	38	4670	54
67	6010	48	4330	35	5420	47
68	4720	38	3710	30	5010	43
69	6850	74	4780	51	5570	64
70	5080	41	3760	30	3950	34
71	8540	69	8160	66	10990	95
72	6630	107	7300	118	7700	133
73	22750	245	17030	183	19920	229
74	6350	68	5130	55	11000	126
75	5770	62	4880	52	6430	74
76	0	0	0	0	2490	43
77	0	0	0	0	10930	188
78	0	0	0	0	0	0
79	0	0	0	0	0	0
80	6320	51	6150	50	9220	79

TABLE 3.6 ESTATES UTILITIES WINTER MONTH DEMANDS (CONTINUED)

CONN. NO.	DECEMBER 1988		JANUARY 1989		FEBRUARY 1989	
	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD
1	6940	112	7710	124	5100	88
2	6310	102	12160	196	3410	59
3	0	0	0	0	0	0
4	4590	49	4120	44	2820	32
5	1480	48	1920	62	1560	54
6	6540	70	7550	81	7490	86
7	5570	90	5790	93	6050	104
8	11350	73	13660	88	10140	70
9	4450	36	10110	82	17550	151
10	18700	151	13940	112	12380	107
11	11350	92	12340	100	10210	88
12	5430	88	6490	105	5110	88
13	7450	48	7290	47	5100	35
14	3730	60	4250	69	3240	56
15	11080	119	9650	104	6460	74
16	4560	74	5060	82	4790	83
17	5860	38	6700	43	5780	40
18	7600	123	5560	90	4840	83
19	14320	154	13390	144	10350	119
20	2610	28	3110	33	3780	43
21	2350	38	12810	207	7270	125
22	3880	31	7190	58	5110	44
23	3780	30	4570	37	3250	28
24	8390	68	8270	67	4780	41
25	5100	82	6900	111	4590	79
26	5610	60	7570	81	8350	96
27	2940	47	4510	73	3230	56
28	19760	71	20890	75	17370	67
29	4330	35	5380	43	3870	33
30	6630	107	7370	119	5980	103
31	9330	150	9430	152	4890	84
32	5060	41	8040	65	5310	46
33	6910	111	8560	138	6480	112
34	9630	78	14040	113	10910	94
35	10830	87	10680	86	8490	73
36	10070	65	16380	106	9240	64
37	8530	138	12360	199	6210	107
38	2940	24	4010	32	2480	21
39	10170	82	11690	94	6940	60
40	4550	73	5520	89	4110	71
41	2500	40	3460	56	1920	33
42	10520	170	12940	209	9420	162
43	5180	42	6890	56	4110	35
44	7260	39	7820	42	6870	39
45	6410	52	22360	180	6430	55

TABLE 3.6 ESTATES UTILITIES WINTER MONTH DEMANDS (CONTINUED)

CONN. NO.	DECEMBER 1988		JANUARY 1989		FEBRUARY 1989	
	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD
46	6540	53	9090	73	7260	63
47	9970	107	9060	97	6510	75
48	11450	123	18700	201	8350	96
49	9490	51	13790	74	5160	30
50	3700	60	4720	76	2900	50
51	4840	52	5840	63	5020	58
52	3680	30	2790	23	3470	30
53	3690	60	4700	76	3000	52
54	6140	66	7540	81	5010	58
55	2110	34	2040	33	3290	57
56	5650	61	6030	65	4190	48
57	20950	135	20330	131	21600	149
58	5730	37	7150	46	5120	35
59	4910	40	6070	49	4280	37
60	8260	67	7580	61	4860	42
61	4780	31	6040	39	4110	28
62	10420	84	13700	110	10340	89
63	7430	60	10160	82	6390	55
64	3500	113	2910	94	3990	138
65	8410	68	10160	82	7030	61
66	5240	56	5920	64	4900	56
67	9220	74	9420	76	7270	63
68	4890	39	7880	64	7580	65
69	5300	57	6500	70	8890	102
70	4120	33	4940	40	3780	33
71	15240	123	19960	161	17410	150
72	2650	43	2740	44	3150	54
73	4480	48	5550	60	5060	58
74	10500	113	11440	123	11180	129
75	4430	48	5400	58	5610	64
76	5090	82	5350	86	6410	111
77	7830	126	3280	53	4590	79
78	5950	64	3990	43	7920	91
79	4880	157	4850	156	5280	182
80	0	0	4590	37	3680	32

TABLE 3.7 ESTATES UTILITIES SUMMER MONTHS DEMAND

CONN. NO.	1988				1989			
	JULY (P = 2.70")		AUG (P = 1.35")		JULY (P = 0.71")		AUG (P = 0.94")	
	GAL USED	GCPD	GAL USED	GPCD	GAL USED	GCPD	GAL USED	GCPD
1	5980	96	8740	141	14910	240	13670	220
2	23180	374	20070	324	21920	354	14260	230
3	5890	48	4860	39	4440	36	4830	39
4	11350	122	10240	110	13960	150	9900	106
5	3430	111	4070	131	4690	151	1280	41
6	17700	190	22700	244	34240	368	24970	268
7	11590	187	13420	216	7240	117	6930	112
8	21010	136	20900	135	23390	151	22160	143
9	3180	26	4780	39	7670	62	12160	98
10	10970	88	11210	90	11160	90	9930	80
11	10420	84	12520	101	13980	113	13820	111
12	15330	247	15610	252	24040	388	16320	263
13	12140	78	18380	119	31580	204	21870	141
14	4090	66	4460	72	6400	103	4370	70
15	17570	189	27020	291	34990	376	20890	225
16	10690	172	10160	164	25400	410	19230	310
17	12010	77	16320	105	39530	255	25890	167
18	14950	241	20450	330	20880	337	19400	313
19	24360	262	32350	348	23610	254	23650	254
20	5170	56	3620	39	4620	50	1890	20
21	7850	127	11660	188	13780	222	10920	176
22	4070	33	33770	272	18540	198	6480	70
23	4290	35	4280	35	10560	85	34220	276
24	15660	126	17460	141	25210	203	20800	168
25	5850	94	5220	84	4870	79	5670	91
26	19950	215	25340	272	37900	408	10250	110
27	4580	74	4000	65	4480	72	6160	99

TABLE 3.7 ESTATES UTILITIES SUMMER MONTHS DEMAND (CONTINUED)

CONN. NO.	1988				1989			
	JULY (P = 2.70")		AUG (P = 1.35")		JULY (P = 0.71")		AUG (P = 0.94")	
	GAL USED	GCPD	GAL USED	GPCD	GAL USED	GCPD	GAL USED	GCPD
28	29260	105	26780	96	44360	159	31360	112
29	12780	103	12290	99	22050	178	9240	75
30	9200	148	10760	174	11100	179	10460	169
31	11310	182	9150	148	14860	240	10950	177
32	11820	95	12570	101	12300	99	11330	91
33	10730	173	19040	307	17530	283	8530	138
34	10660	86	8390	68	9730	78	6030	49
35	10650	86	12630	102	17100	138	13020	105
36	11340	73	25000	161	24250	156	22950	148
37	11640	188	16170	261	33520	541	26460	427
38	8540	69	8140	66	10220	82	11790	95
39	14160	114	13240	107	18810	152	12760	103
40	6840	110	6200	100	7620	123	7180	116
41	5510	89	6200	100	5730	92	4500	73
42	20800	335	19610	316	42430	684	29400	474
43	12190	98	10680	86	19570	158	7570	61
44	13880	75	13190	71	25480	137	15610	84
45	21270	172	18590	150	40230	324	28180	227
46	41810	337	45530	367	47630	384	25060	202
47	7310	79	6990	75	8560	92	7610	82
48	21540	232	22810	245	56850	611	29540	318
49	17610	95	23820	128	22580	121	17240	93
50	7770	125	5360	86	6100	98	4850	78
51	9060	97	9570	103	8590	92	8190	88
52	4240	34	4010	32	11270	91	5390	43
53	8780	142	9340	151	17810	287	9120	147
54	21380	230	25930	279	22240	239	23070	248
55	4780	77	6260	101	4780	77	5150	83

TABLE 3.7 ESTATES UTILITIES SUMMER MONTHS DEMAND (CONTINUED)

CONN. NO.	1988				1989			
	JULY (P = 2.70")		AUG (P = 1.35")		JULY (P = 0.71")		AUG (P = 0.94")	
	GAL USED	GCPD	GAL USED	GPCD	GAL USED	GCPD	GAL USED	GCPD
56	19380	208	22430	241	7950	85	9450	102
57	25090	162	38560	249	75700	488	49850	322
58	5400	35	6420	41	13010	84	8570	55
59	6740	54	7030	57	7310	59	0	0
60	13420	108	20370	164	25720	207	12150	98
61	8370	54	11170	72	22990	148	6480	42
62	17380	140	12570	101	23890	193	17740	143
63	0	0	0	0	12550	101	9180	74
64	3280	106	2720	88	0	0	0	0
65	8570	69	11510	93	11510	93	7960	64
66	5710	61	5740	62	10390	112	7790	84
67	7970	64	8640	70	15370	124	15690	127
68	4350	35	4490	36	6960	56	7510	61
69	9040	97	5340	57	7650	82	7760	83
70	4360	35	4050	33	5060	41	4130	33
71	13770	111	23710	191	13310	107	14370	116
72	2620	42	5730	92	3530	57	3870	62
73	34560	372	40260	433	7660	82	6820	73
74	22500	242	23140	249	39950	430	27880	300
75	5280	57	6580	71	13140	141	12300	132
76	5260	85	6400	103	2970	48	3460	56
77	4300	69	4560	74	5010	81	3760	61
78	0	0	0	0	9340	100	6070	65
79	0	0	0	0	17760	573	8560	276
80	8590	69	7720	62	9670	78	0	0

TABLE 3.8 SUNSET VALLEY WINTER MONTH DEMANDS

CONN. NO.	DECEMBER 1987		JANUARY 1988		FEBRUARY 1988		DECEMBER 1988	
	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD
1	7820	63	7060	61	8120	70	6500	52
2	5630	61	11530	133	8230	95	20600	222
3	3770	61	3540	61	6570	113	4480	72
4	7160	77	14150	163	5910	68	26680	287
5	3220	52	5380	93	6740	116	8430	136
6	3360	54	14440	249	9290	160	4640	75
7	5250	42	10350	89	6530	56	6420	52
8	3840	62	5440	94	5190	89	8200	132
9	8740	70	17120	148	9570	83	14360	116
10	5550	90	6110	105	6430	111	4710	76
11	6970	56	12980	112	7590	65	10710	86
12	7990	86	5770	66	4900	56	6080	65
13	4690	92	5380	93	4160	72	9360	151
14	3040	49	2500	43	2660	46	6340	102
15	2460	79	1410	49	2180	75	2280	74
16	9520	102	8820	101	8540	98	5970	64
17	6000	97	4510	78	4640	80	15000	242
18	4720	76	4260	73	3940	68	6170	100
19	8130	66	8260	71	7900	68	9220	74
20	2860	92	3230	111	4050	140	10690	345
21	9360	151	8270	143	9260	160	9380	151
22	6000	97	22460	387	5550	96	30990	500
23	3530	57	9010	155	8430	145	11140	180
24	3970	32	3880	33	3350	29	4400	35
25	4660	38	10380	89	4360	38	19320	208
26	15810	128	19320	167	14850	128	16980	137
27	5540	45	5270	45	6410	55	6190	50
28	6790	219	3330	115	3440	119	1240	40
29	8880	72	8160	70	8200	71	10900	88
30	8570	46	11080	64	11300	65	8870	48

TABLE 3.8 SUNSET VALLEY WINTER MONTH DEMANDS (CONTINUED)

CONN. NO.	DECEMBER 1987		JANUARY 1988		FEBRUARY 1988		DECEMBER 1988	
	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD
31	7750	125	3290	57	3700	64	10300	167
32	3760	40	4820	55	4400	51	6280	68
33	2210	71	2300	79	2470	85	4180	135
34	6930	75	22250	256	13450	155	11830	127
35	2590	42	3070	53	3000	52	3070	50
36	5710	61	6690	77	5160	59	5740	62
37	5500	89	5730	99	3890	67	9560	154
38	3450	37	6090	70	4910	56	4240	46
39	9680	156	20620	356	4180	72	26710	431
40	12270	79	15040	104	11840	82	15210	98
41	11180	180	23220	400	11410	197	10190	164
42	3940	32	6690	58	4160	36	5080	41
43	3060	99	11790	407	2920	101	7000	226
44	7050	57	7980	69	6850	59	7780	63
45	5010	81	5010	64	3680	63	5010	81
46	5150	166	2340	81	1630	56	15030	485
47	5500	89	11650	201	6980	120	11220	181
48	5260	85	1650	28	1470	25	4220	68
49	2960	48	5240	90	3530	61	5010	81
50	7320	118	13660	236	6490	112	8230	133
51	5760	93	6000	103	4590	79	5840	94
52	1350	22	6620	114	2140	37	1980	62
53	2220	36	2690	46	3060	53	5440	88
54	10670	172	11220	193	10640	183	8340	135
55	3320	21	3790	26	4260	29	3920	25
56	5990	64	6250	72	13890	160	4720	51
57	5060	41	9070	78	7070	61	7360	59
58	3870	62	3710	64	3710	64	5760	93
59	0	0	2140	37	0	0	8450	136
60	5330	43	8230	71	4510	39	15080	122

TABLE 3.8 SUNSET VALLEY WINTER MONTH DEMANDS (CONTINUED)

CONN. NO.	DECEMBER 1987		JANUARY 1988		FEBRUARY 1988		DECEMBER 1988	
	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD
61	1780	19	7400	85	2200	25	10030	108
62	2770	45	6450	111	8410	145	6550	106
63	0	0	4170	29	3890	27	0	0
64	0	0	4720	81	4530	78	9460	153
65	3830	62	9110	157	8530	147	8130	131
66	8740	94	10800	124	9040	104	17220	185
67	0	0	11380	98	0	0	13280	107
68	4100	33	4930	43	4050	35	3520	28
69	7090	57	6060	52	9150	79	6990	56
70	7880	51	11410	79	4330	30	8550	55
71	2700	44	2660	46	2660	46	4930	80
72	10170	164	6340	109	3810	66	11620	187
73	8180	66	0	0	0	0	4100	33
74	1690	27	0	0	0	0	4460	82
75	0	0	0	0	0	0	17950	290
76	0	0	0	0	0	0	3660	59

TABLE 3.8 SUNSET VALLEY WINTER MONTH DEMANDS (CONTINUED)

CONN. NO.	JANUARY 1989		FEBRUARY 1989	
	GAL USED	GPCD	GAL USED	GPCD
1	7390	60	6770	58
2	9030	97	11530	133
3	2300	37	2460	42
4	18340	197	10170	117
5	8350	135	2760	48
6	3980	64	3780	65
7	7770	63	6000	52
8	6300	102	7170	124
9	15130	122	13400	116
10	5840	94	4350	75
11	9800	79	8860	76
12	5780	62	4520	52
13	7020	113	6290	108
14	2310	37	2970	51
15	3030	98	2160	74
16	6910	74	6670	77
17	11440	185	9520	164
18	5610	90	5210	90
19	7790	63	6840	59
20	13780	445	11080	382
21	10040	162	14640	252
22	17270	279	19980	344
23	8770	141	11140	192
24	5060	41	4720	41
25	8720	94	13600	156
26	12430	100	15650	135
27	5960	48	6310	54
28	950	31	740	26
29	9720	78	7850	68
30	8500	46	8540	49
31	4020	65	3070	53
32	5710	61	5530	64
33	3130	101	2930	101
34	7700	83	12620	145
35	2940	47	2590	45
36	5400	58	5720	66
37	10080	163	12500	216
38	3480	37	7870	90
39	10510	170	23930	413
40	36290	234	25330	175
41	10400	168	8670	149
42	4480	36	4400	38
43	3920	126	10910	376
44	8080	65	8250	71

TABLE 3.8 SUNSET VALLEY WINTER MONTH DEMANDS (CONTINUED)

CONN. NO.	JANUARY 1989		FEBRUARY 1989	
	GAL USED	GPCD	GAL USED	GPCD
45	4080	66	4320	74
46	6380	206	5450	188
47	10860	175	4760	82
48	6440	104	2770	48
49	11540	156	6350	109
50	4120	66	4930	85
51	6490	105	3860	67
52	2010	32	1790	31
53	5640	91	5700	98
54	8310	134	7830	135
55	4890	32	4910	34
56	6290	68	6340	73
57	5760	46	4310	37
58	5730	92	4590	79
59	9130	147	7060	122
60	5260	42	4540	39
61	11510	124	9110	105
62	3540	57	2860	49
63	0	0	4460	31
64	9620	155	0	0
65	4900	79	2600	45
66	10100	109	8740	100
67	9450	76	9040	78
68	6410	52	4040	35
69	7930	64	8150	70
70	6620	43	6340	44
71	5780	93	4330	75
72	3770	61	4700	81
73	6380	51	6160	53
74	4930	80	5560	96
75	15510	250	15230	263
76	3240	52	3110	54

TABLE 3.9 SUNSET VALLEY SUMMER MONTH DEMANDS

CONN. NO.	1988				1989			
	JULY (P = 3.15")		AUG (P = 2.58")		JULY (P = 0.89")		AUG (P = 1.61")	
	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD
1	12,540	101	18,120	146	20,370	164	30,600	247
2	0	0	37,780	406	40,700	438	52,220	562
3	16,280	263	17,540	283	21,390	345	20,210	326
4	24,460	263	32,810	353	65,950	709	49,710	535
5	20,080	324	18,430	297	22,940	370	25,210	407
6	22,650	365	32,790	529	57,590	929	61,130	986
7	34,620	279	45,190	364	34,040	275	30,860	249
8	17,370	280	8,670	140	28,020	452	16,420	265
9	12,350	100	13,640	110	16,540	133	22,160	179
10	6,510	105	9,890	160	11,580	187	11,740	189
11	10,580	85	12,140	98	41,110	332	15,900	128
12	6,390	69	8,520	92	14,370	155	14,820	159
13	5,050	81	15,210	245	26,560	428	14,850	240
14	8,260	133	10,140	164	24,390	393	20,430	330
15	2,240	72	1,760	57	3,200	103	1,670	54
16	7,830	84	10,460	112	18,910	203	18,780	202
17	6,790	110	34,750	560	47,730	770	37,470	604
18	8,970	145	11,490	185	46,190	745	29,650	478
19	21,350	172	35,290	285	73,250	591	87,990	710
20	4,220	136	12,160	392	8,690	280	12,120	391
21	8,040	130	8,230	149	9,050	146	10,440	168
22	31,960	515	44,840	723	61,540	993	63,610	026
23	9,750	157	10,180	164	20,880	337	21,350	344
24	25,770	208	14,590	118	43,510	351	42,760	345
25	11,390	122	41,890	450	44,110	474	53,520	575
26	20,140	162	21,290	172	18,090	146	37,920	306
27	8,860	71	13,590	110	30,730	248	17,260	139
28	0	0	0	0	0	0	0	0

TABLE 3.9 SUNSET VALLEY SUMMER MONTH DEMANDS (CONTINUED)

CONN. NO.	1988				1989			
	JULY (P = 3.15")		AUG (P = 2.58")		JULY (P = 0.89")		AUG (P = 1.61")	
	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD
29	6,720	54	8,410	68	25,760	208	28,000	226
30	7,440	40	9,090	49	22,450	121	23,230	125
31	11,4201	84	14,170	229	17,740	286	14,700	237
32	15,2301	64	15,380	165	27,540	296	32,530	350
33	13,5204	36	18,900	610	31,580	1,019	25,160	812
34	38,2204	11	48,410	521	89,650	964	67,020	721
35	3,320	54	7,950	128	22,690	366	9,750	157
36	5,890	63	8,010	86	11,130	120	9,400	101
37	17,970	290	18,500	298	42,650	688	35,990	580
38	6,030	65	17,850	192	21,330	229	37,070	399
39	26,170	422	38,870	627	126,260	2,036	102,070	1,646
40	10,160	66	10,680	69	0	0	0	0
41	22,800	735	34,390	555	48,600	784	37,690	608
42	15,290	493	4,380	197	30,370	245	33,150	267
43	50,300	1,623	37,040	1,195	69,310	2,236	66,130	2,133
44	8,350	269	8,510	69	7,750	63	8,360	67
45	30,620	988	23,070	372	57,080	921	50,500	815
46	10,970	354	11,320	365	14,710	475	14,750	476
47	14,520	468	26,900	434	24,770	400	31,920	515
48	3,880	125	2,920	47	5,910	95	0	0
49	23,290	751	17,800	287	27,390	442	47,260	762
50	12,970	418	17,820	287	15,270	246	14,810	239
51	11,730	378	9,840	159	8,050	130	5,870	95
52	8,900	287	12,690	205	11,020	178	9,580	155
53	7,240	234	5,670	91	8,370	135	27,730	447
54	9,180	296	9,260	149	8,560	138	8,750	141
55	5,730	185	5,210	34	23,200	150	6,130	40
56	3,530	114	7,100	76	5,140	55	6,640	71

TABLE 3.9 SUNSET VALLEY SUMMER MONTH DEMANDS (CONTINUED)

CONN. NO.	1988				1989			
	JULY (P = 3.15")		AUG (P = 2.58")		JULY (P = 0.89")		AUG (P = 1.61")	
	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD	GAL USED	GPCD
57	13,930	449	11,650	94	26,250	212	21,370	172
58	7,080	228	12,620	204	10,250	165	11,770	190
59	6,060	195	12,200	197	29,830	481	23,920	386
60	16,020	517	24,420	197	32,630	263	55,500	448
61	6,600	213	12,810	138	7,100	76	15,410	166
62	12,570	405	23,350	377	29,220	471	34,270	553
63	3,860	125	11,110	72	9,520	154	7,940	128
64	15,380	496	38,260	617	38,790	626	46,250	746
65	14,760	476	53,390	861	51,020	823	49,990	806
66	28,450	918	27,990	301	49,390	531	43,790	471
67	20,210	652	35,440	286	24,930	201	17,190	139
68	8,260	266	11,400	92	9,050	73	4,540	37
69	14,680	474	13,300	107	17,330	140	25,560	206
70	7,840	253	20,940	135	32,040	207	18,490	119
71	9,330	301	10,170	164	13,220	213	13,920	225
72	16,090	519	26,860	433	27,410	442	24,250	391
73	7,610	245	13,370	108	0	0	0	0
74	18,140	585	21,480	346	13,150	212	21,830	352
75	17,670	570	31,340	505	43,580	703	45,150	728
76	14,310	462	8,330	134	3,650	59	4,250	69

TABLE 3.10 ESTATES WSC AND SUNSET VALLEY WINTER AVERAGE DEMAND, SUMMER AVERAGE DEMAND, AND "EXCESS DEMANDS"

SUNSET VALLEY AVERAGE USERS				ESTATES UTILITIES AVERAGE USERS			
CONN. NO.	WINTER AVERAGE GPCD	SUMMER AVERAGE GPCD	EXCESS DEMANDS	CONN. NO.	WINTER AVERAGE GPCD	SUMMER AVERAGE GPCD	EXCESS DEMANDS
1	61.5	164.5	103.0	1	96.0	174.3	78.3
2	127.8	468.7	340.9	2	68.7	320.5	251.8
3	76.8	304.3	227.5	3	108.0	40.5	-67.5
4	148.8	465.9	316.3	4	42.2	122.0	79.8
5	99.3	349.5	250.3	5	74.5	108.5	34.0
6	134.5	702.3	567.8	6	76.3	267.5	191.2
7	59.8	291.8	232.0	7	117.5	158.0	40.5
8	94.3	284.3	190.0	8	72.0	141.3	69.3
9	104.3	130.5	26.3	9	76.3	56.3	-20.1
10	95.5	160.3	64.8	10	86.0	87.0	1.0
11	79.8	160.8	81.0	11	91.8	102.3	10.4
12	68.3	118.8	50.5	12	89.8	287.5	197.7
13	102.0	248.5	146.5	13	35.0	135.5	100.5
14	60.0	255.0	195.0	14	61.8	77.8	15.9
15	69.3	71.5	2.3	15	93.0	270.3	177.3
16	91.3	150.3	59.0	16	128.3	264.0	135.7
17	124.3	511.0	386.8	17	34.8	151.0	116.2
18	79.3	388.3	309.0	18	83.0	305.3	222.3
19	69.8	439.5	369.8	19	136.8	279.5	142.7
20	172.0	299.8	127.8	20	36.2	41.3	5.1
21	151.3	148.3	-3.0	21	118.7	178.3	59.6
22	270.0	814.3	544.3	22	45.8	143.3	97.4
23	134.3	250.5	116.3	23	36.5	107.8	71.3
24	32.3	255.5	223.3	24	50.7	159.5	108.8
25	93.3	405.3	312.0	25	84.7	87.0	2.3
26	140.0	196.5	56.5	26	72.5	251.3	178.8
27	48.8	142.0	93.3	27	83.5	77.5	-6.0

TABLE 3.10 ESTATES WSC AND SUNSET VALLEY WINTER AVERAGE DEMAND, SUMMER AVERAGE DEMAND, AND "EXCESS DEMANDS" (CONTINUED)

SUNSET VALLEY AVERAGE USERS				ESTATES UTILITIES AVERAGE USERS			
CONN. NO.	WINTER AVERAGE GPCD	SUMMER AVERAGE GPCD	EXCESS DEMANDS	CONN. NO.	WINTER AVERAGE GPCD	SUMMER AVERAGE GPCD	EXCESS DEMANDS
28	123.3	0.0	-123.3	28	68.7	118.0	49.3
29	75.3	139.0	63.8	29	44.8	113.8	68.9
30	55.8	83.8	28.0	30	110.5	167.5	57.0
31	103.3	234.0	130.8	31	136.3	186.8	50.4
32	53.5	243.8	190.3	32	52.0	96.5	44.5
33	92.5	719.3	626.8	33	113.5	225.3	111.8
34	153.3	654.3	501.0	34	71.5	70.3	-1.3
35	49.3	176.3	127.0	35	76.5	107.8	31.3
36	64.8	92.5	27.8	36	79.7	134.5	54.8
37	102.3	464.0	361.8	37	131.8	354.3	222.4
38	52.3	221.3	169.0	38	35.0	78.0	43.0
39	253.8	1182.8	929.0	39	84.3	119.0	34.7
40	90.8	67.5	-23.3	40	77.7	112.3	34.6
41	235.3	670.5	435.3	41	47.7	88.5	40.8
42	41.8	300.5	258.8	42	135.5	452.3	316.8
43	208.3	1796.8	1588.5	43	52.7	100.8	48.1
44	62.0	117.0	55.0	44	40.8	91.8	50.9
45	72.3	774.0	701.8	45	69.3	219.3	148.9
46	197.0	417.5	220.5	46	59.2	322.5	263.3
47	147.8	454.3	306.5	47	87.0	82.0	-5.0
48	51.5	89.0	37.5	48	140.7	351.5	210.8
49	70.0	560.5	490.5	49	51.8	109.3	57.4
50	149.8	297.5	147.8	50	66.5	96.8	30.3
51	92.3	190.5	98.3	51	53.3	95.0	41.7
52	51.3	206.3	155.0	52	35.2	50.0	14.8
53	55.8	226.8	171.0	53	60.5	181.8	121.3
54	170.8	181.0	10.3	54	85.3	249.0	163.7

TABLE 3.10 ESTATES WSC AND SUNSET VALLEY WINTER AVERAGE DEMAND, SUMMER AVERAGE DEMAND, AND "EXCESS DEMANDS" (CONTINUED)

SUNSET VALLEY AVERAGE USERS				ESTATES UTILITIES AVERAGE USERS			
CONN. NO.	WINTER AVERAGE GPCD	SUMMER AVERAGE GPCD	EXCESS DEMANDS	CONN. NO.	WINTER AVERAGE GPCD	SUMMER AVERAGE GPCD	EXCESS DEMANDS
55	25.3	102.3	77.0	55	36.0	84.5	48.5
56	86.8	79.0	-7.8	56	77.8	159.0	81.2
57	59.8	231.8	172.0	57	139.5	305.3	165.8
58	70.8	196.8	126.0	58	39.2	53.8	14.6
59	86.5	314.8	228.3	59	42.0	56.7	14.7
60	68.8	356.3	287.5	60	52.5	144.3	91.8
61	59.3	148.3	89.0	61	30.7	79.0	48.3
62	101.8	451.5	349.8	62	91.2	144.3	53.1
63	28.0	119.8	91.8	63	43.3	87.5	44.2
64	104.0	621.3	517.3	64	162.3	97.0	-65.3
65	124.3	741.5	617.3	65	65.2	79.8	14.6
66	126.8	555.3	428.5	66	53.7	79.8	26.1
67	102.5	319.5	217.0	67	57.2	96.3	39.1
68	34.8	117.0	82.3	68	46.5	47.0	0.5
69	61.0	231.8	170.8	69	69.7	79.8	10.1
70	53.8	178.5	124.8	70	35.2	35.5	0.3
71	54.0	225.8	171.8	71	110.7	131.3	20.6
72	131.5	446.3	314.0	72	83.2	63.3	-19.9
73	49.5	176.5	127.0	73	137.2	240.0	102.8
74	49.5	373.8	324.3	74	102.3	305.3	202.9
75	290.0	626.5	336.5	75	59.7	100.3	40.6
76	59.0	181.0	122.0	76	53.7	73.0	19.3
				77	74.3	71.3	-3.1
				78	66.0	82.5	16.5
				79	165.0	424.5	259.5
				80	49.3	69.7	20.3

Second, the TWDB data shows only one total number of connections for the year. In systems which experienced significant growth in connections during the year, the estimates of gallons per connection would be considerably different from demand per actual connection during part of the year.

Third, an estimate of total population served by each system was provided only for 1988. Further, TWDB employees indicated that they have little confidence in the accuracy of these data. Therefore, any estimates of gallons/capita/day may be approximate at best, even if the first two problems noted above do not result in significant errors.

Tables 3.11 through 3.26 display the data for these systems. Due to the lack of confidence in loss rate and population estimates, only pumpage is reflected for 1983 through 1987. For 1988, both pumpage and estimated demand, plus estimated demand per capita per day are shown. The pumpage-based data provide a general indication of the annual patterns of usage, while the 1988 demand estimates provide an indication of actual levels of usage, subject to the errors noted. Except for the City of Buda, the vast majority of accounts in these systems are single-family residences, so the 1988 demand estimates are presented as residential demand profiles.

It is apparent from these data that demand profiles are similar to those systems for which data was provided by the suppliers.
A representative sample of 5 of these systems are plotted on Seasonal peaking patterns and the relative stability of "base" winter demands within each system. Implications for conservation potential indicated by these data are discussed in Section 3.2 and 3.3.

TABLE 3.11 TWDB DATA FOR ARROYO DOBLE

YEAR OF RECORD = 1983												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	2618	1988	2587	3189	3085	3366	3932	4625	3488	2482	1956	2234
GAL/CON	12773	9698	12621	15555	15046	16421	19180	22560	17015	12106	9539	10897
GAL/DAY/CON	412	346	407	518	485	547	619	728	567	391	318	352

YEAR OF RECORD = 1984												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	2464	2112	2457	4808	5011	4864	6931	6856	4767	2580	2079	2120
GAL/CON	10396	8911	10367	20285	21144	20523	29246	28930	20115	10884	8771	8946
GAL/DAY/CON	335	307	334	676	682	684	943	933	670	351	292	289

YEAR OF RECORD = 1985												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	2421	1973	2735	2679	4213	3996	4719	8963	3267	2797	2390	2736
GAL/CON	9607	7827	10854	10632	16719	15856	18724	35568	12963	11101	9485	10857
GAL/DAY/CON	310	280	350	354	539	529	604	1147	432	358	316	350

TABLE 3.11 TWDB DATA FOR ARROYO DOBLE (CONTINUED)

YEAR OF RECORD = 1986												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	2780	2867	4515	4966	3002	3636	9371	6889	2910	2647	2572	2596
GAL/CON	10529	10858	17102	18810	11370	13773	35497	26095	11023	10028	9743	9833
GAL/DAY/CON	340	338	552	627	367	459	1145	842	367	323	325	317

YEAR OF RECORD = 1987												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	2594	2340	2818	3891	3155	3061	4729	8595	3901	3705	2798	2512
GAL/CON	9606	8666	10438	14411	11685	11339	17515	31833	14448	13721	10354	9305
GAL/DAY CON	310	309	337	480	377	378	565	1027	482	443	345	300

YEAR OF RECORD = 1988												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	2676	2763	3223	4283	4214	5364	4773	5714	5309	4508	3559	3080
GAL/CON	9911	10233	11937	15863	15609	19868	17679	21164	19662	16694	13182	11406
GAL/DAY CON	320	353	385	529	504	662	570	683	655	539	439	368

TABLE 3.12 TWDB DATA FOR AQUATEX

YEAR OF RECORD = 1983 CONNECTIONS = 48												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	333	288	303	361	405	417	484	518	386	342	427	340
GAL/CON	6940	6003	6311	7522	8428	8695	10085	10801	8051	7129	8890	7073
GAL/DAY/CON	224	214	204	251	272	290	325	348	268	230	296	228

YEAR OF RECORD = 1984 CONNECTIONS = 70												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	480	398	392	519	588	463	726	674	660	467	330	358
GAL/CON	6857	5685	5594	7408	8404	6611	10374	9624	9432	6675	4718	5107
GAL/DAY/CON	221	203	180	247	271	220	335	310	314	215	157	165

YEAR OF RECORD = 1985 CONNECTIONS = 70												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	411	450	349	536	476	534	533	729	578	381	432	371
GAL/CON	5872	6435	4491	7651	6794	7626	7615	10421	8259	5442	6044	5304
GAL/DAY/CON	189	230	161	255	219	254	216	336	275	176	201	171

TABLE 3.12 TWDB DATA FOR AQUATEX (CONTINUED)

YEAR OF RECORD = 1986 CONNECTIONS = 70												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
PUMPAGE (1000 GAL)	406	396	443	511	414	370	788	666	484	394	353	354
GAL/CON	5796	5659	6332	7294	5921	5287	11250	9518	6918	5634	5043	5057
GAL/DAY/CON	187	202	204	243	191	176	363	307	231	182	168	163

YEAR OF RECORD = 1987 CONNECTIONS = 76												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
PUMPAGE (1000 GAL)	340	350	350	360	360	360	380	380	370	370	360	340
GAL/CON	4474	4605	4605	4737	4737	4737	5000	5000	4868	4868	4737	4474
GAL/DAY CON	144	164	149	158	153	158	161	161	162	157	158	144

TABLE 3.13 TWDB DATA FOR BEAR CREEK PARK

YEAR OF RECORD = 1983
CONNECTIONS = 74

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	498	459	522	762	693	799	1197	1778	1268	713	621	534
GAL/CON	6732	6201	7050	10304	9370	10802	16173	24023	17135	9641	8393	7219
GAL/DAY/CON	217	221	227	343	302	360	522	775	571	311	280	233

YEAR OF RECORD = 1984
CONNECTIONS = 75

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	374	521	700	900	1180	1213	1319	1404	924	634	582	510
GAL/CON	4981	6940	9333	12000	15733	16173	17587	18716	12315	8454	7769	6805
GAL/DAY/CON	131	239	301	400	508	539	567	604	410	273	259	220

YEAR OF RECORD = 1985
CONNECTIONS = 75

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	491	504	553	644	845	872	957	1618	884	582	512	544
GAL/CON	6459	6637	7270	8468	11120	11471	12598	21289	11626	7657	6732	7152
GAL/DAY/CON	208	237	235	282	359	382	406	687	388	247	224	231

TABLE 3.13 TWDB DATA FOR BEAR CREEK PARK (CONTINUED)

YEAR OF RECORD = 1986 CONNECTIONS = 77												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	591	524	788	933	664	866	2091	1749	762	721	623	589
GAL/CON	7699	6809	10235	12113	8625	11245	27152	22714	9767	9369	8090	7650
GAL/DAY/CON	247	243	330	404	278	375	876	733	326	302	270	247

YEAR OF RECORD = 1987 CONNECTIONS = 79												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	613	531	732	967	831	732	1108	1832	797	837	658	649
GAL/CON	7757	6717	9283	12239	10518	9270	14026	23188	10089	10599	8324	8217
GAL/DAY CON	250	240	299	408	339	309	452	748	336	342	277	265

TABLE 3.14 TWDB DATA FOR CITY OF BUDA

YEAR OF RECORD = 1983 CONNECTIONS = 304												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	2378	2145	2479	2779	3641	3713	4554	4229	4133	3613	2802	4325
GAL/CON	7822	7056	8156	9141	11978	12215	14981	13912	13594	11886	9212	14227
GAL/DAY/CON	252	252	263	305	386	407	483	449	453	383	307	459

YEAR OF RECORD = 1984 CONNECTIONS = 312												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	4107	3472	3572	5440	5627	5848	6064	5365	4399	3219	2820	2798
GAL/CON	13163	11128	11487	17435	18034	18742	19437	17197	14099	10318	9038	8969
GAL/DAY/CON	425	284	369	581	582	625	627	555	470	333	301	289

YEAR OF RECORD = 1985 CONNECTIONS = 420												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	3421	3484	3403	3644	4405	4449	4853	7924	4726	3744	3103	3253
GAL/CON	8145	8295	8103	8677	10489	10594	11554	18867	11253	8915	7388	7746
GAL/DAY/CON	263	296	261	289	338	353	373	609	375	288	246	250

TABLE 3.14 TWDB DATA FOR CITY OF BUDA (CONTINUED)

YEAR OF RECORD = 1986 CONNECTIONS = 561												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
PUMPAGE (1000 GAL)	3577	3468	4109	5713	4102	4303	8824	7435	4226	4071	3408	3914
GAL/CON	6375	6182	7325	10184	7312	7669	15729	13253	7533	7257	6076	6978
GAL/DAY/CON	206	221	236	339	236	256	507	428	251	234	203	225

YEAR OF RECORD = 1987 CONNECTIONS = 545												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
PUMPAGE (1000 GAL)	3522	3249	3975	5762	4800	4678	6317	9006	5232	5239	3881	3788
GAL/CON	6462	5962	7294	10573	8807	8584	11590	16528	9601	9613	7121	6913
GAL/DAY CON	208	213	235	352	284	286	374	533	320	310	237	223

YEAR OF RECORD = 1988 CONNECTIONS = 545												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
PUMPAGE (1000 GAL)	4143	4232	4464	5679	5519	6287	6293	7321	6297	5837	4554	4399
GAL/CON	7588	7750	8176	10401	10108	11515	11525	13406	11534	10891	8340	8058
GAL/DAY CON	245	267	264	347	326	384	372	433	384	345	278	260

TABLE 3.15 TWDB DATA FOR CIMARRON PARK

YEAR OF RECORD = 1983 CONNECTIONS = 155												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	698	786	958	1105	1005	1116	1758	1558	1630	1275	966	1110
GAL/CON	4503	5071	6177	7131	6484	7202	11345	10049	10517	8225	6229	7159
GAL/DAY/CON	145	181	199	238	209	240	366	324	351	265	208	231

YEAR OF RECORD = 1984 CONNECTIONS = 246												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	1164	1107	1402	2539	2833	3306	4476	4537	338	2353	1865	1835
GAL/CON	4732	4500	5698	10320	11516	13440	18196	18444	13571	9566	7582	7460
GAL/DAY/CON	153	155	184	344	371	448	587	595	452	309	253	241

YEAR OF RECORD = 1985 CONNECTIONS = 346												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	1983	1941	2330	2649	3922	4063	4824	8337	5079	3065	2817	2648
GAL/CON	5731	5610	6734	7656	11335	11742	13943	24095	14679	8857	8140	7654
GAL/DAY/CON	185	200	217	255	366	391	450	777	489	286	271	247

TABLE 3.15 TWDB DATA FOR CIMARRON PARK (CONTINUED)

YEAR OF RECORD = 1986
CONNECTIONS = 378

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	3000	3219	5480	6488	4056	4535	13547	12680	4628	4473	3946	3807
GAL/CON	7936	8515	14496	17164	10731	11998	33838	33546	12244	11833	10440	10072
GAL/DAY/CON	256	304	468	572	346	400	1156	1082	408	382	348	325

YEAR OF RECORD = 1987
CONNECTIONS = 393

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	3913	3606	4516	7071	5333	5364	7828	14880	6950	6632	4711	4003
GAL/CON	9955	9175	11490	17993	13570	13648	19919	37862	17684	16878	11986	10185
GAL/DAY CON	321	328	371	600	438	455	643	1221	589	544	400	329

YEAR OF RECORD = 1988
CONNECTIONS = 401

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	4383	4492	5881	7869	7944	10176	9539	11162	9660	8314	5729	5209
GAL/CON	10931	11201	14666	19622	19811	25376	23788	37836	24089	20734	14286	12991
GAL/DAY CON	353	386	473	654	639	846	767	898	803	669	476	419

TABLE 3.16 TWDB DATA FOR COPPER HILLS

YEAR OF RECORD = 1988 CONNECTIONS = 6												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	61	58	67	71	96	130	94	91	82	60	38	59
GAL/CON	10123	9637	11243	11850	15942	21647	15612	15225	13707	10002	6250	9484
GAL/DAY/CON	327	332	363	395	514	722	504	491	457	323	208	318
GPCD	109	111	121	132	171	241	168	164	152	108	69	106

TABLE 3.17 TWDB DATA FOR CREEDMOOR-MAHA WSC

YEAR OF RECORD = 1983
CONNECTIONS = 1100

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	8527	6106	7335	7039	7254	8159	12746	13235	14806	9403	10155	10631
GAL/CON	7751	5551	6668	6399	6594	7418	11587	12033	13460	8548	9231	9665
GAL/DAY/CON	250	198	215	213	213	247	274	388	449	276	308	312

YEAR OF RECORD = 1984
CONNECTIONS = 1200

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	11472	10695	10903	10381	12470	13011	17497	16374	16715	14580	10862	11227
GAL/CON	9560	8912	9088	8651	10392	10843	14581	13645	13930	12150	9051	9356
GAL/DAY/CON	308	307	293	288	335	361	470	440	464	392	302	302

YEAR OF RECORD = 1985
CONNECTIONS = 1300

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	9959	9366	10177	12716	13461	12074	16907	17145	17442	11907	8841	9104
GAL/CON	7661	7205	7829	9781	10354	9288	13005	13188	13417	9157	6801	9003
GAL/DAY/CON	247	257	253	326	334	310	420	425	447	295	227	226

TABLE 3.17 TWDB DATA FOR CREEDMOOR-MAHA WSC (CONTINUED)

YEAR OF RECORD = 1986
CONNECTIONS = 1400

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	14546	9294	10966	12096	9106	11945	18381	14649	10603	10807	9862	10596
GAL/CON	10390	6638	7833	8640	6504	8532	13129	10463	7574	7720	7044	7568
GAL/DAY/CON	335	237	253	288	210	284	424	338	252	249	235	244

YEAR OF RECORD = 1987
CONNECTIONS = 1319

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	8290	10317	11513	8494	11200	19273	20129	16629	13424	14404	14135	12978
GAL/CON	6285	7822	8728	6439	8491	14612	15261	12607	10178	10921	10717	9840
GAL/DAY CON	203	279	282	215	274	487	492	407	339	352	357	317

YEAR OF RECORD = 1988
CONNECTIONS = 1300

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	12631	12579	14589	16317	19663	15267	17934	17576	18152	16990	15262	12189
GAL/CON	9716	9676	11222	12551	15125	11744	13795	13520	13963	13069	11740	9376
GAL/DAY CON	313	334	362	418	488	391	445	436	465	422	391	302

TABLE 3.18 TWDB DATA FOR DELANNA HILLS

YEAR OF RECORD = 1988 CONNECTIONS = 25												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	135	215	317	257	420	359	530	571	641	376	398	215
GAL/CON	5393	296	12699	10263	16802	14354	21182	22859	25634	15027	15932	8587
GAL/DAY/CON	174	148	410	342	542	478	683	737	854	485	531	277
GPCD	87	111	205	171	271	239	342	369	427	242	266	139

TABLE 3.19 TWDB DATA FOR G & J WATER

YEAR OF RECORD = 1988 CONNECTIONS = 16												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	119	119	136	204	272	272	272	272	272	204	136	119
GAL/CON	7438	7438	8500	12750	17000	17000	17000	17000	17000	12750	8500	7468
GAL/DAY/CON	240	256	274	425	548	567	548	548	567	411	283	240
GPCD	85	91	97	151	195	201	195	195	201	146	101	85

TABLE 3.20 TWDB DATA FOR LEISUREWOODS

YEAR OF RECORD = 1983
CONNECTIONS = 173

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	1047	982	1043	1821	2412	1960	3212	3683	1999	2303	1992	1373
GAL/CON	6052	5676	6029	10526	13942	11445	18566	21289	11555	13312	11514	7936
GAL/DAY/CON	195	203	194	351	450	382	599	687	385	429	384	256

YEAR OF RECORD = 1984
CONNECTIONS = 289

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	1908	1809	1981	3960	6583	5262	9515	6118	9066	4745	3279	2196
GAL/CON	6602	6260	6855	13702	22779	18208	32924	21170	31370	16419	11346	7599
GAL/DAY/CON	213	216	221	457	735	607	1062	683	1046	530	378	245

YEAR OF RECORD = 1985
CONNECTIONS = 363

MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	2369	2991	2476	2660	4777	7709	6069	13106	10042	4505	2670	2854
GAL/CON	6526	8240	6821	7328	13160	21237	16719	36105	27664	12410	7355	7862
GAL/DAY/CON	211	294	220	244	425	708	539	1165	922	400	245	254

TABLE 3.20 TWDB DATA FOR LEISUREWOODS (CONTINUED)

YEAR OF RECORD = 1986 CONNECTIONS = 377												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	2848	2996	3590	6430	5420	4356	12035	16913	5577	3594	3165	3163
GAL/CON	7555	7947	9523	17055	14377	11553	31922	44863	14792	9533	8395	8390
GAL/DAY/CON	244	284	307	568	464	385	1030	1447	493	308	280	271

YEAR OF RECORD = 1987 CONNECTIONS = 391												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	2922	3205	3118	5374	6268	3795	7232	14079	9995	5954	4875	3104
GAL/CON	7474	8198	7974	12882	16030	9706	18496	36008	23563	15229	12469	7940
GAL/DAY CON	241	293	257	429	517	324	597	1162	852	491	416	256

YEAR OF RECORD = 1988 CONNECTIONS = 397												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	3376	3866	4015	5619	7907	9600	9030	9095	10251	5972	5843	4088
GAL/CON	8504	9737	10113	14154	19916	24181	22745	22910	25821	15042	14717	10248
GAL/DAY CON	274	336	326	472	642	806	734	739	861	485	491	331
GPCD	78	96	93	135	183	230	210	211	246	139	140	94

TABLE 3.21 TWDB DATA FOR MOUNTAIN CITY

YEAR OF RECORD = 1983 CONNECTIONS = 73												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	431	441	464	717	795	937	1201	1623	1143	99	1174	617
GAL/CON	5901	6044	6362	9822	10886	12835	16447	22230	15655	1389	16084	8460
GAL/DAY/CON	190	216	205	327	351	428	531	717	522	435	536	273

YEAR OF RECORD = 1984 CONNECTIONS = 98												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	756	823	1415	2343	2071	2180	2594	2690	2247	1081	866	848
GAL/CON	7142	8398	14439	23908	21133	22245	26468	27449	22929	1102	9041	8653
GAL/DAY/CON	249	290	466	797	682	741	854	885	764	358	301	279

YEAR OF RECORD = 1985 CONNECTIONS = 120												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	917	814	1053	1230	2324	2557	2903	4558	1864	1100	1039	952
GAL/CON	7642	8783	8775	10250	19367	18808	24192	37983	15533	875	8658	7933
GAL/DAY/CON	247	242	283	342	625	627	780	1225	518	312	289	256

TABLE 3.21 TWDB DATA FOR MOUNTAIN CITY (CONTINUED)

YEAR OF RECORD = 1986 CONNECTIONS = 130												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
PUMPAGE (1000 GAL)	997	1060	1999	2486	1273	1812	5614	4550	1372	1270	1309	1240
GAL/CON	7669	8154	15377	19123	9792	13938	43185	35000	10554	977	10069	9538
GAL/DAY/CON	247	291	496	637	316	465	1393	1129	352	315	336	308

YEAR OF RECORD = 1987 CONNECTIONS = 138												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
PUMPAGE (1000 GAL)	1362	1269	1494	2871	2127	1862	3465	5199	1799	2160	1373	1150
GAL/CON	9870	9196	10826	20804	15413	13493	24891	37674	13036	1503	9949	8333
GAL/DAY CON	318	318	349	693	497	450	803	1215	435	507	332	269

YEAR OF RECORD = 1988 CONNECTIONS = 138												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
PUMPAGE (1000 GAL)	1217	1336	1721	2622	2159	3479	3649	3662	2641	2550	1854	1414
GAL/CON	8819	9681	12471	19000	15643	25210	26445	26533	19131	1079	13436	10243
GAL/DAY CON	284	334	402	633	505	840	853	856	638	596	448	330
GPCD	91	107	129	203	162	270	274	275	205	191	144	106

TABLE 3.22 TWDB DATA FOR MYSTIC OAKS

YEAR OF RECORD = 1988 CONNECTIONS = 2.8												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	390	450	466	698	638	896	684	892	760	663	422	430
CONNECTIONS	39	39	39	39	39	39	39	39	39	39	39	39
GAL/CON	10000	11547	11938	17895	16354	22966	17535	22878	19486	17001	10822	11038
GAL/DAY/CON	323	398	385	597	528	766	566	738	650	548	361	356
GPCD	114	141	137	211	187	271	201	262	230	194	128	126

TABLE 3.23 TWDB DATA FOR ONION CREEK MEADOWS

YEAR OF RECORD = 1983 CONNECTIONS = 100												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	877	944	1077	1270	1635	2007	2367	2720	1985	1731	1064	1054
GAL/CON	8774	9437	10772	12698	16345	20068	23672	27197	19854	17314	10642	10538
GAL/DAY/CON	283	337	347	423	527	669	764	877	662	559	355	340

YEAR OF RECORD = 1984 CONNECTIONS = 209												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	956	1047	1500	2000	2343	2160	2815	2661	2280	1853	1235	1251
GAL/CON	4572	5009	7177	9569	11210	10335	13469	12730	10911	8864	5907	5986
GAL/DAY/CON	147	173	232	319	362	345	434	411	364	286	197	193

YEAR OF RECORD = 1985 CONNECTIONS = 212												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	1439	1378	1514	1633	2309	2323	2720	4689	2591	1595	1444	1524
GAL/CON	6787	6501	7143	7703	10890	10955	12832	22119	12221	7524	8809	7190
GAL/DAY/CON	219	232	230	357	351	365	414	714	407	243	227	232

TABLE 3.23 TWDB DATA FOR ONION CREEK MEADOWS (CONTINUED)

YEAR OF RECORD = 1986 CONNECTIONS = 212												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	1432	1634	2514	2031	1696	2057	5177	4239	1855	1919	1656	1510
GAL/CON	6756	7709	11858	9578	8000	9705	24422	19994	8748	9053	7813	7120
GAL/DAY/CON	218	275	383	319	258	324	788	645	292	292	260	230

YEAR OF RECORD = 1987 CONNECTIONS = 213												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	1537	1454	1822	2521	2281	1951	3096	5700	2784	2678	2328	1562
GAL/CON	7217	6824	8555	11834	10710	9159	14534	26760	13071	11164	10929	7335
GAL/DAY CON	233	244	276	394	345	305	469	863	436	360	364	237

YEAR OF RECORD = 1988 CONNECTIONS = 208												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	1526	1717	1841	2403	2444	2974	2419	2979	2654	2389	1711	1713
GAL/CON	7337	8256	8853	11555	11749	14298	11630	14324	12759	11487	8226	8235
GAL/DAY CON	237	285	286	385	379	477	375	462	425	371	274	266
GPCD	70	85	85	114	113	142	111	137	126	110	81	79

TABLE 3.24 TWDB DATA FOR PLUM CREEK

YEAR OF RECORD = 1984 CONNECTIONS = 319												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	3600	3409	2396	2903	4786	4593	5247	6490	4346	4684	3753	4178
CONNECTIONS	619	619	619	619	619	619	619	619	619	619	619	619
GAL/CON	5816	5507	3871	4690	732	7420	8477	10485	7021	7567	6063	6750
GAL/DAY/CON	188	190	125	156	249	247	273	338	234	244	202	218

YEAR OF RECORD = 1985 CONNECTIONS = 921												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	4256	3898	3449	4796	5211	3215	5858	8422	6570	6100	4145	5518
CONNECTIONS	921	921	921	921	921	921	921	921	921	921	921	921
GAL/CON	4621	4232	3745	5207	5658	5662	6360	9144	7134	6623	4501	5991
GAL/DAY/CON	149	151	121	174	183	189	205	295	238	214	150	193

YEAR OF RECORD = 1986 CONNECTIONS = 945												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	5013	3893	5854	7117	4645	4076	11180	10064	6852	3413	6039	6868
CONNECTIONS	945	945	945	945	945	945	945	945	945	945	945	945
GAL/CON	5305	4120	6195	7531	4915	4313	11831	10650	7251	6786	6390	7268
GAL/DAY/CON	171	147	200	251	159	144	382	344	242	219	213	234

TABLE 3.24 TWDB DATA FOR PLUM CREEK (CONTINUED)

YEAR OF RECORD = 1987 CONNECTIONS = 945												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	6381	4947	5915	7805	7742	6536	9072	11369	9213	8260	7314	6944
CONNECTIONS	978	978	978	978	978	978	978	978	978	978	978	978
GAL/CON	6525	5058	6048	7981	7916	6683	9276	11625	9420	8446	7479	7100
GAL/DAY CON	210	181	195	266	255	223	299	375	314	272	249	229

YEAR OF RECORD = 1988 CONNECTIONS = 3.2												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	6276	5813	5361	6627	6800	8188	7671	8661	7954	6483	6358	5962
CONNECTIONS	991	991	991	991	991	991	991	991	991	991	991	991
GAL/CON	6333	5866	5410	6687	6882	8242	7741	8740	8026	6542	6416	6016
GAL/DAY CON	204	202	175	223	221	275	250	282	268	211	214	94
GPCD	63	63	54	69	69	85	77	87	83	65	66	60

TABLE 3.25 TWDB DATA FOR SAN LEANNA

YEAR OF RECORD = 1986 CONNECTIONS = 127												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	1336	1111	1929	2389	1198	1473	4559	4254	1385	1191	1111	1145
GAL/CON	10521	8748	15190	18812	9432	11599	35894	33497	10907	9380	8744	9018
GAL/DAY/CON	339	312	490	627	304	387	1158	1061	364	303	291	291

YEAR OF RECORD = 1987 CONNECTIONS = 127												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	1206	1125	1421	2164	1340	13346	1840	4079	1441	1728	1211	1017
GAL/CON	9492	8860	11193	17040	11023	10502	14486	32119	11349	13606	9538	8006
GAL/DAY/CON	306	316	361	566	356	350	467	1036	378	439	318	258

YEAR OF RECORD = 1988 CONNECTIONS = 129												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	1114	1043	1479	2001	2034	2657	2357	2784	2714	2411	1722	1425
GAL/CON	8634	8086	11468	15512	15771	20597	18268	21583	21037	18892	13352	11043
GAL/DAY/CON	279	279	370	517	509	687	589	696	701	603	445	356
GPCD	93	93	123	172	170	229	196	232	234	201	148	119

TABLE 3.26 TWDB DATA FOR SLAUGHTER CREEK ACRES

YEAR OF RECORD = 1983 CONNECTIONS = 70												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	472	438	520	668	804	698	814	777	623	497	445	576
GAL/CON	6737	6255	7432	9546	11490	9977	11635	11102	8904	7107	6353	8222
GAL/DAY/CON	217	223	240	318	371	333	375	358	297	229	212	265

YEAR OF RECORD = 1984 CONNECTIONS = 71												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	581	480	514	847	1190	1127	1243	1066	667	601	468	435
GAL/CON	6761	7233	11932	16764	15875	17510	15013	9939	9399	8466	6605	6130
GAL/DAY/CON	264	233	233	396	541	529	565	484	313	273	220	194

YEAR OF RECORD = 1985 CONNECTIONS = 70												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	492	436	618	445	577	836	702	1092	832	423	445	448
GAL/CON	7033	6232	8832	6358	8239	11950	10029	15605	11886	6050	6363	6400
GAL/DAY/CON	227	223	285	212	266	398	324	503	396	195	212	207

TABLE 3.26 TWDB DATA FOR SLAUGHTER CREEK ACRES (CONTINUED)

YEAR OF RECORD = 1986 CONNECTIONS = 71												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	448	552	1535	598	686	609	600	1059	1147	1194	956	510
GAL/CON	6315	7774	21623	8416	9663	8575	8440	14916	16154	16819	13472	7188
GAL/DAY/CON	204	278	698	281	312	286	273	481	538	543	449	232

YEAR OF RECORD = 1987 CONNECTIONS = 75												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	639	549	664	872	748	732	858	1474	792	732	590	623
GAL/CON	8516	7317	8853	11627	9968	9765	11435	19656	10559	9761	7882	8301
GAL/DAY CON	275	261	288	388	322	326	369	634	352	315	262	268

YEAR OF RECORD = 1988 CONNECTIONS = 72												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	694	619	678	826	986	1094	948	1217	1019	921	816	761
GAL/CON	9642	8503	9421	11472	13690	15196	13161	16909	14147	12794	11338	10569
GAL/DAY CON	311	296	304	382	442	507	425	545	472	413	378	341

3.1.1.3 Commercial Demands

Limited data describing the level and nature of demands among commercial enterprises were obtained for this study. Only Goforth WSC information provides data for this category specifically. Their data for 1987 and 1988 is displayed in Table 3.27. The nature of the commercial operations served by Goforth WSC varies greatly.

Two general observations on commercial demands are offered. First, commercial demand is expected to be somewhat more stable through the year than residential demand, unless of course the commercial enterprise engages in a great deal of landscape irrigation. Second, conservation opportunities in commercial development are likely to be the same as those which could be applied to residential interior demands and to domestic type demands for industrial users.

3.1.2 INDUSTRIAL, INSTITUTIONAL AND OTHER DEMANDS

Nine industrial and institutional water users were interviewed to determine the nature of their demands. Since the activities of these users vary widely, they are discussed individually below. These discussions should provide some insight into the general nature of water demand among this class of user. It is readily apparent, however, that industrial water demand can be quite specific. That issue is developed further in Section 3.4, where opportunities for conservation in this demand sector are reviewed.

TABLE 3.27 GOFORTH WATER SUPPLY CO. COMMERCIAL SALES

YEAR OF RECORD = 1987												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
COMMERCIAL SALES (1000 GAL)	304	307	205	246	301	227	290	339	363	272	261	372
GPD/CON	265	297	179	222	262	204	253	296	327	237	236	324

YEAR OF RECORD = 1988												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
COMMERCIAL SALES (1000 GAL)	221	208	177	281	293	291	335	448	318	488	229	239
GPD/CON	193	194	155	253	256	262	292	391	286	425	206	208

3.1.2.1 Chatleff Controls

Chatleff Controls manufactures components used in the air conditioning industry. The company uses water for landscape irrigation, for make-up water in process cooling systems, and for domestic supply (toilets, showers and lavatories). Data provided by Chatleff Controls showed usage in April, May and June of 1988 to be just over 50,000 gallons per month, while for July it was just over 80,000 gallons.

Chatleff Controls reported that the cooling water make-up demands averaged only about 120-600 gallons per month. Irrigation usage was reported to range from zero to about 10,000 gallons per month. This indicates that domestic demands predominate their water use. It appears that at least 40,000 gallons per month is demanded for these uses.

3.1.2.2 Tilson Custom Homes

Tilson Custom Homes uses water to irrigate about 6 acres of landscaped area and for domestic supply. The company was not able to offer any data on actual usage through the end of the 1988-89 water year. The company has a permit for 2 million gallons of pumpage annually.

3.1.2.3 Randolph Austin Company

Randolph Austin Co. uses water for process cooling, boiler make-up, pressure vessel make-up, washing of parts, and for domestic sanitation supply. Some minor irrigation was reported during the hotter months. In October of 1988, a recirculation system for the process cooling water was installed. Prior to that time, records provided by the company indicate that monthly demand was over

45,000 gallons. Since then, it has averaged about 30,000 gallons per month.

Based upon on-site investigation and interviews with company personnel, it appears that the vast majority of current demand is for domestic supply. About 5,000 gallons per month is used for pressure vessel make-up, while the other process and wash water demands are believed to be very small. It is estimated that an average of 23,000 gallons per month are used for domestic purposes.

3.1.2.4 Onion Creek Memorial Park

Onion Creek Memorial Park's primary water use is to irrigate about 10 acres of turf landscape. Through the end of the 1988-89 water year, no information on actual use was reported. Annual permitted pumpage is 1.4 million gallons.

3.1.2.5 Texas Lehigh Cement Company

Texas Lehigh Cement Co. uses water for industrial, domestic and agricultural uses. At its main plant, the following demands were reported:

1. Once through cooling water for the product analyzer probe, with an estimated demand of 7.9 million gallons per year;
2. A recirculating cooling system. A new chemical treatment system had just been implemented at the time of the interview, expected to reduce make-up water demand to about 23 million gallons per year;
3. Domestic supply for sanitation purposes, with daily flow reported at about 2,000 to 2,500 gallons per day (0.7 to 0.9 million gallons per year). The wastewater treatment plant is permitted for a maximum flow of 3,000 gallons per day;

4. A Lurgi spray system to cool flue gases, reported to be an 88 gpm system. No estimate of how much time it runs was available, so total demand cannot be estimated;
5. A clinker dump spray system, an emergency spray system for the conveyor system, and washdown of equipment. No estimate of usage for these demands was available; and
6. Landscape irrigation of a very limited area. No estimate of the amount of water used for this was provided.

According to BS/EACD records for the 1988-89 water year, total usage at the main plant ranged from about 4 million to 10 million gallons per month, having averaged 5.4 million gallons for the year. Records provided by Texas Lehigh showed demand for July 1989 to be 5.8 million gallons, with August demand projected at 5.4 million gallons. The company is permitted for an annual pumpage of 73 million gallons at the main plant.

At the main office complex, water is used for irrigation and for domestic supply. BS/EACD records showed that approximately 1,000 gallons per working day was used in water year 1988-89. In the summer, this climbed to about 1,000 gallons per calendar day, presumably due to irrigation demands. The well for the main office complex is permitted for an annual pumpage of 365,000 gallons.

A third well permitted by Texas Lehigh is used for stock watering. Permitted pumpage is 73,000 gallons per year. The reported use for the first 9 months of water year 1988-89 totalled 87,000 gallons.

3.1.2.6 Onion Creek Country Club

Edwards water is used by Onion Creek Country Club as a supplemental supply for golf course and grounds irrigation. Onion Creek is permitted for an annual pumpage of 3.9 million gallons. No information on actual usage was made available.

The major source of irrigation water supply at present is effluent from the development's wastewater treatment plant. At its full permitted capacity of 345,000 gallons per day, effluent contribution to irrigation supply would be almost 126 million gallons per year. This indicates that Edwards water is presently used for only a small percentage of the total irrigation demand. However, Onion Creek's management company is considering abandoning their treatment plant when a City of Austin sewer interceptor main is constructed, perhaps within the next 5 years. If this occurs, demand for Edwards water by Onion Creek may increase drastically.

3.1.2.7 Comal Tackle Company

Comal Tackle Co. manufactures fishing tackle. Water is used in a once through cooling process and for domestic supply. The company indicated that the vast majority of use is for cooling water. Comal Tackle is permitted for an annual pumpage of 5 million gallons. In water year 1988-89, actual reported usage was just over 5.5 million gallons. Part of this time, two shifts were being run at the plant. The company reported that they expect to run only one shift for the foreseeable future, with an average demand being about 15,000 gallons per day. This would drop annual demand to around 3 million gallons.

3.1.2.8 Centex Materials

Edwards water is used by Centex Materials for gravel washing. Total pumpage in water year 1988-89 was over 376 million gallons. The company has instituted a wash water recycling system, and demand is expected to greatly decline. Permitted pumpage was reduced to 11 million for the current water year.

3.1.2.9 Hays Consolidated Independent School District

Hays CISD uses water to meet the following demands: toilets, lavatories, showers, irrigation, cooling towers, kitchen operations, and drinking fountains. During water year 1988-89, reported pumpage at the high school was 8.6 million gallons. Permitted pumpage is 12 million gallons. At Dahlstrom Middle School, where permitted pumpage is 2.51 million gallons, reported pumpage for water year 1988-89 was over 2.5 million gallons.

3.1.3 UNACCOUNTED-FOR WATER

The difference between apparent production and apparent sales is unaccounted-for water. The term "apparent" is used because some of these "losses" may be due to inaccurate meters. Other factors also affect this measure of loss rate (see Section 3.5).

Sufficient information to calculate loss rate profiles (see Tables 3.28 through 3.31) was provided by Goforth WSC, Ridgewood Village WC, Sunset Valley, and Creedmoor-Maha WSC for some or all of the years 1983 through 1988. It is probable that the real losses are due to chronic leaks and breaks. Along with the probable randomness of flushing, fire fighting and other "beneficial" losses, this would account for the large variability in loss rates.

3.1.4 EXISTING CONSERVATION PLANS

According to information made available to this study, no water suppliers have formulated detailed plans dealing with "real" conservation, as that was defined in Section 3.0.1. Except for some specific loss control efforts identified by Goforth WSC and Creedmoor-Maha WSC, all formal "conservation" plans entail only curtailment-type drought contingency measures, such as rationing and restrictions on the timing of lawn watering.

TABLE 3.28 GOFORTH WATER SUPPLY CO. LOSS RATE PROFILE

YEAR OF RECORD = 1983												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	4221	4275	4364	5203	5795	6449	6610	7308	7308	5926	5511	6523
TOTAL SALES ($1000)	3061	3123	2738	3167	5020	4813	5341	5670	6665	5721	4263	4141
LOSSES (1000 GAL)	1160	1152	1626	2036	775	1636	1269	1639	643	205	1247	2382
% LOST	27.5	26.9	37.3	39.1	13.4	25.4	19.2	22.4	8.8	3.5	22.6	36.5
YEAR OF RECORD = 1984												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	6369	5397	6316	9105	9893	10382	10461	10931	9136	8501	8295	6899
TOTAL SALES ($1000)	5628	4192	4119	4484	6946	6923	7911	7831	8819	8213	6468	6209
LOSSES (1000 GAL)	742	1205	2197	4621	2947	3459	2550	3100	317	288	1827	690
% LOST	11.6	22.3	34.8	50.7	29.8	33.3	24.4	28.4	3.5	3.4	22.0	10.0

TABLE 3.28 GOFORTH WATER SUPPLY CO. LOSS RATE PROFILE (CONTINUED)

YEAR OF RECORD = 1985												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	8128	6538	6017	7016	7781	8952	10476	14190	10247	8060	7727	7573
TOTAL SALES ($1000)	5356	6566	5084	5325	6423	7716	7526	13215	11232	7149	5818	5859
LOSSES (1000 GAL)	2772	-28	933	1691	1358	1236	2950	975	-985	911	1909	1714
% LOST	34.1	-0.4	15.5	24.1	17.5	13.8	28.2	6.9	-9.6	11.3	24.7	22.6

YEAR OF RECORD = 1986												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	7478	7621	9091	9552	9920	9226	16108	16659	10496	9207	8973	9588
TOTAL SALES ($1000)	5742	5878	5537	7554	7683	7325	10926	14596	8674	6946	6451	7358
LOSSES (1000 GAL)	1736	1743	3554	1998	2237	1901	5182	2063	1822	2261	2522	2230
% LOST	23.2	22.9	39.1	20.9	22.5	20.6	32.2	12.4	17.4	24.6	28.1	23.3

TABLE 3.28 GOFORTH WATER SUPPLY CO. LOSS RATE PROFILE (CONTINUED)

YEAR OF RECORD = 1987												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	10078	7631	9772	10719	11117	9055	13538	16178	11420	12085	10391	11448
TOTAL SALES ($1000)	7449	5921	5780	7914	10080	6566	9437	13315	10751	8991	8416	6626
LOSSES (1000 GAL)	2629	1710	3992	2805	1037	2489	4101	2863	669	3094	1975	4822
% LOST	26.1	22.4	40.8	26.2	9.3	27.5	30.3	17.7	5.9	25.6	19.0	42.1

YEAR OF RECORD = 1988												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	9973	8453	9135	9334	9578	11744	12050	14358	12674	11763	9510	9704
TOTAL SALES ($1000)	7200	6698	6630	8095	9215	9298	11346	11540	13185	10719	8463	8153
LOSSES (1000 GAL)	2773	1755	2505	1239	363	2446	704	2818	-511	1044	1047	1551
% LOST	27.8	20.8	27.4	13.3	3.8	20.8	5.8	19.6	-4.0	8.9	11.0	16.0

TABLE 3.29 RIDGEWOOD VILLAGE LOSS RATE PROFILE

YEAR OF RECORD = 1983												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	628	536	681	926	1008	835	N/A	N/A	N/A	764	825	926
TOTAL SALES ($1000)	519	464	542	786	879	711	1146	1268	1103	640	740	717
LOSSES (1000 GAL)	109	72	139	140	129	124	0	0	0	124	85	209
% LOST	17.3	13.4	20.4	15.1	12.8	14.9	0.0	0.0	0.0	16.3	10.3	22.5

YEAR OF RECORD = 1984												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	753	952	707	N/A	N/A	N/A	N/A	1884	1447	992	952	725
TOTAL SALES ($1000)	650	911	635	1248	1650	1573	2002	1697	1119	812	827	597
LOSSES (1000 GAL)	103	41	72	0	0	0	0	187	328	180	125	128
% LOST	13.6	4.3	10.1	0.0	0.0	0.0	0.0	9.9	22.7	18.2	13.1	17.7

TABLE 3.29 RIDGEWOOD VILLAGE LOSS RATE PROFILE (CONTINUED)

YEAR OF RECORD = 1985												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
PUMPAGE (1000 GAL)	694	967	779	1047	1345	1342	N/A	N/A	N/A	N/A	691	729
TOTAL SALES ($1000)	542	686	643	779	1133	1211	1494	2139	1133	825	616	615
LOSSES (1000 GAL)	152	281	136	268	212	131	0	0	0	0	75	114
% LOST	21.9	29.1	17.4	25.6	15.8	9.8	0.0	0.0	0.0	0.0	10.9	15.6

YEAR OF RECORD = 1986												
MONTH	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUNE**	**JULY**	**AUG**	**SEPT**	**OCT**	**NOV**	**DEC**
PUMPAGE (1000 GAL)	N/A	N/A	N/A	N/A	642	1170	2682	2027	1139	941	913	738
TOTAL SALES ($1000)	558	589	875	1238	466	871	2221	1599	839	676	605	472
LOSSES (1000 GAL)	0	0	0	0	176	299	461	428	300	265	308	266
% LOST	0.0	0.0	0.0	0.0	27.4	25.6	17.2	21.1	26.4	28.2	33.8	36.0

TABLE 3.29 RIDGEWOOD VILLAGE LOSS RATE PROFILE (CONTINUED)

YEAR OF RECORD = 1987												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	831	826	991	1171	1259	943	1097	2174	1348	1233	986	691
TOTAL SALES ($1000)	521	528	654	861	897	718	848	1809	1071	983	785	518
LOSSES (1000 GAL)	310	298	337	310	362	225	249	365	277	250	201	173
% LOST	37.3	36.1	34.0	26.5	28.7	23.8	22.7	16.8	20.6	20.3	20.3	25.0

YEAR OF RECORD = 1988												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	727	1001	885	1071	1479	1603	1495	1940	1678	1391	1097	789
TOTAL SALES ($1000)	546	798	687	830	1125	1244	1105	1525	1441	1165	916	582
LOSSES (1000 GAL)	181	203	198	241	354	359	390	315	237	226	181	207
% LOST	24.9	20.3	22.4	22.5	24.0	22.4	26.1	16.2	14.1	16.3	16.5	26.2

TABLE 3.30 SUNSET VALLEY LOSS RATE PROFILE

YEAR OF RECORD = 1987												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	528	513	596	1094	794	843	1110	2105	824	977	619	513
TOTAL SALES ($1000)	431	424	495	1015	651	642	1105	1902	749	784	573	407
LOSSES (1000 GAL)	99	89	101	79	143	201	5	203	75	193	46	106
% LOST	18.3	17.3	17.0	7.3	18.0	23.8	0.5	9.7	9.1	19.7	7.4	20.6

YEAR OF RECORD = 1988												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	576	608	781	946	1021	1464	1250	1594	1859	1459	794	760
TOTAL SALES ($1000)	430	579	630	854	985	1188	1039	1434	1586	1205	747	595
LOSSES (1000 GAL)	146	29	151	92	36	276	211	160	273	254	47	165
% LOST	25.3	4.8	19.4	9.8	3.5	18.8	16.9	10.0	14.7	17.4	5.9	21.7

TABLE 3.31 CREEDMOOR-MAHA LOSS RATE PROFILE

YEAR OF RECORD = 1983												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	6122	5546	7146	6834	7062	7754	10996	11426	12756	7603	8353	8631
PURCHASED ($1000)	2405	560	180	205	192	405	1750	1810	2050	1800	1802	2000
TOTAL PROD. (1000 GAL)	8527	6106	7326	7039	7254	8159	12746	13236	14806	9403	10155	10631
TOTAL SALES (1000 GAL)	4306	4493	4185	4563	5508	5751	6767	7037	7123	6868	6564	6539
LOSSES (1000 GAL)	4221	1613	3141	2476	1746	2409	5979	6199	7683	2535	3591	4092
% LOST	49.5	26.4	42.3	35.2	24.1	29.5	46.9	46.8	51.9	27.0	35.4	38.5

YEAR OF RECORD = 1984												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	9972	9605	10603	10291	12340	12001	16207	15262	15630	13479	9882	10202
PURCHASED ($1000)	1500	1090	300	90	130	1010	1290	1112	1085	1101	980	1025
TOTAL PROD. (1000 GAL)	11472	10695	10903	10381	12470	13011	17497	16374	16715	14580	10862	11227
TOTAL SALES (1000 GAL)	5812	6250	5739	5914	9443	8726	7340	9103	11678	7780	6162	6285
LOSSES (1000 GAL)	5660	4445	5164	4467	3028	4285	10157	7270	5038	6801	4700	4942
% LOST	44.2	41.6	47.4	43.0	24.3	32.9	58.1	44.4	30.1	46.6	43.3	44.0

TABLE 3.31 CREEDMOOR-MAHA LOSS RATE PROFILE (CONTINUED)

YEAR OF RECORD = 1985												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	9948	8986	10001	12154	13121	12001	15586	17079	17000	11607	8636	8924
PURCHASED ($1000)	10	380	177	562	340	73	1322	66	442	300	205	180
TOTAL PROD. (1000 GAL)	9959	9366	10177	12716	13461	12074	16907	17145	17442	11907	8841	9104
TOTAL SALES (1000 GAL)	6231	10367	5536	7922	7399	7426	7340	8708	12458	7644	8640	8100
LOSSES (1000 GAL)	3728	-1001	4641	4794	6062	4649	9567	8437	4984	4264	201	1004
% LOST	37.4	-10.7	45.6	37.7	45.0	38.5	56.6	49.2	28.6	35.8	2.3	11.0

YEAR OF RECORD = 1986												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	14049	8903	10440	11863	8898	11581	17646	14258	10481	10673	9265	10515
PURCHASED ($1000)	497	391	526	233	208	363	735	290	123	135	597	81
TOTAL PROD. (1000 GAL)	14546	9294	10966	12096	9106	11945	18381	14547	10603	10807	9862	10596
TOTAL SALES (1000 GAL)	7627	6308	6615	6895	9365	7092	8143	14068	10125	7695	6413	6656
LOSSES (1000 GAL)	6919	2986	4351	5201	-259	4852	10237	480	478	3113	3449	3940
% LOST	47.6	32.1	39.7	43.0	-2.8	40.6	55.7	3.3	4.5	28.8	35.0	37.1

TABLE 3.31 CREEDMOOR-MAHA LOSS RATE PROFILE (CONTINUED)

YEAR OF RECORD = 1987												
MONTH	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
PUMPAGE (1000 GAL)	8079	10057	10830	8468	9958	18054	17105	16369	13031	14110	13826	12691
PURCHASED ($1000)	211	260	683	26	1242	1218	3024	2185	393	295	309	287
TOTAL PROD. (1000 GAL)	8290	10317	11513	8494	11200	19273	20129	18554	13424	14404	14135	12978
TOTAL SALES (1000 GAL)	8198	7638	5887	6846	10138	7500	8713	9382	11876	8200	9800	10658
LOSSES (1000 GAL)	92	2679	5625	1648	1062	11773	11417	9172	1548	6204	4335	2321
% LOST	1.1	26.0	48.9	19.4	9.5	61.1	56.7	49.4	11.5	43.1	30.7	17.9

3.2 CONSERVATION OPPORTUNITIES FOR INTERIOR DOMESTIC DEMANDS

3.2.1 EXPECTED DEMANDS FROM WATER USING FIXTURES

The U. S. Department of Housing and Urban Development (HUD) has conducted an extensive field study and literature review to determine the expected levels of water usage attributable to various fixtures. Based upon HUD study information, three typical water use "models" have been derived. A "non-conserving" scenario is shown in Table 3.32, reflecting the fixture use rates of "old" technology. This model represents homes constructed before about 1980, unless they have been retrofitted or had water using appliances replaced. The second model, displayed in Table 3.33, reflects current "standard" fixtures. It is representative of most homes built in the 80's and older homes which have had all major water using fixtures and appliances replaced--though not with the most efficient models available--since about 1980. The third model, which Table 3.34 details, represents homes which have been appointed with commonly available "state-of-the-art" technology in fixtures and appliances.

In theory, the usage rates of 77.3, 61.8 and 44.6 gallons per capita per day would be experienced in homes appointed as assumed in Tables 3.32, 3.33 and 3.34, respectively. As a reality check upon this, it is noted that the average demand observed among all participants in the HUD study was 66.2 gpcd. HUD notes that many of these homes had experienced retrofits, mainly to toilets and showers, so that an average usage falling between the non-conserving and the current standard practice models should be expected.

HUD study demand rates are based upon observation of actual behavior, not upon some idealized conception of how water ought to be used. The rates therefore reflect some average behavior in

TABLE 3.32 INTERIOR DEMANDS WITH "NON-CONSERVING" FIXTURES

Fixture/Use	Unit Demand	Usage Rate	Water Use (gpcd)	% of Total
Toilets	5.5 gal/flush	4 flush/person/day	22.0	28.5
Showers	3.4 gal/min.	4.8 min/person/day	16.3	21.1
Washing machine	55 gal/load	0.3 load/person/day	16.5	21.3
Dishwasher	14 gal/load	0.17 load/person/day	2.4	3.1
Faucets w/aerators		estimated	9.0	11.6
Baths	50 gal/bath	0.14 bath/person/day	7.0	9.1
Toilet leakage		estimated	4.1	5.3
				Total gal/person/day = 77.3

TABLE 3.33 INTERIOR DEMANDS WITH CURRENT STANDARD FIXTURES

Fixture/Use	Unit Demand	Usage Rate	Water Use (gpcd)	% of Total
Toilets	3.5 gal/flush	4 flush/person/day	14.0	22.7
Showers	1.9 gal/min.	4.8 min/person/day	9.1	14.7
Washing machine	47.5 gal/load	0.3 load/person/day	14.3	23.1
Dishwasher	10 gal/load	0.17 load/person/day	1.7	2.8
Faucets w/aerators		estimated	8.5	13.8
Baths	50 gal/bath	0.14 bath/person/day	7.0	11.3
Toilet leakage		estimated	7.2	11.6
			Total gal/person/day = 61.8	

TABLE 3.34 INTERIOR DEMANDS WITH STATE-OF-THE-ART FIXTURES

Fixture/Use	Unit Demand	Usage Rate	Water Use (gpcd)	% of Total
Toilets	1.5 gal/flush	4 flush/person/day	6.0	13.4
Showers	1.9 gal/min.	4.8 min/person/day	9.1	20.4
Washing machine	42 gal/load	0.3 load/person/day	12.6	28.3
Dishwasher	8.5 gal/load	0.17 load/person/day	1.4	3.1
Faucets w/aerators		estimated	8.5	19.1
Baths	50 gal/bath	0.14 bath/person/day	7.0	15.7
Toilet leakage		estimated	0.0	0.0
Total gal/person/day = 44.6				

regard to water use. An implication is that, if observed interior demands in similarly appointed homes differ greatly from these rates, that would be due mainly to the occupants' behavior.

Data presented in Section 3.1 indicate that apparent average winter demand rates (assumed to be essentially all due to interior demands) run quite a bit more than 77.3 gpcd for many of the supply systems in the study area. While, in many cases, this may be at least partially an artifact of the poor data quality, it may also signal poor conservation habits.

High water demands could be due to inefficient water use habits or to lack of attention to customer-side loss control. The latter is discussed in this section. However, positive alterations in water use habits is not an aspect of conservation which can be readily addressed by the hardware-oriented actions discussed under this heading. Rather, altering habits requires efforts at inducing people to make an effort to improve. That endeavor is the domain of educational programs and pricing policies.

The HUD data implies that, using off-the-shelf technology, about 45 gpcd is a realistic, attainable target for interior water demand. This is a drastic reduction from the apparent average winter demand rates currently experienced in the study area. Means by which this goal may be achieved are discussed in this section.

3.2.2 OPPORTUNITIES FOR REDUCING FLUSH WATER DEMAND

3.2.2.1 Reduction of Toilet Leakage

Tables 3.32 and 3.33 note variable assumptions regarding toilet leakage. These merely reflect what was observed as the <u>average</u> leakage rates experienced in the homes of HUD study participants. Any given toilet which is leaking usually results in a high rate of water loss. For example, when the toilets were fixed in 10 apartment buildings known to have high rates of leakage, average water use rates dropped about 30 gpcd.

Toilet leakage can be checked by dropping dye tablets into the tank. The water in the bowl will quickly turn color as well if the toilet is leaking. Ballcock units and flapper valves can be purchased for less than $15 total, and they can be easily installed by the homeowner.

The average current marginal rate among water suppliers in the study area is about $1.70. Using this price, a 2-year payback at 8% interest on the $15 investment in toilet leak repair is obtained if the toilet is losing as little as 14 gallons per day. At this leakage rate, a continuing savings of about one marginal 1,000 gallon block every two months would accrue. After 5 years, a reasonable useful life for the ballcock and flapper valve, the accrued savings would total almost $60.

Since leaking toilets invariably waste water at rates much greater than 14 gpd, it is apparent that fixing toilet leakage is an extremely fiscally efficient conservation measure, even at today's water rates. If evaluated against a reasonable estimate of the long-run marginal cost of water, payback would be extremely short, a matter of a few weeks.

3.2.2.2 Toilet Dams and Displacement Devices

Devices which reduce the volume of water used by each flush are available from a variety of sources. Many conservation programs have included the free distribution of dams or bags. Householders can also use appropriately sized bottles as a no-cost displacement device. Typically, about one-half to three-quarters of a gallon is saved per flush. The HUD study observed a 0.7 gallon/flush reduction for toilets fitted with bottles, bags or dams. Using HUD's fixture use rates, a water demand reduction of 2.8 gpcd would be realized.

If the cost of displacement devices were free, the payback would, of course, be instant. However, at 0.7 gallons/flush, a three person household would accrue an average savings of one marginal 1,000 gallon block every 4 months, or a savings of only about 43 cents per month at today's average marginal rate. With such small paybacks, it is understandable that few people bother with these devices.

Also, the reduction in flush water volume may result in a need to double flush on occasion, cutting into the savings. This problem becomes more acute when plumbing is arranged with insufficient fall from the toilet to the drain line. In the event of unsatisfactory performance, these devices can be readily removed, making their savings potential somewhat unsure over the long term.

These factors tend to favor fixture replacement rather than retrofitting of dams and displacement devices for long-term reduction of flush water demand. Still, it is apparent that, with thousands of existing toilets drawing water from the Edwards aquifer, broadscale implementation of this strategy would save many millions of gallons per year. Since the cost to the homeowner is nil, proliferation of this strategy should be pursued to the maximum practical extent.

3.2.2.3 Toilet Replacement

Tables 3.32 through 3.34 show that toilet replacement can deliver the largest amount of water savings of any single action. HUD study data indicates that "old" toilets incur about 22 gpcd of water demand, while current standard fixtures demand about 14 gpcd, a reduction of 36%. New "ultra-low" volume toilets, which are becoming readily available, demand only about 6 gpcd, a reduction of 73% below "old" toilets and of 57% below the current standard fixture. These reductions are based upon using toilets demanding 1.5 gallons/flush. A proposed national efficiency standard would impose a limit of 1.6 gallons/flush. However, many models of these "ultra-low" volume toilets demand somewhat less than this.

Using the figures in Tables 3.32 through 3.34, each "old" toilet replaced would save about 16 gpcd, and each current standard fixture replaced would save 8 gpcd. Examination of 22 of the water suppliers in the study area yields an appreciation of the potential savings if toilet replacement were instituted on a broad scale. It is calculated that over 230,000 gallons per day, or about 85 million gallons per year, would be saved in these systems. While one may quibble with the accuracy of the data or the assumptions upon which this estimate is based, it is readily apparent that the water savings potential of this strategy is immense.

Manufacturers responding to requests for information on "ultra-low" volume toilets report--with few exceptions--a "list" price generally in the range of $220 to $285. Less than half the manufacturers responded, however, so others may offer lower suggested retail prices. A few prices in the $100 to $150 range were offered in the information received. A major factor influencing fixture cost is customer preference in regard to aesthetics.

These "list" prices may be somewhat misleading, however. Checking with water authorities and plumbing suppliers in three states where these fixtures are required, retail prices as low as $90 were found. Several models were reported to be available in the $90 to $150 range. It was also reported that a new factory in Mexico is about to offer its product at $65.

There is also potential for obtaining these fixtures in quantity at greatly reduced prices. The Lower Colorado River Authority reports that, in a competitive bidding situation, prices of about $85 and about $175 were obtained for two models, the "list" prices of which are about $125 and about $275, respectively.

Reflecting this broad range of prices, economic analyses of toilet replacement are conducted using installed costs of $125 and of $275. A discount rate of 5.5% is used, approximating what a homeowner might realize if these amounts were instead placed into a passbook savings account. This is probably a conservative analysis, since the real rate of return adjusted for inflation is likely to be less. Also examined is the "simple" payback, since a homeowner might not invest this money in lieu of replacing his or her toilet in any case. In these analyses, it is assumed that a toilet serves, on the average, 1.5 persons. This derives from assuming 3 persons per household and 2 toilets in each home.

Examined first are fiscal implications using the current average marginal water rate of $1.70 per 1,000 gallons. Table 3.35 summarizes the analyses. When replacing an "old" toilet at a cost of $125, "simple" payback--with neither the original investment nor the annual savings drawing interest--is about 8.4 years. Investing the annual savings at the assumed interest rate, 11.5 years would pass before the value of these investments equaled the value obtained by simply investing the $125 cost. At a replacement cost of $275, the "simple" payback is about 18.5 years. If the original payment and the annual savings were invested, the original investment would never pay back.

Replacing a current standard fixture at a cost of $125, "simple" payback is about 16.8 years, and considering investment benefits, it is 48 years. For a $275 installed cost, "simple" payback is

TABLE 3.35 FISCAL ANALYSIS OF TOILET REPLACEMENT USING CURRENT AVERAGE MARGINAL WATER RATES

Replace "Old" Toilet	Replace Current Standard Fixture
Water Savings:	
5.5 - 1.5 = 4 gal/flush 4 gal/flush x 4 flush/person/day x 1.5 persons/toilet = 24 gal/day = 8,760 gal/yr	3.5 - 1.5 = 2 gal/flush 2 gal/flush x 4 flush/person/day x 1.5 persons/toilet = 12 gal/day = 4,380 gal/yr
Fiscal Savings:	
8.76 x $1.70 = $14.89/yr	4.38 x $1.70 = $7.45/yr
Toilet replacement cost = $125	
Simple payback: $125/$14.89 = 8.4 yr Payback with investment benefits included = 11.5 yr	Simple payback: $125/$7.45 = 16.8 yr Payback with investment benefits included = 48 yr
Toilet replacement cost = $275	
Simple payback: $275/$14.89 = 18.5 yr Payback with investment benefits included: will never pay back A perpetual ordinary annuity with an annual payment of $14.89 has a value of only $270.73 at the assumed interest rate.	Simple payback: $275/7.45 = 37 yr Payback with investment benefits included: will never pay back A perpetual ordinary annuity with an annual payment of $7.45 has a value of only $135.45 the assumed interest rate.

almost 37 years, and again the original amount would never pay back when investment opportunities are considered. Clearly, toilet replacement is not a good <u>fiscal</u> investment at today's average water rates.

Table 3.36 shows the marginal water rate required to achieve a 5-year payback, which is assumed to indicate a good investment in a durable good with a long useful life. Replacing an "old" toilet at a cost of $125, the marginal rate required for a "simple" payback is $2.85 per 1,000 gallons. Considering investment benefits of both the original cost and the annual savings yields a rate of $3.34. If the replacement cost is $275, "simple" payback is achieved with a water price of $6.28 per 1,000 gallons. With investment benefits taken into account, a rate of $7.35 is required.

In the case of a current standard fixture, a replacement cost of $125 would require a water price of $5.71 per 1,000 gallons to achieve a 5-year "simple" payback, while a price of $6.68 is required when investment benefits are considered. At a replacement cost of $275, a price of $12.56 nets a 5-year "simple" payback. Taking investment benefits into account, a rate of $14.70 would be required.

Recalling the apparent long-run marginal water costs discussed in Section 3.0, it appears that, as long as replacement costs were under about $200, replacing "old" toilets with "ultra-low" volume models would be economically efficient. Two water suppliers in the BS/EACD area already have marginal rates of $2.85 or greater. If long-run marginal costs of water approach those presented in the Hays County WDB study, then even the replacement of a current standard fixture at a cost of $275 would be economically efficient.

TABLE 3.36 FISCAL ANALYSIS OF TOILET REPLACEMENT WITH A 5-YEAR PAYBACK

Replace "Old" Toilet	Replace Current Standard Fixture
Water Savings (as calculated in Table 3.4):	
8,760 gal/yr	4,380 gal/yr
Toilet replacement cost = $125	
Rate required for simple payback: $125/5 = $25/8.76 = $2.85 Rate required for 5-yr payback with investment benefits included: $3.34	Rate required for simple payback: $125/5 = $25/4.38 = $5.71 Rate required for 5-yr payback with investment benefits included: $6.68
Toilet replacement cost = $275	
Rate required for simple payback: $275/5 = $55/8.76 = $6.28 Rate required for 5-yr payback with investment benefits included: $7.35	Rate required for simple payback: $275/5 = $55/4.38 = $12.56 Rate required for 5-yr payback with investment benefits included: $14.70

The foregoing analyses consider the total cost of fixture replacement, which would be relevant to a program promoting broadscale toilet replacement. However, if a toilet were going to be replaced in any case, or if one were to be purchased for new construction, then only the incremental cost above that required to install a current standard fixture would bear on the efficiency of this investment.

As noted previously, it is not at all certain that choosing an "ultra-low" volume toilet would incur a significant cost increase, and this will become less likely as these fixtures proliferate. However, for the purposes of this analysis, a $50 incremental cost is assumed. Table 3.37 shows that, at the current average marginal price of water, a "simple" payback of this incremental cost would require 6.7 years, and that, with investment benefits considered, the payback period would be 8.6 years. To achieve a 5-year "simple" payback would require a water price of $2.28 per 1,000 gallons. With investment benefits included, a price of $2.67 is required.

This indicates that requiring the use of "ultra-low" volume toilets for all new construction and for all replacements made at the owner's option is extremely economically efficient. As outlined in Section 3.6, if rates structures were constructed in accord with the principles of marginal cost pricing, this action would also be fiscally efficient to the consumer in almost every system which was analyzed. Note that this is a conclusion arrived at without providing for any increase in total system revenue.

Conclusions from these analyses include:

1. It would not be unreasonable to require that all new toilets installed in buildings supplied by Edwards water demand 1.6

TABLE 3.37 FISCAL ANALYSIS OF INCREMENTAL COSTS OF TOILET REPLACEMENT

Water Savings:	Substituting an "ultra-low" volume toilet for a current standard fixture. Therefore, from Table 3.4, Annual water savings = 4,380 gal/year	
Fiscal Savings at current average marginal rate:	4.38 x \$1.70 = \$7.45	
Simple payback:	\$50/7.45 = 6.7 years	Payback with investment benefits included = 8.6 years
To achieve a 5-year payback: Rate required for simple payback: \$50/5 = \$10/4.38 = \$2.28		Rate required with investment benefits included: \$2.67

gallons/flush or less, especially since "ultra-low" volume fixtures are likely to become the industry standard in the near future;

2. Broadscale replacement of "old" toilets with "ultra-low" volume models may require an incentive program to gain significant penetration, but this action should be very economically efficient. Therefore, appropriate incentive programs should be formulated; and

3. If future conditions indicate that long-run marginal cost of water will approach those derived from the Hays County WDB study, then broadscale replacement of the current standard fixture toilets would also be economically efficient. Again, it is likely that an incentive program would be required to induce a significant number of such replacements.

3.2.3 OPPORTUNITIES FOR REDUCING SHOWER WATER DEMAND

Tables 3.32 and 3.33 indicate that replacing an "old" showerhead with a "low-flow" model would cut average demand from 16.3 gpcd to 9.1 gpcd, a 44% decrease. An appreciation for the savings available from broadscale replacement is gained by again examining the 22 water systems used in the toilet savings example. Data from these systems indicate that savings would total over 30 million gallons annually.

Two factors dictate that this level of savings may not actually be attainable. First is the question of how "secure" such savings are. A showerhead is readily replaced by the user. There is some history of dissatisfaction with the performance of "low-flow" showerheads. Much of this may have been due to using "flow restrictor" inserts in non-conserving heads instead of using heads designed to operate at restricted flow rates. However, there is an element of preference at work here. Even very well designed "low-flow" showerheads might be rejected by people who are simply used to a higher volume spray.

In the future, however, there may not be much choice in this matter. A proposed national efficiency standard would restrict flow rates to 2.75 gpm. Observe that Tables 3.33 and 3.34 show an average flow rate of only 1.9 gpm. It was observed in the HUD study that most people throttle back their showers. The nominal rating of the showerheads for which the 1.9 gpm rate was observed is 3 gpm.

The second factor that may influence actual savings is that many of the "old" showerheads may have already been replaced. This is especially likely because these fixtures are not so durable that too many 10-year-old heads would still be in service. Although many models which flow at actual in-use rates well above 2.75 gpm continue to be available, there has been a great deal of information disseminated in recent years about the merit of using "low-flow" heads. Indeed, many local conservation programs have included free distribution of such models. Therefore, some significant percentage of "old" showers are now likely to be fitted with "low-flow" showerheads.

For whatever fraction of the population that is still employing "high-flow" showerheads, whether the originally installed model or a subsequent replacement, converting to a "low-flow" model is an excellent conservation opportunity. Savings accrue not only from the water savings, but from energy cost savings as well.

Many models of "low-flow" showerheads are available, with retail prices ranging from about $2 on up. A variety of national brands can be obtained for under $15. This cost is used to analyze the fiscal efficiency of showerhead replacement. The householder can readily install the unit, so there is no additional cost for installation. The analysis assumes that each showerhead replaced serves an average of 2.5 persons.

From Tables 3.32 and 3.33, estimated water savings per showerhead replaced is 7.2 gpcd. Under the assumptions employed, this results in an annual savings of about 6,570 gallons, or an average 6.57 marginal 1,000 gallon blocks. At the current average marginal price of $1.70, the annual value of water savings per head replaced is $11.17.

To calculate expected energy savings, a 35 degree average temperature increase of the total flow is assumed, yielding an annual energy demand of almost 2 million Btu. Since the majority of Edwards water users in the BS/EACD area are beyond the reach of natural gas distribution systems, it is assumed that electric water heaters predominate. The energy requirement translates to about 577 Kwh of electricity. At 6 cents/Kwh, the annual value of the energy saved would be $34.60.

The total estimated value of water and energy savings is therefore $45.77. This results in a "simple" payback period on the investment in a "low-flow" showerhead of about 4 months. Since the energy savings predominate and the payback is so short, higher long-run marginal costs would not significantly alter the results. Showerhead replacement is an excellent investment in both fiscal and economic terms.

3.2.4 OPPORTUNITIES FOR SAVINGS FROM OTHER FIXTURES AND APPLIANCES

Tables 3.32 through 3.34 indicate that savings attainable from replacement of other fixtures are relatively minor. Of the 32.7 gpcd difference between the total demand in Table 3.32 and the total demand in Table 3.34, toilets, replacement and leakage control, and showers account for 27.3 gpcd, leaving only 5.4 gpcd. This implies that most efforts should be targeted to the opportunities already considered. However, some specific opportunities should not be ignored.

Washing machines constitute a potential opportunity for significant savings. From "old" models to some more efficient models currently available, a reduction in average demand per load of 13 gallons is reflected in Tables 3.32 and 3.34. Models with much higher efficiency are becoming available, reported to use about 27 gallons/load. At the usage rate reflected in Tables 3.32 through 3.34, this machine would decrease demand to 8.1 gpcd, a further reduction of 4.5 gpcd beyond that shown in Table 3.34.

Since washing machines are expensive items and the water savings potential--even with the "advanced" machine noted above--are limited, replacement for the value of the water savings would be neither fiscally justified nor economically efficient. Adding energy savings from reduced hot water usage may bring this action into the range of economic efficiency. However, many people prefer to do quite a bit of washing with cold water, so the magnitude of actual savings would be highly questionable.

When people chose to purchase a new washing machine, they should be encouraged to buy more efficient models, perhaps through some form of incentive program. The marginal cost of the more efficient model should at least be economically efficient--and may be fiscally efficient as well--for their water supplier to fund.

Tables 3.32 through 3.34 list "faucets with aerators" and indicate that there is little opportunity for savings from this fixture. The implication from the HUD study is that aerators on faucets are already so ubiquitous that no future savings are available from retrofitting. However, this is an artifact of the sample observed. Where faucets without aerators do exist, some savings are available from retrofitting them with aerators or from replacing the fixtures, and efforts should be made to induce these actions. Quantification of savings is very difficult, due to lack of data on faucet usage. Therefore, fiscal feasibility and economic efficiency of these activities would have to be judged in each case, based upon estimated water usage and retrofit/replacement costs in the situation at hand.

3.2.5 CUSTOMER-SIDE LOSS CONTROL

As in the case of toilet leakage, general customer-side loss control is likely to be fiscally beneficial, so it would certainly be economically efficient. Losses can be minimized by fixing leaks and by reducing the supply pressure.

Even a slow drip can result in the loss of considerable water over the course of a year. Leaky faucet valves, the most common situation in the home, can usually be repaired at little expense by the householder. People should be instructed how to observe their meters when none of their fixtures or appliances are drawing water to determine if undetected leaks in their piping or appurtances is occurring. While repairs of leaks in the piping system may be considerably more costly, a significant leak can create a sizable fiscal justification over time.

Pressure reduction minimizes the losses through any leaks in the system. Water using fixtures generally operate quite well at pressures as low as 20 psi, although 30-50 psi is generally preferred. Many of the local water suppliers routinely install a pressure-reducing valve at each meter. Therefore, it is a simple matter for the householder or a utility employee to determine and properly set the customer-side pressure.

3.2.6 SAVINGS IN NEW DEVELOPMENT

The savings opportunities discussed above would be more fiscally sound when applied to new rather than existing development. In new development, the only premium paid for achieving conservation is the incremental cost of the more efficient fixture or appliance rather than the entire cost. This greatly reduces the water price which must be posited in order to make the action fiscally or economically efficient.

The primary determinant of the water savings which may be realized from new construction are the standards, regulations, and incentives which determine the choice of fixtures and appliances by the builder or owner. Savings available from applying higher efficiency standards in new construction would be dominated by flush water savings. As previously stated, "ultra-low" volume toilets should be adopted as the standard for all new development. Additionally, efforts should be made to encourage the installation of "low-flow" showerheads and more efficient washing machines and dishwashers.

3.2.7 PURVEYING INTERIOR CONSERVATION MEASURES

3.2.7.1 Public Education

Any conservation program should include efforts to inform the public about the available options and the need for and economic merits of water conservation. Many types of public information and education programs have been instituted around the country. Locally, informational material is available from the Texas Water Development Board, the Lower Colorado River Authority, the Edwards Underground Water District, and other agencies. The BS/EACD is already disseminating much of that material and is publishing a newsletter to provide more localized information. The local media has also been utilized to some extent in an effort to inform the public of conservation opportunities.

Efforts to utilize all those sources should continue, augmented as necessary to reach the maximum number of people possible. An additional aspect which must be stressed is informing and educating people about the nature of the Edwards aquifer and its vulnerabilities, as outlined in Section 3.0, and about the apparent economic efficiency of many conservation measures. Getting this message across will help to build a "conservation ethic" among the users of Edwards water. This will generate support for and participation in various programs to purvey, encourage or mandate these measures. Instituting a comprehensive information and education strategy should be a high priority for the BS/EACD and area water suppliers.

A good place to begin building this "conservation ethic" is in the public schools. Creating a basic awareness of water resources issues in today's children will hopefully lead to a better understanding of those issues by tomorrow's adults. The Lower Colorado River Authority has created a water resources curriculum aimed at mid-grade school ages. Efforts should be made to assure that this and/or similar courses are offered at all area schools.

3.2.7.2 Home Water Audits

Urging people to maximize their water conservation opportunities may reap little tangible return unless it is accompanied by efforts to directly assist in evaluating their water use and in determining how best to reduce it. One means of providing such assistance is a home water audit program. Similar services could also be provided to address domestic demands in the commercial sector.

Several means of promoting home water audits have been tried. These include direct mail "solicitation", announcements included as inserts in the water bill, media announcements, and direct contact of "target groups". Different efforts around the country have reported varying degrees of success in obtaining participation by each method. A combination of these methods should be tried in the BS/EACD area. The approaches which are most successful should be employed on an ongoing basis.

Program objectives would determine how it would be conducted and how much effort, both by the "auditor" and by the resident, would be required to complete the audit. In general, a home water audit should include an evaluation of the integrity of the building's plumbing, an inventory of the water demands of the major fixtures and appliances, and gathering information on the water use habits. A program targeting water use habits could be conducted by mailing forms to be completed by the occupants at their leisure. This would allow them time to observe--and therefore, hopefully, to more accurately report--the number of showers taken, the number of toilet flushes, etc. A program focusing on decreasing demand by fixing toilets and other leaks, installing toilet dams, making sure a "low-flow" showerhead is in place, etc., might not include much effort to detail water using habits.

Actions taken upon the results of an audit would determine the effectiveness of the program. Three basic options for actions can be defined:

1. Provide remedial actions during the water audit home visit. This is applicable to such actions as fixing leaks, installing toilet dams, and providing a "low-flow" showerhead;

2. Provide recommendations and leave it to the residents' discretion and iniative to implement. This strategy could be

applied to any proposed measures, but would be most applicable to those entailing significant expense, like replacement of fixtures or appliances; and

3. Provide follow-up assistance to implement available options. This strategy can be used for the implementation of low cost/no cost options, or to provide information about options entailing significant expense or effort. Details on incentive programs could also be provided during follow-up efforts.

Home water audits can also be used as an educational tool, offering another means of "raising the consciousness" of citizens regarding water conservation issues. During the audit process, the message that conservation is more economically efficient than supply augmentation is readily conveyed. This will help to build that "conservation ethic" among the citizens of this area.

3.3 OPPORTUNITIES FOR CONSERVATION IN LANDSCAPE IRRIGATION

3.3.1 POTENTIAL WATER SAVINGS FROM EXTERIOR USE CONSERVATION

As discussed previously, it appears that landscape and garden irrigation usage dominates exterior demands among customers of the water suppliers in the study area. To be sure, some of the summer peaking observed may be due to "natural" seasonal increases in usage. It may also be partly due to more frequent car washing, to increased evaporation from swimming pools, etc. Relative to irrigation demands, however, it is expected that peaking due to these causes is quite small.

Table 3.38 displays the differences between average winter demand and average demand for the remaining 9 months in 20 water supply systems in the study area. Taking this measure as an indication of usage for landscape and garden irrigation, an appreciation for the magnitude of water savings available in this sector can be gained.

Table 3.38 reviews data for 1987 and 1988. In 1987, extremely high rainfalls were experienced in May and June, considerably depressing irrigation demand. In 1988, although rainfall for the year as whole was quite a bit below normal, above normal rainfalls were experienced in July and near normal rainfalls were experienced in August, so irrigation demands for that year probably also do not reflect anywhere near the potential peak demand.

Based upon the assumptions and data used, the average irrigation demand for these systems over the two years reviewed was almost 700,000 gallons per day, or about 254 million gallons per year. One can readily question the accuracy with which the assumptions and/or data reflect true irrigation demand, but it is still evident that the savings potential in this usage sector is huge.

TABLE 3.38 ESTIMATES OF IRRIGATION DEMANDS IN 20 WATER SYSTEMS

SYSTEM NAME	1987 EXCESS GPD/CONN	1987 GPCD	1988 EXCESS GPD/CONN	1988 GPCD	SYSTEM AVG. GAL/DAY
Arroyo Doble	156	52	172	57	44,300
Bear Creek Park	116	33	108	31	30,900
City of Buda	94	36	77	30	46,600
Chaparral	N.A.	N.A.	141	47	18,500
Cimarron Park	217	70	257	83	94,200
Copper Hills	N.A.	N.A.	99	33	600
Creedmoor-Maha WSC	63	25	75	30	89,700
Dellana Hills	N.A.	N.A.	267	133	6,700
Estates WSC	173	52	165	50	13,300
G & J Water Co.	N.A.	N.A.	185	66	3,000
Goforth WSC	74	32	72	31	73,300
Leisure Woods	253	72	258	74	100,700
Mountain City	239	77	276	89	35,800
Mystic Oaks	N.A.	N.A.	180	64	7,000
Onion Creek Meadows	156	46	100	29	27,000
Plum Creek	56	17	30	9	42,200
Ridgewood Village	185	62	205	68	14,800
San Leanna	154	51	224	75	24,200
Slaughter Creek Acres	79	23	97	28	6,500
Sunset Valley	188	68	222	81	15,400

Total avg. gpd = 695,100
= 254 million gal/yr.

Note: Excess gpd/connection is the difference between the average usage in December, January and February and the average usage in the other 9 months.

Discussed in the following are three basic methods of reducing irrigation demand:

1. Improving irrigation system efficiency, so that the amount of water applied more closely matches the actual demands of the plants;

2. Use of landscapes which require less water for proper maintenance; and

3. Employing alternate water sources.

3.3.2 IMPROVING WATER EFFICIENCY IN IRRIGATION OPERATIONS

There are two avenues by which improvement of irrigation efficiency can be approached. One is to employ more efficient hardware, and the other is to assure that this hardware is used properly. To maximize the water savings available from this strategy, both approaches must be pursued.

3.3.2.1 Efficient Irrigation Habits

It is commonly acknowledged that people tend to apply more water to their landscapes than the plants demand for good maintenance. An indication of this is provided by examining some of the water use data collected for this study. For Estates WSC, those accounts identified in Table 3.10 as having an average summer demand more than 250 gpd in excess of average winter demand were taken as a sample group of householders which practice significant landscape irrigation. Their collective behavior is examined in Table 3.39 for the months of May through September, 1988.

The total pan evaporation minus the total precipitation is shown as a "demand index" representing the relative amount of water

TABLE 3.39 RELATIONSHIP OF PLANT NEEDS TO ACTUAL USAGE IN ESTATES WSC

Month	Evapotranspiration (in/mo)	Precipitation (in/mo)	ET minus P (in/mo)	Demand Index	Avg. Irr. (gpd/conn)	Usage Index
May	8.33	3.50	4.83	1.00	295	1.00
June	9.98	3.02	6.96	1.44	738	2.50
July	9.03	2.70	6.33	1.31	325	1.10
August	9.64	1.35	8.29	1.72	474	1.61
September	8.63	1.85	6.78	1.40	523	1.77

actually needed by the landscapes being irrigated. If water were applied in rough proportion to these real needs, then the averages of "excess" usages (defined as observed gpd for the month in question minus the winter average gpd from Table 3.10, and taken as a relative measure of irrigation usage) should follow a pattern similar to that of the demand index. As Table 3.39 shows, actual behavior is rather erratic, indicating that irrigation usage was not in proportion to the plants' demands.

Some conservation efforts have attempted to minimize this source of inefficiency by offering advice to irrigators on the proper volume to apply relative to actual demands, and by offering assistance in setting up irrigation systems so that this is accomplished. Two programs might be considered.

One or more weather stations might be operated within the BS/EACD area and the weather data used to determine a good estimate of the actual moisture deficit which irrigation systems need to make up. Advisories might be issued, perhaps once a week, allowing irrigators to adjust their systems accordingly. These advisories might provide information for a range of prevalent landscapes, such as different types of grasses, shrubs, ground covers, etc.

While this approach would certainly offer the opportunity to most accurately match water supplied to the true demands, it is questionable if, in practice, the information made available would be properly applied. To do so would require an irrigator to know the precipitation rates throughout the irrigation system and how to adjust them to achieve the rather fine changes which are likely to occur from week to week during the irrigation season. Even in professionally managed commercial irrigation systems, such good operation of the system is not often found.

Perhaps a more practical approach is to directly assist the irrigator in determining irrigation rates in the system. Then a schedule of fairly simple and specific changes in the weekly operating scheme would be provided. These would match the weather patterns typically experienced. In combination with hardware options for wet soil override (discussed below), this approach has been shown to achieve significant reductions in irrigation water demand.

It is also important to educate irrigators about how diurnal timing of system operation can impact on efficiency. The optimal time to operate a spray irrigation system is early in the morning. Winds are usually calmer then, minimizing drift losses, and relative humidity is generally higher, which decreases evaporative losses. In practice, many people irrigate during the middle of the day or in the early evening. Often this is because a manual system is being used. The householder irrigates at times when it is convenient to be there to turn it on and off. Again, employing appropriate hardware can overcome this limitation.

3.3.2.2 Efficient Hardware

Two categories of hardware offer opportunities to increase irrigation system efficiency. One category is the equipment used to apply water. Application efficiencies of various types of equipment vary widely. For example, oscillating sprinklers which throw water high into the air can be very inefficient, especially if used at midday in a breeze, while bubblers and drip systems can be close to 100% efficient even when diurnal scheduling is not optimal.

Altering application hardware of in-ground systems may be expensive, and this may not be economically justified by the water savings. However, whenever a change of hardware is being considered in any case, efforts should be made to induce the owner to install the most efficient system practical. Texas' licensed irrigator program has recently given more attention to conservation issues, so that professionally designed and installed systems may in the future be executed with more regard to water conservation. BS/EACD should consider requesting even further emphasis on this aspect in the licensing process.

For those executing irrigation with a hose-end system, changes in application hardware can be made quickly and relatively inexpensively. It may even be economically efficient to directly provide more efficient sprinklers in concert with efforts to educate the users on when and how to irrigate efficiently. The cost of such a program may, in fact, be trivial. For example, one company offers a fan spray hose-end sprinkler which sprays large droplets at a low angle--characteristics which should make this a very efficient fixture--at a retail price of about $3.

Whenever a change in irrigation equipment is being considered, the use of drip irrigation, or other forms of "micro" irrigation, needs to be given a high priority. Such systems are generally much more water efficient than spray systems. The Texas Agricultural Extension Service in its publication "Efficient Use of Water in the Garden and Landscape" estimates that as much as 60% of irrigation water demand might be avoided by the use of drip systems. These systems should be particularly preferred for gardens and for shrubs and other bedded plants.

Implementing drip irrigation need not entail a very costly in-ground system. "Efficient Use of Water in the Garden and Landscape" illustrates how drip irrigation can be instituted in a hose-end system. The cost of drip hardware is not excessive, and local supply houses stock all necessary components. As an example of equipment prices, one supplier offers a "kit" which provides everything needed to cover ten 50-foot garden rows at a price of about $160. A general cost estimate of $15 to $30 per 100 foot row is offered in "Efficient Use of Water in the Garden and Landscape".

The other category of equipment through which increased efficiency may be obtained are various types of control devices. The addition of timers to manual systems, or the substitution of more versatile timers in systems already operated by one, can improve the efficiency of the system. Irrigation cycles can be set by the timer for appropriate watering based on the time of year, the type of application equipment in use, and the type of plant being watered. These devices vary in price from several dollars for an in-line timer for a hose-end system to about $50 and up, depending upon the number of stations controlled and versatility of operation afforded, for hardwired controllers intended for use with in-ground systems.

Another control device which may significantly improve the water efficiency of a typical system is a wet soil override switch. New technology in moisture sensing is making such devices more dependable and affordable. Wired in series with the system controller, they suppress operation of the system when the soil moisture is above some preset limit, usually field capacity. This prevents irrigation from occurring when it is not needed, and also "modulates" the application time of a clock-controlled system so that only the amount of water actually needed is applied.

Two companies offering such devices claim to have documented up to 50% reductions in irrigation water usage due solely to the effect of the override switch. The basic unit offered by each company is priced at about $150. The extent to which implementing a soil moisture override at this price is economically efficient or fiscally justifiable would depend upon the volume demanded by the system in question.

To operate in an automated manner, these devices must be hardwired into the control system, so they are most practically applied only to in-ground systems. However, soil moisture indicators can also be used manually. Manufacturers of these units offer a meter which plugs into the in-ground sensor. The irrigator who is running a system manually could take a reading or readings in order to determine whether or not to water. This is a fairly trivial amount of additional operational effort which could produce rather sizable savings in irrigation demand.

3.3.3 WATER EFFICIENT LANDSCAPES

Landscapes can be designed to demand far less water for maintenance than "traditional" turf-dominated landscapes which are typically found in this area. The principles of water efficient landscaping have been packaged into a nationally promoted program called Xeriscape. These principles include:

1. Thoughtful design, which, besides considering aesthetics gives attention to grouping plants with similar water requirements, arranging landscape components for efficient irrigation coverage, etc;
2. Good soil preparation to build up the organic matter content and balance required nutrients, providing a high water-holding capacity and allowing good growth with the minimum amount of irrigation;
3. Limited, "appropriate" turf areas, arranged so that they provide maximum function and visual impact while covering minimum area, and so that they can be efficiently irrigated, without throwing large quantities of water onto adjacent areas which may not require irrigation;

4. Use locally adapted plants with lower water demands;
5. Use efficient irrigation methods;
6. Use mulch around all bedded plants to enhance water penetration during irrigations and to minimize water loss from the soil through evaporation; and
7. Provide proper maintenance, since plants kept in good condition can be adequately maintained with less water.

One Xeriscape brochure indicates that water savings of 30 to 80 percent can be realized relative to that required to irrigate typical turf-dominated landscapes. The actual savings would, of course, vary with the extent to which turf was limited, with the level of irrigation efficiency attained, with the degree to which mulch was employed, etc., particularly the former. Savings obtainable is a function of individual system design. Since this entails the capricious matter of aesthetics, it is not possible to offer an estimate of the overall savings which might be achieved by broadscale application of Xeriscape principles.

Despite long-standing efforts to publicize Xeriscape, including those by the City of Austin and the Lower Colorado River Authority locally, there remains a widely held impression that Xeriscape imposes a parched "desert" landscape. This indicates that there is still much public education needed to decrease the demand for irrigation water through this means.

Two strategies for promoting more water efficient landscapes can be entertained. One is to continue to provide information and trust that a developing water conservation ethic in this area will eventually cause more people to begin putting that information into action. The other is to actively assist people in transforming their landscapes. Various methods of providing assistance and incentives are discussed later in this section.

As noted, the extent to which turf is limited is a major determinant of water savings attained. The type of turf employed can also have a significant impact. In concert with promoting the general Xeriscape concept, efforts should be made to encourage the use of grasses with lower water demands. Buffalo grass is purported to be the best choice in this regard. New varieties with better aesthetics are now available, which may make it more acceptable to those who place a high value on an attractive lawn.

3.3.4 USE OF ALTERNATE WATER SOURCES FOR IRRIGATION

Two possible alternative sources of water might be employed in lieu of Edwards water for landscape irrigation. One is the Trinity aquifer. Issues which must be confronted in order to utilize this source on a broad scale are discussed in Section 3.4 in the context of industrial supply. Similar considerations would apply to large irrigation demands, such as a separate supply for irrigation in a new development. For smaller demands, such as a single home, it is unlikely that the cost of a second well for irrigation supply would be economically efficient, much less fiscally reasonable.

The other source is wastewater effluent. Two alternatives for the utilization of this resource can be entertained. The first is the institution of "dual distribution" systems in areas served by a centralized wastewater treatment plant. This entails installation of a second water supply system through which appropriately treated effluent can be routed to lots which demand irrigation water.

Except for Onion Creek, which is already reusing its effluent for golf course irrigation, Buda is the only area drawing water from the Barton Springs segment of the Edwards aquifer presently served by a centralized wastewater management system. As the development trends in this area do not appear to favor "regionalization" of wastewater management, it does not appear that dual distribution systems would be an option in other areas. For Buda, however, this strategy offers the opportunity for significant water savings--about 34 million gallons annually according to Table 3.38--with savings perhaps increasing as the Buda service area continues to develop. Determining the merit of a dual distribution system should therefore be a high priority in Buda's conservation program.

The other possibility for wastewater reuse is in on-site and small scale "collective on-site" systems, which are expected to be the only fiscally reasonable mode of wastewater management over much of the study area. Technology which can cost efficiently produce high quality effluent in an on-site system in readily available. A TWDB-funded study for the City of Hays found that on-site treatment in a system consisting of a septic tank, an anaerobic upflow filter and an intermittent sand filter, along with disposal via drip irrigation systems on the lot where the wastewater is generated appears to be the most fiscally reasonable means of providing organized wastewater service for the city.

An appreciation for the water savings potential from this strategy can be gained by examining the detailed water use data for Estates WSC, which serves the City of Hays. The average winter demands shown in Table 3.10 provides an estimate of average daily wastewater flow from each home. Using the excess above this as an estimate of the irrigation demand yields an approximation of the proportion of irrigation demand which could be covered by wastewater effluent. The results of such an analysis for the months of May through September, 1988 are shown in Table 3.40 The average wastewater flow from the 27 accounts evaluated was 293 gallons per day per connection. If this were used to defray irrigation demands, those demands would have been reduced by 37% to 73% in the months analyzed. It can be questioned whether some of these savings might have been gained by employing drip irrigation systems without wastewater reuse, but it is still

TABLE 3.40 ESTIMATED IRRIGATION DEMAND REDUCTION POTENTIAL DUE TO WASTEWATER REUSE IN ESTATES WSC

Acct. No.	Base-wastewater flow (gpd)	Net irrigation in excess of w/w flow-gpd				
		May	June	July	August	Sept.
2	209	235	559	330	229	538
6	229	76	546	113	274	136
8	360	0	0	0	0	0
12	179	361	385	137	146	141
13	176	40	245	40	241	381
15	280	37	360	7	312	234
17	174	0	58	39	178	155
18	166	419	490	150	328	614
19	411	0	0	0	222	0
22	183	161	1134	0	723	512
24	203	44	461	99	157	0
26	216	157	1489	212	385	64
28	616	0	0	0	0	0
29	180	0	33	52	36	17
36	399	0	236	0	8	0
37	265	0	179	0	0	60
42	271	34	356	129	91	891
44	246	0	116	0	0	76
45	278	243	818	130	44	1591
46	237	108	2218	875	995	628
48	420	150	485	0	0	89
49	311	50	244	0	146	99
54	257	0	298	176	322	274
57	699	0	992	0	0	---
60	210	12	761	13	237	157
73	411	0	157	293	455	101
74	305	0	0	116	136	180
Averages:	293	79	467	108	210	267
Avg. actual irrigation demand-from Table 4.2:		295	738	325	474	523
Reduction potential:		73%	37%	67%	56%	49%

evident that there is a significant savings potential from this strategy.

At an estimated cost of about $5,500 per house (including the drip irrigation system), it is unlikely that a system like this would be found economically efficient simply for the water savings. However, where improved wastewater management must be considered in any case, or when considering service for new development, reuse for irrigation should be considered. In such cases, only the increment of cost incurred to allow irrigation reuse needs to be justified. In conjunction with Xeriscape principles, this strategy might radically reduce potable water demand for landscape irrigation.

3.3.5 PLANNING NEW DEVELOPMENT FOR MAXIMUM WATER EFFICIENCY

By formulating development plans with due regard for water efficiency, it may be practical to minimize demands for landscape irrigation water. Roads, lot line locations, easements, etc., might be located to take maximum advantage of existing native vegetation. The need to irrigate medians might be eliminated, while enhancing efforts of lot owners to implement water efficient landscapes. In other cases, medians or "common" areas may be landscaped in concert with Xeriscape principles. Efforts should be made to induce developers to minimize, if not eliminate, demands for public area irrigation through these or any other means.

Also, new developments could be planned so that maximum benefit from wastewater reuse were derived. It would be more practical and cost efficient to plan in and construct a dual distribution system from the outset than to retrofit it later. Further, a system planned to collectively serve the entire development could more readily accommodate long-term storage. The savings potential for on-site systems in the City of Hays noted previously assumed no carryover of effluent from wet months to dry months. Development-wide reuse, in conjunction with other efforts to make irrigation more efficient and to reduce demands through Xeriscape, could totally eliminate the use of potable water for irrigation.

3.3.6 PURVEYING CONSERVATION OF EXTERIOR DEMANDS

3.3.6.1 Demonstration Projects

As part of the effort to show that Xeriscape need not impose a parched "desert" effect, installing "example" Xeriscape projects should be considered for each community or neighborhood where significant irrigation demands exist. Along with information on the savings available from instituting Xeriscape principles, this may spur some people to action.

Documentation of those savings is another area where demonstration projects would prove helpful. There is currently little locally derived information on the relative demands for not only water, but also for labor, chemicals and energy needed to properly maintain Xeriscapes vs. traditional landscapes. Projects with fairly well controlled side-by-side landscapes should be installed and monitored to gain this information. Both the City of Austin and the Lower Colorado River Authority have expressed an interest in such a project.

Another candidate for demonstration projects are on-site or small scale "collective on-site" wastewater systems, with the effluent being reused to serve landscape irrigation demands. While the technology is available and essentially ready for routine use, on-site irrigation reuse is a concept which is unfamiliar to regulators as well as the general public. Implementation of demonstration projects would not only document the costs and benefits of this strategy, but should also serve to create a better regulatory climate for the future proliferation of such systems.

3.3.6.2 Dissemination of Information Material

There are a number of sources of information regarding opportunities for exterior use conservation. The BS/EACD already makes some of it available and should increase its efforts. In addition to the brochures and informational booklets distributed by the Texas Water Development Board, the Texas Agricultural Extension Service and the National Xeriscape Council, more information needs to be made available about locally adapted, drought tolerant plants, and about sources of these plants and required materials (mulches, drip irrigation equipment, etc.) The Texas Department of Agriculture's native plant program is a resource which should to be integrated into local informational programs. Finally, information needs to be made available regarding how to choose and work with a landscape professional.

To aggressively promote exterior use water efficiency, various outreach programs should be considered. Suggestions include:

1. Produce a video on Xeriscape, including a demonstration of the specific steps involved in transforming a typical "traditional" landscape into a more water efficient plan;

2. Conduct seminars on water efficient landscaping, perhaps in cooperation with local landscape professionals. A series of such seminars might eventually evolve into local Xeriscape garden clubs, like that which is currently active in Austin. These could become self-perpetuating sources of information and expertise within the neighborhoods and communities; and

3. Produce a video and/or conduct seminars showing how to implement on-site/small scale wastewater irrigation systems. A video on this subject could be produced in conjunction with the installation of a demonstration project.

On a more general level, it is necessary to convey the need for and economic justification of exterior use conservation. These efforts can help to instill a "conservation ethic" in the citizens of this area. This will lead to greater support for and participation in any other programs instituted to achieve conservation in the exterior demand sector.

3.3.6.3 Direct Interaction: The Landscape Audit

In a similar manner to the home water audit for interior use conservation, a program offering landscape audits may serve as an effective tool for disseminating information on how to enhance exterior water use efficiency. People are more likely to take action in response to this relatively more "hands-on" approach. Such a program could include:

1. An evaluation of the existing irrigation system. Specific recommendations for efficiency improvement could be offered. As noted previously, it may even be economically efficient to distribute more efficient hose-end application equipment through this program. Information about local sources of more efficient equipment, particularly drip system components, could also be provided;

2. An analysis of soils and recommendations for improvement. A list of local sources for the necessary materials could be provided;

3. Guidelines for and/or direct assistance with planning to transform the existing landscape to a more water efficient form. Local sources of plants and other materials could be provided; and

4. Technical assistance in the implementation of the audit's recommendations.

Perhaps these activities could be provided through local landscape professionals. Some form of incentive, such as a cash rebate to at least partially cover the cost of the consultation, could be offered to induce the owner to involve a landscape professional in efforts to enhance water efficiency. The merit of this approach is that the landscape professional would have an interest in assuring that the owner acts upon the audit's recommendations, thereby increasing the level of water savings.

3.3.6.4 Direct Financial Assistance

In an effort to induce specific water-saving actions, it may be desirable to offer fiscal incentives. These may be justified by the economic (or possibly fiscal) efficiency of cutting peak demands as well as the long-term reduction in total demands. Actions which might be promoted include technical improvements in irrigation efficiency and some form of "measurable" landscape alterations which reduce water demand.

The one landscape alteration most likely to deliver the greatest reduction of irrigation demand is a decrease in the area of turf, replacing it with hardscapes, mulched areas, or bedded plants which require less water. This suggests that an incentive program should concentrate on this readily measurable action.

The North Marin Water District in California has instituted a "cash for grass" program which has proven successful at inducing significant reductions of turf areas. It is reported that the level of rebate offered ($50 per 100 s.f., with a $310 maximum for a single family home) and the savings from water bill reduction probably do not fiscally justify the relandscaping costs. Rather, this incentive is seen as a "spur" that motivates people that may have been thinking about landscape improvements to act on them. In any case, there have been many participants and a consequent reduction in overall demand for irrigation. The program is reported to be very economically efficient for the district.

Consideration should be given to the merit of similar programs for this area. This type of incentive program might be employed with equal effectiveness to promote improvements to the technical efficiency of irrigation systems. Some study regarding what level of incentive appears to be economically justified for each water supply system should be undertaken. As noted previously, providing some equipment free of charge may be an effective and economically efficient way of proliferating greater irrigation efficiency.

A possible method of funding programs that provide fiscal incentives is with a surcharge of water used during the irrigation season. This "seasonal pricing" is discussed further in Section 3.6. An attractive option would be to rebate the previous year's excess charges to a user implementing the prescribed actions. This would tend to target the largest irrigation users, and it would "automatically" make the value of the incentive proportional to the amount of the water expected to be saved.

3.4 CONSERVATION OPPORTUNITIES IN THE INDUSTRIAL AND INSTITUTIONAL DEMAND SECTORS

A variety of demands make up the industrial and institutional usage sector. From a review of existing uses, these demands can be divided into three basic categories:

1. Domestic type supply for sanitation;
2. Process water demands, including cooling water; and
3. Irrigation supply.

To illustrate the potential for and barriers to conservation in this sector, opportunities available to the nine members of this category for which demands were detailed in Section 3.1 are reviewed. Following those discussions, general issues impacting upon this usage sector and methods of encouraging or mandating such measures are considered.

3.4.1 A REVIEW OF OPPORTUNITIES FOR EXISTING USERS

3.4.1.1 Chatleff Controls

The majority of demand at Chatleff Controls is for domestic type supply, with irrigation demands being significant in months with little precipitation. Given this situation, retrofitting or replacing bathroom fixtures, reuse of domestic wastewater for irrigation, and flush water recycling constitute the major conservation opportunities.

Flush water recycling could perhaps save in excess of 40,000 gallons per month. However, since Chatleff's apparent cost of water is only 25 cents per thousand plus pumping and chlorination costs, the rate of return on the investment required to recycle flush water would be quite poor. A savings of 40,000 gallons per month would reduce the pumpage fee by only $10 per month.

Savings from fixture retrofit would be more modest, but due to the low costs involved, these actions may produce an acceptable payback. The potential for dissatisfaction with fixture performance must also be considered. Fixture replacement might cut total water demand by as much as 50%. However, with 10 toilets and 2 urinals to be capitalized, the rate of return on these investments would also be rather poor.

3.4.1.2 Tilson Custom Homes

Even assuming a liberal demand per employee, interior usage at Tilson's sales center is estimated at less than 100,000 gallons per year. Therefore, if Tilson is pumping anywhere near their permitted 2 million gallons per year, the vast majority of the usage must be for landscape irrigation. Substituting Xeriscape landscaping concepts for a large portion of their turf area and/or providing a conveniently accessible source of sub-potable water for irrigation constitute the major conservation opportunities for Tilson.

One possibility for the latter is wastewater generated by the adjacent Fuqua plant. There does not appear to be any "improved" landscaping on the Fuqua site, so that beneficial reuse of their wastewater might be best obtained by routing treated effluent to Tilson's grounds. Relatively minor savings would also be achieved by using Tilson's wastewater for this purpose.

The investments required to implement any of these conservation opportunities are probably not fiscally justifiable to Tilson, given that their apparent cost of water is only 25 cents per 1,000 gallons plus pumping costs. Other considerations, such as aesthetics of their site, might provide an incentive for them to consider replacing some of their turf area with a well-conceived, attractive Xeriscape. This would aid in highlighting their model homes, so perhaps this strategy might be justified if Tilson viewed it as a good marketing tool.

3.4.1.3 Randolph Austin Company

Pressure vessel make-up, which is the only significant process water demand at Randolph Austin, requires a very high quality source water. Therefore, it would probably not be cost efficient to substitute another source for Edwards water. This dictates that reduction of domestic sanitation demands constitute the only significant conservation opportunity.

Flush water recycling might save around 13,000 gallons per month. All plumbing to the bathrooms is reported to be readily accessible, so that physical barriers appear to be minimal. But, as with Chatleff Controls, the rate of return on the investment required to recycle flush water would be very low, since apparent water cost is only 25 cents per 1,000 gallons plus pumping costs.

The other component of domestic supply is lavatory use. It is estimated that the volume of this demand is similar to toilet flush water demand. A more cost efficient approach might be to treat lavatory wastewater and use the effluent to supply flush water demands, and perhaps to supply parts wash water as well. Again, however, it is questionable whether the costs of these facilities would be low enough to deliver an adequate rate of return.

3.4.1.4 Onion Creek Memorial Park

If turf is the only landscape deemed acceptable for a cemetery, then using an alternative water supply constitutes the only means by which Onion Creek Memorial Park could conserve Edwards water. The only other water source available is Trinity wells--an option considered in detail later in this section. If, in the future, surrounding developments should opt for some form of organized wastewater treatment system, that effluent might be routed to this demand.

3.4.1.5 Texas Lehigh Cement Company

Almost all of the demands at Texas Lehigh's plant are of a non-potable nature. This suggests that significant conservation may be obtained by substituting sources other than Edwards water. Wastewater from internal processes might be reused as well. Presently, some of the waste flow is already being reused for dust control on haul roads around the plant.

The recirculating cooling system could operate well with any source which does not contain too high a level of TDS. Possibilities for substitute sources are Trinity wells, rainwater harvesting, and the City of Buda's wastewater effluent. Buda currently produces approximately 100,000 gallons per day of effluent. This could completely supply the average daily cooling tower demand of 63,000 gallons per day. A very preliminary analysis indicates that something less than 3 million gallons per year of rainwater could be harvested from the roofs of the two large buildings at the plant. The Trinity option is considered further later in this section. Cooling tower blowdown might be reused for flush water make-up or to supply the clinker dump spray water.

The analyzer probe apparently requires high purity water. Perhaps this is a demand that rainwater harvesting can be used to defray. Being laden with chemicals, it is questionable if the waste flow from this process could be reused for anything other than dust control.

Wastewater treatment plant effluent might be reused for landscape irrigation. Flush water recycling might also be considered, with any residual being routed to cooling tower supply. The volume of flow to the wastewater treatment plant could be reduced through a fixture retrofit or replacement program.

The quality of the waste flow from equipment washdown, the emergency spray system and/or the clinker dump spray system could also be investigated to see if it could be reused for anything other than dust control. It is expected that, since it is routed to the final settling pond and intermittently discharged from the plant site to surface waters of the state, it is very lightly polluted.

Presumably, the Lurgi spray system could operate with any well clarified water having a TDS level similar to that of Edwards water. Possible alternate sources include rainwater harvesting and the City of Buda's effluent. Since the total volume and temporal distribution of this demand have not been detailed for this study, it is not possible to evaluate whether either of these actions is feasible.

At the main office complex, interior demands could be decreased through fixture retrofit/replacement and/or flush water recycling. Wastewater might also be reused for irrigation of the grounds. Irrigation demand could be reduced by relandscaping using Xeriscape concepts.

The costs for implementing of these conservation measures are not likely to be fiscally justifiable to Texas Lehigh under present circumstances. With an apparent cost of water of 25 cents per 1,000 gallons plus pumping costs, the measures considered would probably not produce a favorable rate of return.

3.4.1.6 Onion Creek Country Club

At present, the vast majority of Onion Creek's irrigation water is supplied by its wastewater treatment plant effluent. Edwards water is used only for supplemental supply during periods of high demand. Onion Creek is contemplating the abandonment of its wastewater treatment plant in favor of delivering its wastewater to the City of Austin when an interceptor main is constructed. If the effluent were replaced by Edwards water, Onion Creek would probably have to increase it pumpage over 30-fold.

The immediately obvious solution is for Onion Creek to continue to operate its own treatment plant and to utilize the effluent for irrigation. Management appears to be somewhat adverse to this idea, partly because of the "hassle factor" of dealing with plant permit and compliance, but mostly because they are not convinced that operating the treatment plant would be less expensive than paying 25 cents per 1,000 gallons plus pumping costs for Edwards water. It is questionable, however, if the fiscal situation has been duly considered in light of all its implications. Besides the microeconomic impacts upon the Onion Creek management company, capacity charges and wastewater fees charged by the City of Austin to Onion Creek residents should also be taken into account. Losing the nutrients in the effluent should cause increases in golf course fertilization costs as well.

Three other possible opportunities for decreasing dependence upon Edwards water at Onion Creek can also be identified. One is to alter some of the landscaping using Xeriscape concepts. Since irrigation of the golf course fairways and greens dominates, it is questionable if a significant fraction of total demand could be saved in this manner.

Second, drilling a well in the "bad water" zone could be investigated. It would have to be determined whether that water would be so high in TDS or other undesirable constituents as to require treatment for irrigation usage. If so, it is unlikely that this course of action would be cost efficient relative to other options.

The third possibility would be to participate with the City of Austin to extend to Onion Creek an effluent line which is currently being planned to serve Jimmy Clay Golf Course. There are two problems with this course of action, however. In addition to capital costs, there would be a charge for the water. Austin is currently charging Bergstrom Air Force Base 24 cents per 1,000 gallons for effluent used to irrigate their golf course. Therefore, paying 25 cents per 1,000 gallons for Edwards water appears to be a more fiscally sound option for Onion Creek. Also, it is uncertain whether the Jimmy Clay line--much less any extensions of it--would be constructed within the next five years.

3.4.1.7 Comal Tackle Company

Comal Tackle could reduce its demand considerably by implementing a recirculating cooling system. The company has investigated this possibility and has drafted plans to pursue it. However, implementation is not fiscally justifiable at this point. The estimated cost of the recirculation system is $10-15 thousand. Usage average about 15,000 gallons per day, with approximately 99% of this demand being used for the cooling system. Assuming that the recirculation system would result in 100% savings in cooling water (unrealistic as there would be evaporative and blowdown losses, which would vary with weather and supply water quality) the total amount saved would be about 3.9 million gallons per year. Neglecting costs for operation and maintenance, the net payback at 25 cents per 1,000 gallons would be $975 per year. Even under these highly idealized conditions, the rate of return is very low, as the payback period is in excess of 20 years.

Another option which could be considered is to provide an alternate source of water. Candidates include Trinity wells and the City of Buda's effluent. The latter is not favored by company management due to health concerns. In any case, it would be practically necessary to implement the recirculation system along with these options to reduce the waste flow to a manageable magnitude. It is even more unlikely that both actions together would be found economically efficient, so Comal Tackle could not be expected to pursue an alternate source of supply under present conditions.

Demands for domestic type supply could be reduced as well by fixture retrofit or replacement or by flush water recycling. However, especially given the apparently small savings potential, an acceptable rate of return on these investments is not to be expected at the present apparent cost of water.

3.4.1.8 Centex Materials

The recently instituted wash water recycling system is expected to result in significant reductions in demand. Annual usage is now expected to be about 11 million gallons. Gravel washing is a non-potable demand which could be satisfied with lower quality water sources. Two possible sources are a Trinity well and the City of Buda's effluent. The former option is discussed later in this section. Buda's effluent could only supply about 36 million gallons per year. While this may be a significant percentage of total requirement, there are practical problems in implementing this option, i.e., water demand by Centex is not constant and continuous. At the apparent present price of Edwards water, there is no fiscal incentive for Centex to pursue any alternative supply sources.

3.4.1.9 Hays Consolidated Independent School District

Demands at Hays schools include domestic type supply, irrigation, and cooling towers. Available conservation opportunities include:

1. Treatment of domestic waste flows and reuse as cooling tower and irrigation system supplies;
2. Treatment of greywater fractions and reuse for flush water supply;
3. Flush water recycling; and
4. Fixture retrofit or replacement.

Both fiscal justification and implementation feasibility must be considered for these courses of action. Additional study of these options should be pursued.

3.4.2 SUMMARY AND ANALYSIS OF CONSERVATION OPPORTUNITIES

3.4.2.1 Fixture Retrofit or Replacement

As a percentage of total demand for most users in this sector, it does not appear that savings from fixture retrofit or replacement would be significant. However, every gallon saved in this sector is just as valuable as a gallon saved in the residential interior use sector, where these activities constitute a major conservation strategy. This indicates that these activities should be pursued wherever practical. In situations where a user is self-supplied, the present apparent cost of water is so low that fiscal justification of these measures is a highly questionable proposition. In such cases, regulation and/or fee-based incentives to encourage institution of these measures may have to be pursued.

3.4.2.2 Treatment and Reuse of Waste Flows

This category probably provides the greatest opportunity for long-term reduction in demand. Possibilities include:

1. Treatment and reuse of greywater, process water and/or combined flows to satisfy appropriate non-potable demands;
2. Process water recycling;
3. Flush water recycling.

These strategies should become standard operating procedure for entities running facilities in this area. Again--due to the very low apparent cost of water to self-supplied entities--regulation, fiscal aid programs, and/or fee-based incentives may have to be instituted to induce these actions.

3.4.2.3 Substitution of Alternate Supply Sources

3.4.2.3.1 Wastewater Effluent Reuse

Presently, the City of Buda provides the only readily accessible source of wastewater effluent which could be used to satisfy non-potable demands in this sector. Present and anticipated development within the study area does not appear to favor the implementation of other centralized wastewater management systems.

As discussed previously, it appears more advantageous and cost efficient for Buda to reuse its effluent for irrigation supply in its service area through a dual distribution system. This would also provide a means to cost efficiently route effluent to other non-potable demands, such as industrial process waters, within the confines of that system.

It would appear that Buda has an incentive to pursue effluent reuse. Under present arrangements, any expansion of treatment plant capacity will require a higher degree of treatment--to "5/5/2/1" standards, with the "1" being a total phosphorus limitation--and discharge into Onion Creek. The cost of this plant upgrading will be high, and, particularly due to the phosphorus removal requirement, the operating costs of this plant would also be high. For the reuse option, even though the required facilities might also be costly, this strategy would produce an income flow from effluent sales, and operating costs would probably be much lower.

However, Buda currently has a large excess treatment capacity, constructed during the mid-80's "boom". With the capital burden of all this excess capacity, Buda has little incentive in the short term to expend further capital for reuse projects. Any efforts to institute effluent reuse may therefore require some form of incentive or fiscal aid.

3.4.2.3.2 The Trinity Aquifer

It has often been suggested that Edwards water might be conserved by supplying large non-potable demands from the Trinity aquifer. This suggestion may have merit, at least for specific demands in specific locations. Anecdotal evidence, a limited review of drillers' logs, and data in TWDB reports LP-205 ("Ground-Water Conditions of the Trinity Group Aquifer in Western Hays County") and No. 276 ("Occurrence, Availability, and Quality of Ground Water in Travis County, Texas") indicate that good quality water at reason-able flow rates can be obtained from some Trinity wells.

There are significant concerns, however, about the general long-term viability of this strategy. In the Balcones Fault Zone, where the Trinity underlies the Edwards, little is known about two important factors. One is whether pumping from Trinity wells would eventually cause drawdown of Edwards storage levels due to inter-aquifer leakage. While there is generally an effective aquiclude between these two water-bearing strata, local faulting may create the opportunity for significant "drainage" of Edwards water into Trinity strata if the latter is drawn down sufficiently. Therefore, neither local nor regional problems of reductions in Edwards storage level may be solved by shunting demands to the Trinity aquifer.

The second concern is the long-term availability of Trinity water. It appears that recharge to these strata is very slow. In addition, local faulting patterns may have isolated "pools" of Trinity water which are not recharged at all except by interaquifer leakage along fault lines. Use of Trinity wells may therefore constitute groundwater mining, implying that this strategy has a limited useful lifetime. At any particular location, the length of this useful lifetime would be determined by local geohydrology and the extent of demand.

Regardless of these concerns, water from Trinity wells is certain to be more expensive than water from Edwards wells. First, depths from which water would be pumped are greater, in the vicinity of 1,000 feet for a typical Trinity well versus 150-400 feet for Edwards wells. Second, while good quality water is obtained in places from Trinity wells, water from these strata is generally of lower quality than Edwards water. Treatment costs may be incurred in order to utilize Trinity water for some purposes.

In order to evaluate the merit of pursuing this strategy, additional investigations must be undertaken. This strategy should not be viewed as an immediate panacea, nor should it be rejected out of hand. A program to determine the extent and quality of supply available from the Trinity aquifer throughout the BS/EACD jurisdictional area should be instituted.

3.4.3 ECONOMIC DEVELOPMENT ISSUES

Neither the volume nor character of present demands in this sector may be representative of those imposed by future development in this sector. To hold future demands in check, water use must become an important factor in deliberations over economic development. Two considerations are immediately obvious.

One is to preferentially recruit "dry" industries, or, at least only those in which process water can be readily recycled, resulting in minimal net demand. Some may argue that such a restriction might unduly inhibit economic opportunities for this area. However, this is countered by considering the high costs of alternative water supply, which may be necessitated if industrial demands escalate.

Alternatively, or in concert with the above consideration, the location of industries relative to one another can also serve to hold industrial demand in check. Complexes might be planned with complementary industries, so that opportunities for reuse are maximized by facilitating transfer of waste flows from a generator to a possible user.

3.5 OPPORTUNITIES FOR REDUCING UNACCOUNTED-FOR LOSSES

3.5.1 STANDARDS FOR "ACCEPTABLE" LOSS RATES

Though a 10 to 15 percent loss rate is often touted as a "rule of thumb" level indicating adequate effort at loss control, it is impractical to apply a single numerical criterion uniformly to all suppliers, especially for a group so heterogeneous as those in the study area. The key to determining what level is "acceptable" for any utility is knowing its characteristics and knowing where the water goes. The American Water Works Association (AWWA) in its research report "Water and Revenue Losses: Unaccounted-for Water" states this succinctly: "A responsible utility should know where <u>all</u> of the water it purchases or produces is going." [Emphasis in original.]

Determination of "acceptable" levels of unaccounted-for water also depends upon how that term is defined. Often, the "metered ratio" is taken as a measure of unaccounted-for losses. This neglects many "authorized" uses which are not metered, such as fire fighting and training, sewer and street cleaning, hydrant and water main flushing, freeze protection, water quality testing, etc. The nature of the area served by the utility will determine the level of "losses" to each of these functions.

AWWA recommends a new system of definitions which better quantify the nature of "losses". All water flowing to a metered account is termed "account water" and all other water is labelled "non-account water". Water uses known and approved or authorized by the utility, whether measured or estimated, are termed "authorized water uses". Water lost through theft, malfunctioning controls, or illegal connections, and all water apparently "lost" due to metering inaccuracies is called "system water losses". Water lost through leakage is termed "system leakage".

It is this latter category--the true waste--which is the major target of a conservation program aimed at minimizing pumpage from the Edwards aquifer. This is not to imply that efforts to conserve on "authorized" losses are not important as well, and they should be pursued.

Within the "system leakage" category, AWWA recognizes two components: "unavoidable" and "recoverable". The former is defined as losses which would cost more to locate and repair than the value of the water saved over a reasonable amount of time. The latter are losses through leaks and breaks which are considered economical to repair. Thus, the perceived value of water and the characteristics of the supply system are the major determinants of what constitutes an "acceptable" level of this true waste.

AWWA provides an "unavoidable leakage index" equation which attempts to quantify "acceptable" loss rate, based upon the characteristics of the supply system. Factors incorporated include:

1. A pipe age factor;
2. Number of joints in the length of pipe being considered;
3. Number of fire hydrants connected to the pipe;
4. Number of valves connected to the pipe;
5. Other appurtances connected to the pipe;
6. Number of service connections to the pipe;
7. The nominal diameter of the pipe;
8. The average pressure maintained in the pipe; and
9. A pipe material conversion factor.

This equation might be used by water suppliers as a first approximation of "unavoidable" or "acceptable" leakage losses. However, because it does not explicitly include any measure of the value of water, it must be assumed that it is based upon some presumption of water value. This is extremely likely to be rooted in historical observations of water supply costs. As detailed in Section 3.0, this may not be very good measure of the true value of the water lost in the study area.

3.5.2 LOSS CONTROL MEASURES

As outlined above, leak detection and repair is the heart of a loss control program aimed at achieving a reduction in true waste. Also, attention to accurate metering of actual usage and of production/purchases can serve to assure that the utility is not losing revenue, and that the metered ratio more accurately reflects a real loss rate. Several methods can be used to detect leaks, identify inaccurate accounting of water, and maximize the utility's efforts to reduce losses of water and revenue.

3.5.2.1 Meter Reading

The meter reader is an important part of an overall leak detection program. These people should be properly trained to observe the area as they go about their rounds, watching for continuous wet spots, leakage in meter boxes, etc. They can report stopped or broken meters so that repairs or replacements can be made as soon as possible. Meter readers must carefully record their readings to ensure that system records are properly interpreted, so they will accurately reflect metered usage.

Utilities should make every effort to obtain qualified people for these positions, to give them adequate training, and to provide them with proper incentives to remain on the job and be motivated to perform their critical surveillance function.

3.5.2.2 Customer Accounts

Water may appear to be lost from the distribution system because of overlapping billing cycles, misread meters, improper calculation methods, computer programming errors and other "paper" problems. Apparent losses due to these accounting errors can be identified by a careful, step by step review of the procedures and practices for record keeping by the utility.

3.5.2.3 System Records

Keeping good records of line breaks and leak repairs assists the utility in determining estimates of system leakage. Along with records of metered usage and master meter readings, these estimates can provide the utility with an indication of the probable accuracy of their metering systems. It also allows the utility to better determine the merit of conducting a detailed leak detection survey.

If records show that leak and break locations tend to cluster in certain sections of pipe, this may indicate where line replacement should be given a high priority or where pressure reduction might be considered. These actions may in turn result in considerable long-term water savings. Good records can indicate which construction techniques and pipe materials ought to be favored for future line construction in various soil types. They can also reveal if certain contractors appear to be using improper construction techniques, as an aid to selection of contractors for future projects.

3.5.2.4 System Inspection

A comprehensive inspection of the system can reveal unauthorized connections and augment the observations of meter readers in their efforts to detect leaks. It can also reveal malfunctioning controls or other problems which might lead to water losses. System inspections should be conducted regularly by every utility.

3.5.2.5 District or Zone Measurements

Measuring water flow into various zones or districts of a water system can be an aid to monitoring losses. Of particular use in spotting leakage is measurement of nighttime flows into a zone or district. Such measurements are often used during leak detection surveys to help prioritize where to begin the detailed monitoring. Equipment is available which allows real time monitoring. This can be used to achieve quick response to major breaks.

3.5.2.6 Leak Detection Surveys

Methods of leak detection range from very simple, passive methods to extremely complex and complicated methods using electronic correlators and requiring specially trained personnel. The success of any leak detection program is dependent upon accurate system records, reflecting system components and areas where leakage has been a problem. Accurate system maps, upon which the locations of leaks found during the survey can be plotted, are also necessary for the maximum benefit from this process. This reinforces the above observations that good record keeping is essential to minimizing losses.

One approach to leak detection is what AWWA terms the "do-little" or "lay-back" approach. Leaks observed during the normal course of system operation and maintenance or are reported to the utility by others are fixed as they are found. Any non-surfacing leaks are ignored unless they lead to complaints of excessive pressure losses. According to AWWA, only 30% of leaks surface. This emphasizes the need for a comprehensive leak detection survey. Most underground leaks will not become evident during the course of normal operating procedures and consequently would not be found by passive methods.

Water leaking from an underground pipe produces noise due to vibration and impact, so leak detection surveys employ listening devices. Before the advent of the electronic micro-chip, mechanical listening devices were used. Though still effective, these are being replaced with electronic devices, which can filter out background noise and amplify leak sounds to provide more accurate location. The more sophisticated the equipment, the greater the expense for purchase and operation. Therefore, choice of equipment and methods is basically determined by the expected extent of the problem and the perceived value of the water lost through leaks which would be detected by the survey.

3.5.2.7 Meter Testing and Repair

Master meters measuring production or purchases of water should be checked for accuracy on a regular basis to assure that the utility is getting a proper reflection of the water being introduced into its distribution system. Lacking confidence in these readings, all measurements of system loss rates will be suspect. For pumpage from Edwards wells, BS/EACD operating rules now provide that master meters may be checked for accuracy "... not more often than once every three ... years" at the utility's expense, or at any time at BS/EACD's expense.

Customer meters generally lose accuracy over time. Meters of this size almost invariably err to the side of under-registering consumption, so it is in the utility's interest to assure that they remain accurate. It is good practice to replace customer meters on a regular basis, rotating them through a maintenance program.

3.5.2.8 Water Audits

A complete water audit combines many of the above techniques into a comprehensive review of where and how water is introduced into and exits from the utility's system. The audit process is similar to that conducted by any business which desires to know how much product it has acquired, sold, given away, lost or had stolen. If properly utilized, the audit can be a valuable management tool helping managers to reduce water and revenue losses, reduce inefficiencies, plan renovations, and evaluate operations and water rates. Periodic water audits are necessary if a utility hopes to accurately track--and thus minimize--system losses.

AWWA states that water audits should include the following activities:

1. Verifying and updating system maps and records;
2. Master or source meter testing;
3. Verifying, quantifying, and updating water source inflow records, metered use records, and unmetered use records;
4. Testing commercial, industrial and domestic sales meters for accuracy;
5. Inspecting water measuring devices for proper sizing, installation, and operation;
6. Field checking distribution controls and system operating procedures; and
7. Compiling the adjusted information to determine water and revenue loss quantities and loss categories.

3.5.3 EFFECTIVENESS OF LEAK DETECTION PROGRAMS

The actual benefits accruing to any given utility from conducting a leak detection survey would depend upon its particular circumstances, e.g., how well prepared the utility is maximize the effectiveness of the survey, prevailing system leakage, perceived value of the water to be saved, the costs of making the required repairs, etc. Indications of water savings attainable from this effort are provided by the experiences of utilities having conducted a leak detection survey.

The Lower Colorado River Authority has conducted leak detection surveys for a number of Central Texas water utilities. A summary report on 20 of those surveys showed the following:

1. Average number of connections surveyed = 1112;
2. Average number of leaks found = 31;
3. Average estimated leakage loss per month = 757,858 gallons;
4. Average estimated meter error loss/month = 880,213 gallons; Average $ value of losses at local rates = $2,076.00/month; and
5. Average reduction in losses from survey = 46.2 percent.

One of the systems receiving these services was Goforth WSC. Specific benefits for Goforth were reported to be a savings of 118,800 gallons/month from 16 identified leaks, and identification of 1,361,700 gallons in paper losses due to metering errors. The fiscal benefit to Goforth of applying the survey results was estimated at $1,480 per month.

In Goforth's case, a rather small potential for "real" water savings was identified. However, Goforth had been executing a fairly intensive leak reduction campaign for about a year while they were on the waiting list for LCRA's leak detection services. This is reflected in the reduction of their annual average loss rate from 24.1% in 1987 to 12.7% in 1988, as shown in Table 3.28. In terms of volume, average losses dropped from 2.68 million gallons per month in 1987 to 1.34 million gallons per month in 1988, an apparent savings of 1.34 million gallons per month.

3.5.4 METHODS OF PURVEYING LOSS REDUCTION ACTIVITIES

While every water supplier can probably augment its surveillance activities and improve the quality of its records for minimal additional expense, detailed water audits and leak detection surveys are rather costly undertakings. Many of the water suppliers within the study area are unlikely to consider these services to be affordable.

This perspective may be at least partially attributable to the relatively low perceived value of water which might be saved. Perhaps water suppliers should be asked to estimate their long-run marginal cost of water, then to judge the merit of loss control programs against that price rather than the presently perceived value. This would "automatically" render their loss control measures economically efficient. The real level of economic efficiency would be limited, however, by the accuracy within which the long-run marginal cost could be determined.

Even using a realistic estimate of the long-run marginal cost, however, local water suppliers--especially the numerous small systems which predominate in the study area--still might not be able to justify the costs of these programs, due to the low volume of attainable savings. By pooling resources with other water suppliers, however, water audit and leak detection survey programs may be instituted in an affordable manner. A function of BS/EACD might be to sponsor such a collective loss control program.

BS/EACD could either capitalize in-house capability to conduct these programs, or could work with LCRA, the City of Austin, the TWDB, or other appropriate entities to pass their services through to the water suppliers. As outlined in Section 3.6, funding for this program might be provided by placing the portion of pumpage fees determined to be attributable to lost water in a fund dedicated for this purpose.

3.5.5 LOSS PREVENTION THROUGH CONSTRUCTION STANDARDS

Many water lines installed in this area are constructed without an embedment envelope around the pipe. Especially in the highly expansive clay soils which cover much of the study area, this is likely to be the cause of many leaks. Without embedment, expansion and contraction of the soils with cycles of wetting and drying can cause pipes to crack and pipe joints to separate. The justification offered for not embedding water lines is the excess cost. Once again, it is perceived that the value of the water potentially lost due to this practice is too low to justify incurring the cost for measures which would prevent the loss.

Based on preliminary cost calculations, it is estimated that about a 15% increase in construction cost per foot of pipeline would be incurred by providing a high-quality embedment envelope. In the general case, pipeline costs are far less than the full project costs, which also include appurtances, engineering and inspection. Therefore, the premium imposed upon any project by requiring pipe embedment is likely to be something less than 10%.

Investigations should be made to determine how effective embedment might be at reducing system leakage. If the potential volume reduction appears significant, it should be determined whether it would be economically efficient to embed new or replacement water lines, taking into account a reasonable estimate of the long-run marginal cost of water. If so, consideration may then be given to encouraging or mandating this practice through regulation and/or fee-based incentives.

3.6 PRICING AS A COMPONENT OF CONSERVATION PROGRAMS

3.6.1 A GENERAL REVIEW OF PRICING ISSUES AND POLICIES

The impact of water rates upon demand has been studied and debated a great deal, and there appears to be little unanimity of opinion on this issue. While most well conceived and executed studies have shown price elasticities significantly different from zero, there is some disagreement over what this means in practical terms.

It has been argued that, at least in the range of prevailing prices, water bills do not comprise a large enough fraction of many consumers total expenses for alterations or increases in rates to make much difference. So, while there may be some "shock" reductions in demand in response to rate changes, customers soon adjust to the new rates and go on using water along the lines of their old habit patterns. Even when elasticities have been shown to be enduring, they are often quite low. The Organization for Economic Co-operation and Development (OECD) publication "Pricing of Water Services" states that "... it now seems safer to quote price elasticities for year-round and off-peak use in the -0.005/-0.30 range rather than the -0.4 figure derived in many of the earlier studies."

Indeed, it may be that alterations in price structure--at least those which result in relatively minor impacts on the consumer's total budget--cannot, by themselves, directly induce significant conservation. OECD points out four specific limitations of pricing:

1. Elasticities may be too low to justify the costs of complex charging schemes, thus limiting the extent to which costs can be accurately represented by any practical tariff;

2. Customers may not understand the charging scheme, especially if it is complex, and so not respond to it "rationally";
3. Consumers may not possess adequate technical and financial information concerning their options for economizing on water use, so may fail to act on those opportunities; and
4. The "first cost barrier" may prevent consumers from implementing water saving opportunities because, in the short term, it appears less onerous to pay the increased water use costs.

The third and fourth limitations tend to induce the use of low cost or no cost "removable" conservation measures as the customers' response to a water price increase. Studies which have indicated that demand reductions are merely temporary may have been reflecting just such a reaction.

These limitations demonstrate that using pricing policy to induce conservation would be most useful within the context of a comprehensive program promoting conservation through regulation, education, incentives, and operational improvements as well as tariff adjustments. Under such circumstances, there is evidence to suggest that a shift to "conservation oriented" rate structures would have a significant impact upon demand.

It is important, even if price elasticities appear to be low, to send the proper signal to water users about the true long-run marginal cost of the water. OECD states this emphatically: "The experience of Member countries ... makes it seem certain ... that long-term water conservation requires first and foremost the use of prices as incentives to further the rational use and allocation of water services." Perhaps price should be viewed as a "psychological spur" to induce the implementation of "durable" conservation measures.

3.6.1.1 Average vs. Marginal Costs and Prices

Most rate setting practices are based on average cost pricing methods. First the revenue requirements are determined, followed by the processes of cost functionalization, cost classification, interclass cost allocation, unit average cost calculation, and finally rate design. One starts with the premise of the equality of revenues and costs, then performs a class cost allocation which achieves this equality. It is important to note that these are historic accounting costs, so that average cost pricing methods "look back" for their basis.

Marginal cost pricing, on the other hand, starts with the selection of a planning period, followed by estimates of unit marginal cost--the additional cost of producing or selling an incremental unit of water supply--for expanding, operating and maintaining the system throughout that period. Then a rate structure is designed, and finally, there is a reconciliation of costs and revenues. One starts with the premise of the equality of prices and costs, followed by price adjustments to assure this equality. Note that marginal cost pricing methods "look ahead" for their basis.

The discussions in Section 3.0 regarding the long-run marginal costs in the BS/EACD area make it immediately obvious why a pricing system which "looks ahead" is preferred there. Water rates based on marginal cost provide the foundation for attaining efficient utilization of system capacity and attaining economic efficiency for the capital investment required to provide the necessary capacity. Rates need to reflect--to the maximum extent practical--the true long-run value of water so that fiscal paybacks on conservation measures deliver the full value of the supply so created.

To be sure, there are many practical problems with implementing "pure" marginal cost pricing, including prediction problems, cost calculation, excess revenue generation, income distribution, etc. In most cases, the problems are surmountable and should not be used as excuses for avoiding rate reforms to send proper price signals.

It is called to question whether consumers respond to the marginal price of additional water usage or to the average price of all the water used. This only bolsters the argument that consumers should be confronted by rate structures with increasing marginal costs. All available evidence indicates that future marginal costs will be in excess of historic average costs, due to a number of factors--e.g., need to pipe in a new supply, need to deepen wells, need to pump from a greater depth, need to treat a new water supply, need to fund artificial recharge projects, etc. With this in mind, perhaps it is a good "rule of thumb" for rate structures that marginal rates should at least equal--and preferably exceed--average rates at all levels of consumption.

In practice, this rule would probably have to be modified in order to ensure revenue stability. Average rates for very small demands may have to exceed the marginal rate because some minimum cost for maintaining and administering that account would still be incurred. It may be helpful in this regard to view what are generally considered to be "fixed" costs as actually being commodity-related. That is, there would be no need for general administration, meter reading, etc., if the commodity was not demanded. By packing these costs into the commodity charge, it would be possible to fiscally justify smaller fixed or minimum charges and higher commodity charges, serving to boost the marginal/average rate ratio.

3.6.1.2 Options for Tariff Structures

3.6.1.2.1 Flat Rates

Under a flat rate structure, all customers are assessed a fixed charge per billing period, regardless of demand. While this rate structure may be viewed by the water supply entity as the best way to guarantee revenue stability, it is notoriously anti-conservation. OECD states the case against the flat rate structure quite succinctly: "... the marginal price to the consumer of all units of consumption, including those contributing to system peaks, is zero. Only the high cost of introducing metering ... may justify the maintenance of such systems."

3.6.1.2.2 Declining Block Rates

This structure has been justified in the past by the perception that a utility tends to experience decreasing unit costs with increasing usage through load factor improvement and economies of scale. It also enhances revenue stability. Since water demand is affected in a somewhat random manner by weather and customer mix, placing the more price elastic demands in lower cost tail blocks tends to dampen changes in revenue due to changes in usage.

It can be readily questioned whether the declining block structure really tracks costs. Small users are likely to be subsidizing large users under this rate structure, particularly so in this area, where long-run marginal costs of water are likely to be higher, not lower, than average costs. And naturally, with prices less than costs in the tail blocks, this rate structure is also not very conducive to conservation.

3.6.1.2.3 Increasing Block Rates

This rate structure has often been adopted as a form of conservation pricing, in that it tends to discourage increasing demand through price signals. Support for this rate structure comes from utilities experiencing increasing costs with system expansion, which is the situation expected to face water supply entities here. The BS/EACD by-laws, in fact, require all water suppliers to adopt an increasing block rate.

A criticism of this structure is that large users are not necessarily contributors to peak demand, nor are they necessarily inefficient users. This method also alters income distribution, and it is questionable that usage--or at least efficiency of usage--is positively correlated with income levels. Further, the increasing block rate renders system revenue more unpredictable. More of the revenue potential is packed into the more price elastic higher demand blocks. Thus, the vagaries of weather, etc., can more readily cause over-production or under-production of revenue. Finally, in an effort to reduce water bills, users may cut average demands without cutting peak demands, resulting in decreasing load factors and needle peaking.

3.6.1.2.4 Uniform Commodity Rate

Given the limitations of both declining and increasing block rate structures, the uniform commodity rate structure has gained increasing favor. While it may not track costs with precision, it is simple to understand, and, since each unit of demand is priced the same, it is compatible with common notions of fairness and equity. If the commodity price is derived through marginal cost pricing methods, it can be argued that this rate structure also advances conservation, since the price would more closely signal the long-run marginal value of the water.

In practice, this structure is usually implemented in combination with a fixed or minimum charge, aimed at recovering the "fixed" costs of service. A high fixed or minimum charge minimizes the impetus for conservation, making the structure appear more like a flat rate. As OECD points out: "Flat-rate payments resulting from high minimum charges in a situation of universal metering are even more difficult to justify [than a true flat rate structure]."

3.6.1.2.5 Seasonal Pricing

When peaking is a major determinant of system costs, seasonal pricing may offer a method for signaling to the customer the higher marginal costs of peak period demand. This is becoming recognized as superior to increasing block rates as a method of reducing peak demands, as it avoids some of the equity problems. All consumers experience the peak period surcharge in proportion to their actual use in the peak period.

Two methods of implementing seasonal pricing have been used. One is to impose a higher commodity charge for all use during the peak period. The other is to impose a higher commodity charge only upon "excess" use, which is usually defined as all demand greater than average off-peak period demand. Under the latter scheme, only users which increase their demands during the peak period experience the higher charge, which satisfies one view of equity. But an alternate view is that all consumption in the peak period contributes to the peak, whether this is "excess" use or not, so all contributors should pay equally, favoring the former scheme.

Another method of penalizing peaking is to impose a "demand charge". The amount of this charge would be determined by a customer's maximum usage for a previous billing period, e.g., the last 12 months. This charge would be imposed upon each bill until that customer establishes a new level. This encourages the user to cut peak usage in order to obtain a lower demand charge. This scheme has been extensively employed by electric utilities.

A problem with any attempt to impose seasonally differentiated rates is that meters are not read with sufficient frequency to assure that the objectives of the charging scheme are achieved. Consumers may cut average demands in peak periods in an effort to decrease their total bills, but may not cut peak demands, resulting in needle peaking and a deteriorating load factor. This may be detrimental to individual supply systems, but in terms of minimizing depletion of aquifer storage, it is irrelevant. For that purpose, it is the reduction in total annual demand which is important. As noted in Section 3.1, there appears to be considerable potential for such savings through lowering of seasonal peak demands.

3.6.1.3 Capacity Charges

Many utilities recover some or all of the cost of system expansion, supply augmentation, etc., through the imposition of capacity charges. These usually take the form of a one-time charge when the customer is connected to the system. Capacity charges are noted here because they may "hide" some of the long-run marginal cost. To the extent that a utility attempts to cover marginal costs through the capacity charge rather than through commodity charges, water savings gained by conservation measures would not yield water bill reductions commensurate with the true value of the relieved capacity.

Utilities which employ capacity charges should take this problem into account when attempting to design a rate structure conducive to conservation. A possibility is to institute a reduction or rebate of the capacity charge in response to demonstrable efforts to achieve "durable" conservation--e.g., installing an ultra-low volume toilet.

3.6.2 RATE STRUCTURES IN CURRENT PRACTICE

Shown in Table 3.41 are the tariff structures currently employed by many of the water supply entities in the study area. Tables 3.42 through 3.59 display analyses of those tariffs, showing the total bill and average cost per 1,000 gallons for monthly demands between 1,000 and 30,000 gallons. Many of the tariffs now in use employ a high minimum charge--some of which include a fairly high water allowance--along with a relatively low commodity charge. The analysis tables show that these result in average rates exceeding marginal rates in all cases. This is so even in the one system which employs an increasing block rate, since it imposes such a high minimum charge in relation to the top block charge.

In terms of promoting conservation by sending the proper price signals to customers, it is apparent that the tariffs which have been analyzed in Tables 3.42 through 3.59 are quite deficient. In concert with the other conservation programs suggested in this report, water suppliers should consider revising their tariffs to more accurately reflect the apparent high long-run marginal costs of failing to cut back upon per capita water demands.

The levels of apparent average winter (base) demand and apparent average summer (peak) demand in each system and the bills incurred at these two levels are compared in Table 3.60. This shows that there is a great disparity between the ratio of demands and the ratio of the water bills that these demands incur. The fiscal penalty that even rather high peaking imposes is relatively small. Some of the tariffs differ only superficially from a flat rate structure.

TABLE 3.41 TARIFF STRUCTURES CURRENTLY USED IN BS/EACD AREA

SYSTEM NAME	RATE	MIN. GALLONS	COMMODITY CHARGE
Arroyo Doble	$ 14.38	3000	$1.69/1000
Bear Creek Park	17.37	3000	$1.59/1000
Buda, City of	4.25	1000	$1.50/1000
Chaparral Park	25.00	3000	$2.15/1000
Cimarron Park	22.45	5000	$1.29/1000
Creedmoor-Maha	15.00	3000	$2.85/1000
Copper Hills	22.25	5000	$1.75/1000
Dellana Hills	30.00	Flat Rate	
Estates W.S.C	18.00	1500	(1500-5000) $.75/500 (5000-10000) $1.00/500 (>10000) $1.50/500
G&J W.S.C.	35.00	Flat Rate	
Goforth	12.00	0	(up to 10000) $1.25/1000 (>10000) $2.25/1000
Leisurewoods	25.40	2000	$1.99/1000
Mountain City Oaks	15.55	3000	$1.35/1000
Onion Creek Meadows	17.37	3000	$1.59/1000
Ridgewood Village	15.87	3000	$1.785/1000
San Leanna	13.50	10000	$1.50/1000
Slaughter Creek Acres	17.00	5000	(up to 20000) $1.00/1000 (>20000) $1.40/1000
Sunset Valley	22.50	10000	$1.00/1000

TABLE 3.42 ANALYSIS OF TARIFF USED BY ARROYO DOBLE

TARIFF SYSTEM ANALYSIS SYSTEM NAME: ARROYO DOBLE MARGINAL RATE = $1.69		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 14.28	$ 14.38
2,000	14.38	7.19
3,000	14.38	4.79
4,000	16.07	4.02
5,000	17.76	3.55
6,000	19.45	3.24
7,000	21.14	3.02
8,000	**22.83**	**2.85 Winter Avg.**
9,000	24.52	2.72
10,000	26.21	2.62
11,000	27.90	2.54
12,000	**29.59**	**2.47 Summer Avg.**
13,000	31.28	2.41
14,000	32.97	2.36
15,000	34.66	2.31
16,000	36.35	2.27
17,000	38.04	2.24
18,000	39.73	2.21
19,000	41.42	2.18
20,000	43.11	2.16
21,000	44.80	2.13
22,000	46.49	2.11
23,000	48.18	2.09
24,000	49.87	2.08
25,000	51.56	2.06
26,000	53.25	2.05
27,000	54.94	2.03
28,000	56.63	2.02
29,000	58.32	2.01
30,000	60.01	2.00

TABLE 3.43 ANALYSIS OF TARIFF USED BY BEAR CREEK PARK

TARIFF SYSTEM ANALYSIS SYSTEM NAME: BEAR CREEK PARK MARGINAL RATE = $1.59		
VOLUME	TOTAL COST	AVERAGE RATE
1,000	$ 17.37	$ 17.37
2,000	17.37	8.69
3,000	17.37	5.79
4,000	18.96	4.74
5,000	20.55	4.11
6,000	**22.14**	**3.69 Winter Avg.**
7,000	23.73	3.39
8,000	25.32	3.17
9,000	26.91	2.99
10,000	**28.50**	**2.85 Summer Avg.**
11,000	30.09	2.74
12,000	31.68	2.64
13,000	33.27	2.56
14,000	34.86	2.49
15,000	36.45	2.43
16,000	38.04	2.38
17,000	39.63	2.33
18,000	41.22	2.29
19,000	42.81	2.25
20,000	44.40	2.22
21,000	45.99	2.19
22,000	47.58	2.16
23,000	49.17	2.14
24,000	50.76	2.12
25,000	52.35	2.09
26,000	53.94	2.07
27,000	55.53	2.06
28,000	57.12	2.04
29,000	58.71	2.02
30,000	60.30	2.01

TABLE 3.44 ANALYSIS OF TARIFF USED BY THE CITY OF BUDA

TARIFF SYSTEM ANALYSIS SYSTEM NAME: BUDA, CITY OF MARGINAL RATE = $1.50		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 4.25	$ 4.25
2,000	5.75	2.88
3,000	7.25	2.42
4,000	8.75	2.19
5,000	10.25	2.05
6,000	11.75	1.96 Winter Avg.
7,000	13.25	1.89
8,000	14.75	1.84
9,000	16.25	1.81
10,000	17.75	1.78 Summer Avg.
11,000	19.25	1.75
12,000	20.75	1.73
13,000	22.25	1.73
14,000	23.75	1.70
15,000	25.25	1.68
16,000	26.75	1.67
17,000	28.25	1.66
18,000	29.75	1.65
19,000	31.25	1.64
20,000	32.75	1.64
21,000	34.25	1.63
22,000	35.75	1.63
23,000	37.25	1.62
24,000	38.75	1.61
25,000	40.25	1.61
26,000	41.75	1.61
27,000	43.25	1.60
28,000	44.75	1.60
29,000	46.25	1.59
30,000	47.75	1.59

TABLE 3.45 ANALYSIS OF TARIFF USED BY CHAPARREL WATER CO.

TARIFF SYSTEM ANALYSIS SYSTEM NAME: CHAPARREL WATER MARGINAL RATE = $2.15		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 25.00	$ 25.00
2,000	25.00	12.50
3,000	25.00	8.33
4,000	27.15	6.79
5,000	29.30	5.86
6,000	**31.45**	**5.24 Winter Avg.**
7,000	33.60	4.80
8,000	35.75	4.47
9,000	37.90	4.21
10,000	40.05	4.01
11,000	**42.20**	**3.84 Summer Avg.**
12,000	44.35	3.70
13,000	46.50	3.58
14,000	48.65	3.48
15,000	50.80	3.39
16,000	52.95	3.31
17,000	55.10	3.24
18,000	57.25	3.18
19,000	59.40	3.13
20,000	61.55	3.08
21,000	63.70	3.03
22,000	65.85	2.99
23,000	68.00	2.96
24,000	70.15	2.92
25,000	72.30	2.89
26,000	74.45	2.86
27,000	76.60	2.84
28,000	78.75	2.81
29,000	80.90	2.79
30,000	83.05	2.77

TABLE 3.46 ANALYSIS OF TARIFF USED BY CIMARRON PARK

TARIFF SYSTEM ANALYSIS SYSTEM NAME: CIMARRON PARK MARGINAL RATE = $1.29		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 22.25	$ 22.25
2,000	22.25	11.13
3,000	22.25	7.42
4,000	22.25	5.56
5,000	22.25	4.45
6,000	23.54	3.92
7,000	24.83	3.55
8,000	26.12	3.26
9,000	**27.41**	**3.05 Winter Avg.**
10,000	28.70	2.87
11,000	29.99	2.73
12,000	31.28	2.61
13,000	32.57	2.51
14,000	33.86	2.42
15,000	35.15	2.34
16,000	36.44	2.28
17,000	37.73	2.22
18,000	39.02	2.17
19,000	40.31	2.12
20,000	41.60	2.08
21,000	**42.89**	**2.04 Summer Avg.**
22,000	44.18	2.01
23,000	45.47	1.98
24,000	46.76	1.95
25,000	48.05	1.92
26,000	49.34	1.90
27,000	50.63	1.88
28,000	51.92	1.85
29,000	53.21	1.83
30,000	54.50	1.82

TABLE 3.47 ANALYSIS OF TARIFF USED BY CREEDMOOR-MAHA WSC

TARIFF SYSTEM ANALYSIS SYSTEM NAME: CREEDMOOR-MAHA MARGINAL RATE = $2.85		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 15.00	$ 15.00
2,000	15.00	7.50
3,000	15.00	5.00
4,000	17.85	4.46
5,000	20.70	4.14
6,000	23.55	3.93
7,000	**26.40**	**3.77** Winter Avg.
8,000	29.25	3.66
9,000	32.10	3.57
10,000	34.95	3.49
11,000	**37.80**	**3.44** Summer Avg.
12,000	40.65	3.39
13,000	43.50	3.35
14,000	46.35	3.31
15,000	49.20	3.28
16,000	52.05	3.25
17,000	54.90	3.23
18,000	57.75	3.21
19,000	60.60	3.19
20,000	63.45	3.17
21,000	66.30	3.16
22,000	69.15	3.14
23,000	72.00	3.13
24,000	74.85	3.12
25,000	77.70	3.11
26,000	80.55	3.10
27,000	83.40	3.09
28,000	86.25	3.08
29,000	89.10	3.07
30,000	91.95	3.06

TABLE 3.48 ANALYSIS OF TARIFF USED BY COPPER HILLS

TARIFF SYSTEM ANALYSIS SYSTEM NAME: COPPER HILLS MARGINAL RATE = $1.75		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 22.25	$ 22.25
2,000	22.25	11.13
3,000	22.25	7.42
4,000	22.25	5.56
5,000	22.25	4.45
6,000	24.00	4.00
7,000	25.75	3.68
8,000	**27.50**	**3.44 Winter Avg.**
9,000	29.25	3.25
10,000	31.00	3.10
11,000	32.75	2.98
12,000	34.50	2.88
13,000	**36.25**	**2.79 Summer Avg.**
14,000	38.00	2.71
15,000	39.75	2.65
16,000	41.50	2.59
17,000	43.25	2.54
18,000	45.00	2.50
19,000	46.75	2.46
20,000	48.50	2.43
21,000	50.25	2.39
22,000	52.00	2.36
23,000	53.75	2.34
24,000	55.50	2.31
25,000	57.25	2.29
26,000	59.00	2.27
27,000	60.75	2.25
28,000	62.50	2.23
29,000	64.25	2.22
30,000	66.00	2.20

TABLE 3.49 ANALYSIS OF TARIFF USED BY DELANNA HILLS

TARIFF SYSTEM ANALYSIS SYSTEM NAME: DELANNA HILLS MARGINAL RATE = $0.00		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 30.00	$ 30.00
2,000	30.00	15.00
3,000	30.00	10.00
4,000	30.00	7.50
5,000	30.00	6.00
6,000	**30.00**	**5.00 Winter Avg.**
7,000	30.00	4.29
8,000	30.00	3.75
9,000	30.00	3.33
10,000	30.00	3.00
11,000	30.00	2.73
12,000	30.00	2.50
13,000	30.00	2.31
14,000	30.00	2.14
15,000	30.00	2.00
16,000	30.00	1.88
17,000	30.00	1.76
18,000	30.00	1.67
19,000	**30.00**	**1.58 Summer Avg.**
20,000	30.00	1.50
21,000	30.00	1.43
22,000	30.00	1.36
23,000	30.00	1.30
24,000	30.00	1.25
25,000	30.00	1.20
26,000	30.00	1.15
27,000	30.00	1.11
28,000	30.00	1.07
29,000	30.00	1.03
30,000	30.00	1.00

TABLE 3.50 ANALYSIS OF TARIFF USED BY ESTATES WSC

TARIFF SYSTEM ANALYSIS SYSTEM NAME: ESTATES W.S.C. MARGINAL RATE = $3.00		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 18.00	$ 18.00
2,000	18.75	9.38
3,000	20.75	6.75
4,000	21.75	5.44
5,000	23.25	4.65
6,000	**25.25**	**4.21 Winter Avg.**
7,000	27.25	3.89
8,000	29.25	3.66
9,000	31.25	3.47
10,000	33.25	3.33
11,000	36.25	3.30
12,000	39.25	3.27
13,000	42.25	3.25
14,000	45.25	3.23
15,000	**48.25**	**3.22 Summer Avg.**
16,000	51.25	3.20
17,000	54.25	3.19
18,000	57.25	3.18
19,000	60.25	3.17
20,000	63.25	3.16
21,000	66.25	3.15
22,000	69.25	3.15
23,000	72.25	3.14
24,000	75.25	3.14
25,000	78.25	3.13
26,000	81.25	3.13
27,000	84.25	3.12
28,000	87.25	3.12
29,000	90.25	3.11
30,000	93.25	3.11

TABLE 3.51 ANALYSIS OF TARIFF USED BY GOFORTH WSC

TARIFF SYSTEM ANALYSIS SYSTEM NAME: GOFORTH WATER SUPPLY MARGINAL RATE = $2.25		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 13.25	$ 13.25
2,000	14.50	7.25
3,000	15.75	5.25
4,000	17.00	4.25
5,000	18.25	3.65
6,000	**19.50**	**3.25 Winter Avg.**
7,000	20.75	2.96
8,000	22.00	2.75
9,000	23.25	2.58
10,000	**24.50**	**2.45 Summer Avg.**
11,000	26.75	2.43
12,000	29.00	2.42
13,000	31.25	2.40
14,000	33.50	2.39
15,000	35.75	2.38
16,000	38.00	2.38
17,000	40.25	2.37
18,000	42.50	2.36
19,000	44.75	2.36
20,000	47.00	2.35
21,000	49.25	2.35
22,000	51.50	2.34
23,000	53.75	2.34
24,000	56.00	2.33
25,000	58.25	2.33
26,000	60.50	2.33
27,000	62.75	2.32
28,000	65.00	2.32
29,000	67.25	2.32
30,000	69.50	2.32

TABLE 3.52 ANALYSIS OF TARIFF USED BY G & J WATER CO.

TARIFF SYSTEM ANALYSIS SYSTEM NAME: G & J WATER COMPANY MARGINAL RATE = $0.00		
VOLUME	TOTAL COST	AVERAGE RATE
1,000	$ 35.00	$ 35.00
2,000	35.00	17.50
3,000	35.00	11.67
4,000	35.00	8.75
5,000	35.00	7.00
6,000	**35.00**	**5.83 Winter Avg.**
7,000	35.00	5.00
8,000	35.00	4.38
9,000	35.00	3.89
10,000	35.00	3.50
11,000	35.00	3.18
12,000	35.00	2.92
13,000	35.00	2.69
14,000	**35.00**	**2.50 Summer Avg.**
15,000	35.00	2.33
16,000	35.00	2.19
17,000	35.00	2.06
18,000	35.00	1.94
19,000	35.00	1.84
20,000	35.00	1.75
21,000	35.00	1.67
22,000	35.00	1.59
23,000	35.00	1.52
24,000	35.00	1.46
25,000	35.00	1.40
26,000	35.00	1.35
27,000	35.00	1.30
28,000	35.00	1.25
29,000	35.00	1.21
30,000	35.00	1.17

TABLE 3.53 ANALYSIS OF TARIFF USED BY LEISUREWOODS

TARIFF SYSTEM ANALYSIS SYSTEM NAME: LEISUREWOODS WATER CO. MARGINAL RATE = $1.99		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 25.40	$ 25.40
2,000	25.40	12.70
3,000	27.39	9.13
4,000	29.38	7.35
5,000	31.37	6.27
6,000	33.36	5.56
7,000	35.35	5.05
8,000	**37.34**	**4.67 Winter Avg.**
9,000	39.33	4.37
10,000	41.32	4.13
11,000	43.31	3.94
12,000	45.30	3.77
13,000	47.29	3.64
14,000	49.28	3.52
15,000	51.27	3.42
16,000	53.26	3.33
17,000	55.25	3.25
18,000	57.24	3.18
19,000	59.23	3.12
20,000	61.22	3.06
21,000	63.21	3.01
22,000	**65.20**	**2.96 Summer Avg.**
23,000	67.19	2.92
24,000	69.18	2.88
25,000	71.17	2.85
26,000	73.16	2.81
27,000	75.15	2.78
28,000	77.14	2.76
29,000	79.13	2.73
30,000	81.12	2.70

TABLE 3.54 ANALYSIS OF TARIFF USED BY MOUNTAIN CITY

TARIFF SYSTEM ANALYSIS SYSTEM NAME: MOUNTAIN CITY MARGINAL RATE = $1.35		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 15.55	$ 15.55
2,000	15.55	7.78
3,000	15.55	5.18
4,000	16.90	4.23
5,000	18.25	3.65
6,000	19.60	3.27
7,000	20.95	2.99
8,000	**22.30**	**2.79 Winter Avg.**
9,000	23.65	2.63
10,000	25.00	2.50
11,000	26.35	2.40
12,000	27.70	2.31
13,000	29.05	2.23
14,000	30.40	2.17
15,000	31.75	2.12
16,000	33.10	2.07
17,000	34.45	2.03
18,000	35.80	1.99
19,000	37.15	1.96
20,000	38.50	1.93
21,000	39.85	1.90
22,000	**41.20**	**1.87 Summer Avg.**
23,000	42.55	1.85
24,000	43.90	1.83
25,000	45.25	1.81
26,000	46.60	1.79
27,000	47.95	1.78
28,000	49.30	1.76
29,000	50.65	1.75
30,000	52.00	1.73

TABLE 3.55 ANALYSIS OF TARIFF USED BY ONION CREEK MEADOWS

TARIFF SYSTEM ANALYSIS
SYSTEM NAME: ONION CREEK MEADOWS
MARGINAL RATE = $1.59

VOLUME	TOTAL COST	AVERAGE RATE
1,000	$ 17.37	$ 17.37
2,000	17.37	8.69
3,000	17.37	5.79
4,000	18.96	4.74
5,000	20.55	4.11
6,000	22.14	3.69 Winter Avg.
7,000	23.73	3.39
8,000	25.32	3.17
9,000	26.91	2.99
10,000	28.50	2.85
11,000	30.09	2.74
12,000	31.68	2.64
13,000	33.27	2.56
14,000	34.86	2.49
15,000	36.45	2.43
16,000	38.04	2.38
17,000	39.63	2.33
18,000	41.22	2.29
19,000	42.81	2.25
20,000	44.40	2.22
21,000	45.99	2.19
22,000	47.58	2.16 Summer Avg.
23,000	49.17	2.14
24,000	50.76	2.12
25,000	52.35	2.09
26,000	53.94	2.07
27,000	55.53	2.06
28,000	57.12	2.04
29,000	58.71	2.02
30,000	60.30	2.01

TABLE 3.56 ANALYSIS OF TARIFF USED BY RIDGEWOOD VILLAGE

TARIFF SYSTEM ANALYSIS SYSTEM NAME: RIDGEWOOD VILLAGE MARGINAL RATE = $1.79		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 15.87	$ 15.87
2,000	15.87	7.94
3,000	15.87	5.29
4,000	17.65	4.41
5,000	19.44	3.89
6,000	21.23	3.54
7,000	**23.01**	**3.29 Winter Avg.**
8,000	24.80	3.10
9,000	26.58	2.95
10,000	28.37	2.84
11,000	30.15	2.74
12,000	31.93	2.66
13,000	33.72	2.59
14,000	35.51	2.54
15,000	37.29	2.49
16,000	39.08	2.44
17,000	**40.86**	**2.40 Summer Avg.**
18,000	42.65	2.37
19,000	44.43	2.34
20,000	46.22	2.31
21,000	48.00	2.29
22,000	49.79	2.26
23,000	51.57	2.24
24,000	53.36	2.22
25,000	55.14	2.21
26,000	56.93	2.19
27,000	58.71	2.17
28,000	60.50	2.16
29,000	62.28	2.15
30,000	64.07	2.14

TABLE 3.57 ANALYSIS OF TARIFF USED BY SAN LEANNA

TARIFF STRUCTURE ANALYSIS SYSTEM NAME: SAN LEANNA MARGINAL RATE = $1.50		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 13.50	$ 13.50
2,000	13.50	6.75
3,000	13.50	4.50
4,000	13.50	3.38
5,000	13.50	2.70
6,000	13.50	2.25
7,000	**13.50**	**1.93 Winter Avg.**
8,000	13.50	1.69
9,000	13.50	1.50
10,000	13.50	1.35
11,000	15.00	1.36
12,000	16.50	1.38
13,000	18.00	1.38
14,000	19.50	1.39
15,000	21.00	1.40
16,000	22.50	1.41
17,000	**24.00**	**1.41 Summer Avg.**
18,000	25.50	1.42
19,000	27.00	1.42
20,000	28.50	1.43
21,000	30.00	1.43
22,000	31.50	1.43
23,000	33.00	1.43
24,000	34.50	1.44
25,000	36.00	1.44
26,000	37.50	1.44
27,000	39.00	1.44
28,000	40.50	1.45
29,000	42.00	1.45
30,000	43.50	1.45

TABLE 3.58 ANALYSIS OF TARIFF USED BY SLAUGHTER CREEK ACRES

TARIFF STRUCTURE ANALYSIS SYSTEM NAME: SLAUGHTER CREEK ACRES MARGINAL RATE = $1.40		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 17.00	$ 17.00
2,000	17.00	8.50
3,000	17.00	5.67
4,000	17.00	4.25
5,000	17.00	3.40
6,000	18.00	3.00
7,000	19.00	2.71
8,000	**20.00**	**2.50 Winter Avg.**
9,000	21.00	2.33
10,000	22.00	2.20
11,000	23.00	2.09
12,000	24.00	2.00
13,000	**25.00**	**1.92 Summer Avg.**
14,000	26.00	1.86
15,000	27.00	1.80
16,000	28.00	1.75
17,000	29.00	1.71
18,000	30.00	1.67
19,000	31.00	1.63
20,000	32.00	1.60
21,000	33.40	1.59
22,000	34.80	1.58
23,000	36.20	1.57
24,000	37.60	1.57
25,000	39.00	1.56
26,000	40.40	1.55
27,000	41.80	1.55
28,000	43.20	1.54
29,000	44.60	1.54
30,000	46.00	1.53

TABLE 3.59 ANALYSIS OF TARIFF USED BY SUNSET VALLEY

TARIFF STRUCTURE ANALYSIS SYSTEM NAME: SUNSET VALLEY MARGINAL RATE = $1.00		
VOLUME	**TOTAL COST**	**AVERAGE RATE**
1,000	$ 22.50	$ 22.50
2,000	22.50	11.25
3,000	22.50	7.50
4,000	22.50	5.63
5,000	22.50	4.50
6,000	22.50	3.75
7,000	**22.50**	**3.21** Winter Avg.
8,000	22.50	2.81
9,000	22.50	2.50
10,000	22.50	2.25
11,000	23.50	2.14
12,000	24.50	2.04
13,000	25.50	1.96
14,000	26.50	1.89
15,000	27.50	1.83
16,000	28.50	1.78
17,000	**29.50**	**1.74** Summer Avg.
18,000	30.50	1.69
19,000	31.50	1.66
20,000	32.50	1.63
21,000	33.50	1.60
22,000	34.50	1.57
23,000	35.50	1.54
24,000	36.50	1.52
25,000	37.50	1.50
26,000	38.50	1.48
27,000	39.50	1.46
28,000	40.50	1.45
29,000	41.50	1.43
30,000	42.50	1.42

TABLE 3.60 COMPARISON OF BASE AND PEAK DEMANDS AND CONSEQUENT WATER BILLS

	BASE PERIOD		PEAK PERIOD		PEAK/BASE RATIO	
SYSTEM NAME	AVG. DEMAND	WATER BILL	AVG. DEMAND	WATER BILL	DEMAND	BILL
Arroyo Doble	8,700	$ 24.52	16,500	$ 30.04	1.90	$1.55
Bear Creek Park	6,700	23.73	10,700	30.09	1.60	1.27
Buda, City of	6,600	13.25	10,600	19.25	1.61	1.45
Chaparral Park	6,000	31.45	11,200	42.20	1.87	1.34
Cimarrom Park	9,700	28.70	21,600	44.18	2.23	1.54
Creedmoor-Maha	6,700	26.40	11,000	37.80	1.64	1.43
Copper Hills	8,300	27.50	13,100	36.25	1.57	1.32
Dellana Hills	6,400	30.00	19,700	30.00	3.08	1.00
Estates W.S.C	6,700	27.25	15,000	48.25	2.24	1.77
G&J W.S.C.	6,300	35.00	14,500	35.00	2.30	1.00
Goforth	6,500	20.75	10,400	24.50	1.60	1.18
Leisurewoods	8,000	37.74	19,400	59.23	2.43	1.59
Mountain City Oaks	8,100	22.30	22,500	42.55	2.78	1.91
Onion Creek Meadows	6,600	23.73	12,000	31.69	1.82	1.34
Ridgewood Village	7,800	24.80	17,800	42.65	2.28	1.72
San Leanna	7,800	13.50	16,500	24.00	2.12	1.78
Slaughter Creek Acres	8,100	20.00	12,800	25.00	1.58	1.25
Sunset Valley	7,200	22.50	16,200	28.50	2.25	1.26

3.6.3 BS/EACD'S PUMPAGE FEE AS A PRICING POLICY TOOL

The legislation creating the BS/EACD states that it "... may utilize fees as both a regulatory mechanism and a revenue-producing mechanism." This being so, it is relevant to explore whether pumpage fees could be employed to augment pricing policy. Three possibilities for using it in this manner are outlined below.

3.6.3.1 Unaccounted-for Loss Reduction Incentives

It has often been suggested that "excessive" unaccounted-for losses could be discouraged through the imposition of fiscal penalties. As outlined in Section 3.5, the currently low perceived value of the water lost does not provide a strong incentive for utilities to aggressively pursue loss reduction programs. Imposing a cost upon this inaction, it is argued, may motivate them to make greater efforts.

It was also noted in Section 3.5 that not all of the unaccounted-for losses are "real" losses. As illustrated by the Goforth WSC example, a great deal of the apparent loss may be due to cumulative metering errors. It was also explained why it is difficult to peg a given numerical value as the limit of "acceptable" loss. These considerations suggest three counter-arguments to the imposition of penalties upon "excessive" unaccounted-for losses:

1. Variability in the fraction of unaccounted-for losses that is system leakage implies that penalties imposed in an effort to reduce these real losses would be inequitable;
2. Unless a penalty were applied only to that portion of unaccounted-for losses which is true waste (system leakage), then the water supplier would be penalized twice for metering inaccuracy, once through the penalty fee and again through the

loss of revenue. It would also be penalized unduly to the extent that non-metered uses were authorized; and

3. Unless the "acceptable" loss rate were determined for each water supplier based upon its specific characteristics, any penalties would be inequitably applied. But applying a different numerical standard to each water supplier might appear to be due to favoritism.

A possible method of blunting such objections is to impose a pumpage fee surcharge only upon that portion of unaccounted-for losses that is found to be system leakage. As suggested in Section 3.5, the fees assessed on this portion of pumpage could be dedicated to funding loss reduction programs for the water suppliers. Therefore, the suppliers would fund these programs whether or not they perceived that the value of the water lost would fiscally justify them. Assuming that the loss rate control measures are indeed economically efficient, this is the effect desired.

The problem, of course, is the cost and effort required to identify what portion of unaccounted-for losses constitutes system leakage. It was outlined in Section 3.5 how making this determination is a necessary facet of conducting a solid, comprehensive loss control program. The cost of making these determinations could be paid by the monies funded by the pumpage fee surcharge.

Until that determination can be made, some estimate of loss rate would have to be used as the basis of the surcharge. Perhaps the only reasonable interim measure is the metered ratio, since it appears to be the only unequivocal measure currently available. This implies that there would be a loss of equity in the early years of the program, which would be corrected as the program succeeds. A problem would be how to prioritize which districts receive water audit and leak detection survey services first. All these issues must be dealt with if such a program is to be considered.

3.6.3.2 Transfer of Non-Potable Demands to Alternate Supplies

It has been continually pointed out in this report how the prevailing apparent low cost of water is retarding the investments necessary to implement conservation measures. This appears to be a particular problem in regard to the largely non-potable demands of the self-supplied users discussed in Section 3.4. Much of this demand does not require a high quality source water. Therefore, a conservation measure with significant water savings potential is the transfer of these non-potable demands to alternate, lower quality sources of supply.

It has been suggested that the pumpage fee for supplies routed to these non-potable demands might be subject to a surcharge, thus offering an additional fiscal incentive to shunt these demands to alternative supplies. These excess charges might be dedicated to a fund to aid these non-potable users in locating and accessing appropriate alternatives. Possible candidate projects include the investigation of the Trinity aquifer and facilitating the transfer of wastewater effluent to possible points of reuse, as outlined in Section 3.4.

It may be argued, of course, whether it is equitable to impose a surcharge on non-potable demands for this group of users but not upon the non-potable demands posed by clients of water suppliers. In the case of commercial or industrial customers of water utilities, perhaps the surcharge could be applied to the relevant portion of the water supplier's pumpage. Obviously, this could become a significant accounting problem for the supplier. In the case of residential users, since a great deal of the non-potable demand is for landscape irrigation, it may be preferable to place a surcharge upon these demands through seasonal pricing, as discussed below.

3.6.3.3 Seasonal Surcharge to Reduce Peak Demands

Seasonal pricing as a method of inducing a reduction of peaking demands, discussed previously in regard to water suppliers' tariffs, can also be applied to the pumpage fee. A seasonal surcharge--either on the entire pumpage volume in the peak season or on the supplier's "excess" pumpage only--might be added to the pumpage fee. These additional charges might then be dedicated to programs aimed at reducing these peak demands, which were discussed in Section 3.3.

An issue which demands attention if such a proposal were considered is how to guarantee that the desired price signal is "passed through" in the water suppliers' tariffs to the users which create the peak demands. If rate structures are reorganized in concert with the principles of marginal cost pricing, and if such a surcharge is incorporated into the marginal rates only, then the desired result would be achieved. However, if the surcharge were simply added onto all demands, this would have the effect of decreasing the marginal to average cost ratio, at least partially deflecting the intended price signal.

3.7 MECHANISMS FOR IMPLEMENTATION OF CONSERVATION MEASURES

Summarized in Table 3.61 are the conservation measures which have been discussed in Sections 3.2 through 3.6. Those sections also outlined some programs through which these measures might be purveyed. In this section, those programs are detailed further, defining the potential roles which BS/EACD might play to encourage, enhance, implement, augment or mandate the various conservation measures listed in Table 3.61. Possible roles of the other entities are also noted.

3.7.1 EDUCATIONAL PROGRAMS

Public education is vital to the success of any water conservation program. The public must be convinced of the need to alter habits, purchase more efficient equipment, etc., and convinced that these actions will prove more economically efficient than paying for "corrective" measures later on. Otherwise support for any programs to purvey, encourage or require water conservation measures will be lacking. Methods by which BS/EACD can advance public education about these matters are detailed below.

3.7.1.1 Funding Public School Programs

The Lower Colorado River Authority has formulated a water resources education curriculum for use in grade schools. The cost of this program is about $30 per classroom per year. At this rate, it would require only a small expenditure to fund the institution of such a program at schools attended by residents of the study area. These types of programs should be investigated by BS/EACD, and strong consideration should be given to funding this effort.

TABLE 3.61 SUMMARY OF RECOMMENDED WATER OF CONSERVATION MEASURES

Measures for Reduction of Interior Domestic Demands: * Minimize--if not eliminate--toilet leakage * Install toilets dams or displacement devices * Replace toilets with "ultra-low" volume models * Replace showerheads with "low-flow" models * Replace washing machines and dishwashers with more water-efficient models * Install aerators on all faucets which lack them * Repair leaks in faucets, building plumbing, etc. * Reduce pressure to 30-50 psi range to minimize leakage losses * Institute efficiency standards for new construction * Disseminate informational material about how to attain interior conservation, where to obtain necessary materials, the fiscal and economic efficiency of each measure, etc.
Measures for Reduction of Irrigation Demands: * Collect weather data and offer "real time" advisories on how much water to apply onto various landscapes or crops * Provide irrigation schedule by season to assist in setting up system to obtain proper application rates * Offer general guidance on when and how much to water * Provide information on more efficient application equipment particularly for drip irrigation systems * Provide information on better control systems--more flexible timers, wet soil override switches * Promote Xeriscape * Promote use of grasses with lower water demands * Provide dual distribution systems for wastewater reuse * Implement on-site/small scale systems for wastewater reuse * Plan developments to minimize irrigation demand
Measures for Reduction of Demands by Industry, Institutions, Etc.: * Fixture retrofit and/or replacement * Flush water recycling * Treatment and reuse of greywater, process water, etc. * Reuse of wastewater effluent from centralized systems * Utilize Trinity aquifer for non-potable demands * Recruit "dry" industries * Plan industrial complexes to facilitate reuse
Measures for Reduction of Water System Losses: * Water audits, leak detection surveys * Internal operations improvements * Water line and appurtenance repair and replacement * Upgrade construction standards

TABLE 3.61 SUMMARY OF RECOMMENDED WATER CONSERVATION MEASURES (CONTINUED)

Price-Related Measures to Encourage Implementation of Conservation Opportunities:

* Alter rate structures using marginal cost pricing principles
* Implement seasonal rates
* Modify capacity charges to give credit for conservation measures
* Surcharge on pumpage fee for volume due to losses
* Surcharge or higher rate for non-potable demands
* Seasonal surcharge on pumpage fee

3.7.1.2 Information Clearinghouse

BS/EACD has served as a conduit for dissemination of various materials on conservation opportunities. This program should be continued and augmented. There are a number of sources for such materials. These include the Texas Water Development Board, the Lower Colorado River Authority, the Edwards Underground Water District, the City of Austin, the Texas Department of Agriculture, the Texas Agricultural Extension Service, and the National Xeriscape Council.

BS/EACD should also consider developing informational material dealing directly with the local situation. This could provide insights regarding the economic efficiency of conservation and stress the activities which merit the most attention in this area. Specifically, information needs to be made available regarding local sources of supplies and materials needed to implement both in-home and irrigation efficiency improvements. A locally oriented Xeriscape brochure may also be worthwhile to produce and disseminate. This might be executed in conjunction with other local agencies which are interested in this concept.

3.7.1.3 Seminars and Informational Videos

Since the majority of the population in the BS/EACD area have lived their entire lives during the "television age", it is to be expected that audio/visual presentations would be more immediately effective--especially for specific subjects--than would printed material. Seminars could be conducted and/or videos could be produced to provide detailed information on conservation activities. This could include: transforming a landscape to a more water efficient form using Xeriscape principles, increasing the efficiency of an irrigation system, and installing an on-site system which reuses wastewater for irrigation. Similarly, these methods may be used to convey information on interior conservation methods as well, in lieu of or in conjunction with home water audits.

Videos could be produced in the course of implementing demonstration projects. Perhaps the RTF program at the University of Texas can be enlisted in this endeavor to minimize BS/EACD's expense. Once produced, copies of the videos could be widely disseminated essentially for the cost of the tapes. If distributed on a "loan" basis like library materials, just a few copies of each video are all that would be required.

Seminars on landscapes and/or irrigation might be conducted in cooperation with local professionals. Many of these people might either donate their time or provide it for a nominal fee in exchange for the marketing opportunities. BS/EACD should investigate what services could be provided in this manner and evaluate the merit of conducting such activities.

3.7.1.4 Demonstration Programs

Demonstration programs would be valuable for disseminating information on and creating interest in specific conservation opportunities, such as the Xeriscape concept and on-site systems incorporating irrigation reuse. BS/EACD should investigate the costs of these activities, potential sites for implementation, and possible sources of funding. Given the potential savings available from reduction of irrigation demand, this effort should have a high priority in BS/EACD's activities.

Another demonstration project which BS/EACD could consider is to cooperate with a local college or university to investigate all manner of conservation measures that could be designed into a home. The University of Arizona has conducted a project of this type called "Casa del Agua". The house is occupied by a university staff member and his family, which allows evaluation of conservation measures in a "real" setting. The house incorporates advanced fixtures, greywater reuse, rainwater harvesting, appropriate landscaping, etc. Evaluating the merit of such concepts in the local situation may be a valuable contribution to conservation efforts here.

3.7.2 HOME WATER AUDIT PROGRAM

A home water audit program could be instituted on a BS/EACD-wide basis, or it could be left to the individual supply entities to implement. Four factors favor an omnibus program run by BS/EACD:

1. A single BS/EACD-wide program would allow for more efficient utilization of resources. It would eliminate the need for each entity to derive and fund programs, to solicit participation, to conduct the audits, to provide follow-up services, etc;
2. Smaller suppliers, especially the private, for-profit entities, are not likely to consider an audit program fiscally feasible;
3. Programs run only by water suppliers would deny these benefits to homes served by private wells; and
4. Uniformity in the assessment of conservation opportunities, in the level of effort and thoroughness of follow-up services, etc., would be better assured by implementing a single audit program for the entire BS/EACD.

BS/EACD should determine if it would be more efficient and effective to carry out such a program with its own resources, or to conduct it under contract with other entities. The City of Austin, for example, already conducts a home water audit program.

It should be investigated whether the form and content of such programs would convey the benefits deemed to be desired in a program for the BS/EACD area, and whether arrangements can be made to provide these services to water users in the study area.

3.7.3 TOILET REPLACEMENT PROGRAM

As noted in Section 3.2, the home water audit could focus on simply maximizing the efficiency of the fixtures in place, or it could go further and offer guidance and assistance to the residents on fixture replacement. Since they offer the greatest savings potential, toilets are the fixture upon which replacement programs should be concentrated. While toilet replacement appears to be economically efficient if the replacement price is low enough, this measure entails a considerable first-cost barrier and a rather poor fiscal payback. Two programs are suggested to attack this problem.

First, it may be beneficial for a management entity to serve as a purchasing agent to obtain wholesale prices on "ultra-low" volume toilets. This might be a role for BS/EACD. A problem with this strategy is that, unless arrangements can be made with a supply house that can offer several models and colors, anyone desiring to purchase a new toilet through this program would have a limited choice of fixtures. Some study of the potential demand for replacement toilets would have to be conducted in order to estimate the probable volume of sales. This would undoubtably impact upon the prices which can be offered by the suppliers.

The second program is suggested to help increase the number of participants in a toilet replacement program. To defeat the first cost barrier, the fixture purchase might be financed interest-free, with the user paying off the purchase over a predetermined time period. Table 3.62 details the financial calculations for replacing an "old" toilet at an installed cost of $175 (expected

TABLE 3.62

FISCAL ANALYSIS OF TOILET REPLACEMENT PROGRAM

Assumed cost of toilet replacement = $175
Repayment period assumed = 36 months

COSTS TO USER:

Monthly payment = $175/36 = $4.86

Savings from reduction in flush water demand:

(5.5 - 1.5) = 4 gal/flush x 4 flushes/person/day = 16 gpcd
Assume 1.5 persons/toilet: Water savings = 24 gal/day = 8,760 gal/yr

8.76 x $1.70 = $14.89/12 = $1.24/month averge savings

Net payout per month = $4.86 - $1.24 = $3.62

COSTS TO SUPPLIER:

Assume 8% discount rate is available; interest is calculated quarterly.
Assume that customer payments are accumulated and used to buy down principle quarterly.

Opportunity cost = $175 x .02 + ($175 - $14.58) x .02 + ($175 - 2 x $14.58) x.02 + ($175 - 3 x $14.58) x .02 + (and so on, thru 12 quarters) = $22.76

$22.76/24 gal/day = $0.95 per gpd of system capacity

Assuming useful life for toilet of 15 years:

Total water saved = 8.76 x 15 = 131.4 kgal

Cost of water saved = $22.76/131.4 = $0.17 per 1,000 gallons to be readily achievable even for "designer" models if a wholesale purchase program were in place). Since much lower prices have been observed, the analysis in Table 3.62 may be rather conservative. In this analysis, a 36 month payoff period is assumed, but this could be adjusted to any length of time which seemed feasible in practice.

This analysis uses the current average marginal price of water, calculated at $1.70, so it would be conservative for some suppliers and unrealistically optimistic for others at their current prices. If suppliers adjust their rate structures in concert with marginal cost pricing principles, this average marginal rate would increase, perhaps to something more like the average cost at winter average demand rates, shown in Tables 3.42 through 3.59.

Illustrated in Table 3.62 are the multiple benefits of this program. First, the user is afforded an opportunity to pay off the purchase over time. The monthly payment of $4.86 is defrayed by the water savings achieved through the toilet replacement. Given the same assumptions on usage rate that were used in Table 3.35, average monthly savings would be $1.24, so the net payout is $3.62 per month. After 36 months, the user's net cost is $130.32.

At a savings rate of $1.24 per month, it would take about 8.75 more years to pay back this amount and bring the net outlay by the user to zero. This is an artifact of the current marginal cost of water. If a price approximating the average cost at average winter demand rates were used instead, monthly savings would rise to $2.47. This would decrease the net monthly payout to $2.39 and the total payout after 36 months to $86.04. Less than 3 additional years of further savings at this rate would be required to bring the net outlay to zero.

From the water suppliers' perspective, the fiscal picture is considerably brighter. The cost incurred is the lost opportunity cost of the money provided at no interest. Assuming an 8% annual rate and that the payments from the consumer are accrued and applied to a buydown of the principle quarterly, the total interest lost would be $22.76. Since the action financed saves 24 gpd, the cost of capacity purchased in this manner is about 95 cents per gpd. This is probably less than the cost of simply upgrading the capacities of current system components, and well below the long-run marginal cost of new supply projects.

Assuming that 15 years is a reasonable service life of a new toilet, the total water savings over the life of the fixture would be about 131.4 thousand gallons. At a cost to the supply system of $22.76, the cost of this water would be about 17 cents per 1,000 gallons. This is one-tenth the current marginal price and well below even the current pumpage fee. Clearly this is a superior investment for a supply system. It would be economically efficient to subsidize the replacement to an even greater extent, thereby improving the fiscal attractiveness for the user.

As with the wholesale supply program, any fixture replacement program would best be conducted by a single entity for the entire BS/EACD. Again, this is a role which BS/EACD could play. The feasibility of this type of program should be investigated. To be workable, it would probably be necessary for the participant's water supplier to serve as the "collection agency" through its billing process.

3.7.4 LANDSCAPE AUDIT PROGRAM

One possibility for purveying a landscape audit is to encourage the user to work with a qualified landscape professional. A rebate could be provided to at least partially defray the cost incurred by the user in engaging these services. In practice, it would be necessary to fix any such rebate at a standard amount, regardless of the actual water savings potential in the case at hand. While this would make the level of economic efficiency of the rebate program somewhat indeterminant, this approach has the advantage of involving a party who would have an interest in assuring that the homeowner followed through on the audit's recommendations. This might maximize actual savings.

If the landscape audit program is purveyed directly by the public sector, choices include having it run by individual water suppliers, having BS/EACD provide the services directly, or having BS/EACD arrange to pass through these services from other agencies. The former has the advantage that the program would be targeted specifically to those areas which experience heavy irrigation demand. But, as detailed for the home water audit, this approach would probably be less efficient and less uniformly applied than a BS/EACD-wide program. The latter two strategies should be investigated to determine the best way to proceed.

Funding of either a rebate program or of a public sector program might be provided by seasonal surcharges on the pumpage fee or by requiring each supplier to institute seasonal pricing, with part of the "excess" charges dedicated to funding irrigation reduction programs. The constraints on such strategies are largely political. Their feasibility therefore needs to be investigated through the appropriate bodies.

3.7.5 INDUSTRIAL DEMAND REDUCTION PROGRAM

While the specific characteristics of water demand in this sector may vary greatly with the type of activity, it may still be possible to institute general programs aimed at reduction of some of these demands. Two possibilities are discussed here.

BS/EACD may be able to facilitate the transfer of some of this demand to non-Edwards sources. Possibilities include wastewater reuse from centralized systems and drawing water from the Trinity aquifer. BS/EACD could aid in developing and financing such projects. Possibilities include facilitating negotiations with a non-potable water provider, assisting with grant or loan programs, and direct financing of a Trinity test well program. Also, since flush water demands are a significant portion of total usage by some users in this sector, BS/EACD should implement a flush water recycling demonstration project.

The other general method of demand reduction for this sector is to offer or require industrial/institutional water audits. The nature of water demands peculiar to the user in question would be examined in detail in this program. Strategies for decreasing usage could then be formulated in light of that user's particular circumstances. Options for acting on the audit's recommendations include:

1. Provide audit findings and recommendations to the user and leave to its discretion how, when and where to act. Due to the gap between short-term fiscal considerations and long-term economic considerations noted throughout this report, it is questionable whether this strategy would produce significant savings;
2. Identify actions which appear to be economically efficient for the water supply system as a whole and require implementation as a condition of permit renewal. A problem with this approach is gaining a consensus on what "economically efficient for the water supply system as a whole" means; and
3. Identify actions which appear to have significant water savings potential and assist the user in determining fiscally reasonable means of implementation, including direct funding or assistance with grant or loan programs.

Some or all of the funding for the industrial audit program and for any assistance programs might be derived from pumpage fees imposed upon these non-potable demands. Since this would mean that the users would be paying some of the costs of the efficiency enhancements in any case, they should be more receptive to considering them.

3.7.6 SYSTEM LEAK DETECTION AND WATER AUDIT PROGRAMS

It was indicated in Section 3.5 that there appears to be considerable potential for reduction in system leakage through the implementation of leak detection surveys and subsequent repair programs. The microeconomic situation of individual water suppliers could also be further enhanced through water audits, which would aid in minimizing "paper" losses as well. An efficient means of providing these services to water suppliers in the study area would be for BS/EACD to institute such programs. By pooling resources, more cost efficient services could be provided.

Most of the "paper" processes and field work in a water audit would probably be handled directly by the water system management. In support of this program, BS/EACD might provide the following assistance:

1. Mapping services, perhaps placing system information on a GIS;
2. Meter testing services;
3. Meter maintenance and rehabilitation; and
4. Miscellaneous technical services.

Meter testing, maintenance and rehabilitation would be most efficiently handled by contracting with firms offering those services. The water suppliers could do this directly, but cost advantages may be obtained by passing the service through BS/EACD, due to the increased volume and the constant flow of business so assured. The merit of this strategy should be explored.

For leak detection services, BS/EACD may either capitalize the necessary equipment and hire qualified people to conduct the program. Alternatively, this service may be passed through to the water supplier from entities already possessing the equipment and staff. The former would give the local program maximum autonomy and flexibility, while the latter might be more cost efficient, at least in the short term. The availability and capabilities of existing services should be investigated and a determination made as to the best way to proceed.

If the contract route is chosen, the individual suppliers could arrange for these services without BS/EACD involvement. However, the ability of BS/EACD to centrally administrate and schedule the services might be seen as a significant advantage by the service supplier. By arranging for a consistent flow of work, better prices might be obtained.

In any case, BS/EACD could cover some or all the costs of leak detection and water audit services. Funds for this would, of course, be derived from pumpage fees. Justification of these expenses is that waste reduction benefits all the water users. As discussed previously, funding for these services might be provided by dedicating to this purpose the part of the pumpage fee found to be due to system leakage. Augmenting this fund with a surcharge on part or all of the unaccounted-for water might also be considered.

3.7.7 PRICE INCENTIVE PROGRAMS

A price incentive program for reduction of unaccounted-for losses was just mentioned. A similar program for reduction of non-potable demands has also been discussed in this report. The merit of each of these actions should be considered in light of all their ramifications.

The major price incentive program which must be instituted, however, is a revamping of rate structures to a more "conservation oriented" form, as outlined in Section 3.6. BS/EACD can provide assistance to the water suppliers in the pursuit of this goal by making available literature, conducting workshops on marginal cost pricing, and contracting for the necessary legal and accounting expertise. All efforts should be made to persuade water suppliers to reassess their current rate structures.

If persuasion fails, BS/EACD might further consider requiring implementation of "appropriate" rate structures. Already included in BS/EACD rules is a requirement that "[a]ll Water Suppliers ... shall ... institute an increasing block rate structure ...." If indeed authority exists to dictate the form and/or function of each supplier's rate structure, this rule should be rethought in light of the discussions in Section 3.6. As the tariff analyses in that section showed, merely requiring an increasing block <u>structure</u> does not guarantee that an economically efficient pricing system would derive. Revisions to the form and intent of this rule should be considered. The practicality of any omnibus rule on rate structures may also need to be reevaluated, as the fiscal situation of the suppliers varies greatly.

A final point regarding price incentives is that businesses and residences served by private wells--similarly to self-supplied industries in this area--have little fiscal incentive to conserve. The cost of their water supply is already sunk, so except for a relatively minor decrease in energy costs, conservation would provide no fiscal return. For properties already in these circumstances, due to their exempt status under the legislation creating the BS/EACD, there is probably little that can be done except to try to persuade them to "do their part" to help assure that their wells do not go dry. For new properties of this class, a reduction in the well registration fee in recognition of various conservation measures might be considered as an incentive.

3.7.8 SUMMARY OF RECOMMENDATIONS

Listed below is a summary of the specific recommendations for action by the BS/EACD which are offered by this study. It is recommended that the issues impacting upon any given action be thoroughly reviewed before adopting these or any other set of recommendations.

3.7.8.1 Recommendations on Educational Programs

Educational efforts do not directly save any water. Rather, they sensitize people to the need to take water-conserving actions and facilitate obtaining information needed to pursue those actions. Any given educational effort may be more or less successful in reaching a specific audience, so it is not possible to assign a water savings potential to each effort. The following is a list of recommended educational programs (not shown in order of priority):

1. BS/EACD should participate in the funding of public school programs on water conservation;
2. BS/EACD should continue to serve as an information clearing-house, disseminating materials provided by other entities;
3. BS/EACD should develop its newsletter "The Water Line" into a source of information dealing directly with local conservation issues, such as providing information on the fiscal and economic efficiency of a given measure, sources of aid, sources of materials, etc.;

4. BS/EACD should, unilaterally or in conjunction with other local entities, produce a locally oriented Xeriscape brochure/booklet;
5. BS/EACD should conduct seminars and/or produce videos detailing the specifics of given conservation measures; and
6. BS/EACD should, unilaterally or in conjunction with other local entities and/or universities, implement demonstration programs.

3.7.8.2 Recommendations on Interior Water Demand

The recommendations for this category are listed below in order of priority, based upon the expected effort/expense for implementation and expected water savings which can be derived. It is projected that water savings available from all interior use efficiency measures could total over 200 million gallons per year if implemented throughout the BS/EACD. The following measures should be augmented by providing general information on the cost and availability of water conserving fixtures and appliances.

1. BS/EACD should, unilaterally or in conjunction with other local entities, implement a home water audit/leak repair/fixture retrofit program. The LCRA/PEC effort being planned might serve as an excellent vehicle for this effort;
2. BS/EACD should require that all toilets installed within its jurisdiction, whether in new construction or retrofit into existing buildings, meet a 1.6 gallon per flush standard; and
3. BS/EACD should implement a program to assist/encourage the replacement of all "old" toilets.

3.7.8.3 Recommendations on Landscape Irrigation

BS/EACD should implement a landscape audit program as a means of purveying opportunities for reduction of landscape irrigation demands. Most of the measures listed in Table 3.61 can be assisted and encouraged through this program. This program should be augmented by providing general information on Xeriscape and water efficient irrigation methods. Available data indicates that landscape irrigation demand within the district currently totals over 250 million gallons per year. Vigorous pursuit of all measures listed in Table 3.61 should reduce this demand by at least 50%.

3.7.8.4 Recommendations on Industrial Water Demand

Since demands in this category are almost exclusively non-potable, the potential for water savings approaches, at least theoretically, the permitted pumpage of about 209 million gallons per year.

1. BS/EACD should assist industries in evaluating the cost and feasibility of shifting their demands to alternate sources; and
2. BS/EACD should implement an industrial water audit program, as a vehicle for assisting and encouraging the implementation of the measures listed in Table 3.61.

3.7.8.5 Recommendations on Unaccounted-for Losses

It appears reasonable that about 10% of the permitted pumpage among all water supply systems may be saved by attainable reductions in unaccounted-for losses. This would total about 90 million gallons per year. BS/EACD should implement a water audit/leak detection service for its water supply systems, as a vehicle for achieving these savings.

3.7.8.6 Recommendations on Price-Related Issues

While it is not possible to assign a specific water savings potential to price-related measures, it is to be expected that creating a more economically efficient price structure would help the implementation of many water-saving measures.

1. BS/EACD should revise its rule regarding increasing block rate structures, affirming that the intent is to render tariffs more economically efficient;
2. BS/EACD should encourage the implementation of tariffs by its supply systems which reflect marginal cost pricing principles; and
3. BS/EACD should evaluate means of using its fee structure to penalize waste and to encourage the implementation of water-saving measures. If these evaluations indicate that those goals can be achieved by altering the fee structure in a non-regressive manner, this strategy should be implemented.

3.7.9 A CLOSING NOTE

It cannot be stressed enough that achieving the high levels of conservation which appear to be attainable--and which, as outlined in Section 3.0, may also be necessary to preserve the integrity of the Edwards aquifer--will require a cooperative effort among all the users of this resource. Various levels of authoritarianism have been noted as possible strategies for implementing water conservation efforts. It should be understood that the more cooperation which is offered by water users, the more these strategies could lean toward the "encourage" rather than the "mandate" end of the spectrum.

The level of cooperation offered will hinge, it is suspected, upon whether the water users believe that they collectively pose any threat to the integrity of the aquifer. It will also depend upon whether they believe that supply projects must be undertaken in the future and that their marginal costs would be much higher than present water prices. Each water user must decide the apparent level of risk and whether to gamble on those risks by failing to aggressively pursue conservation at every opportunity. Upon the outcome of those judgments hangs the probable effectiveness of a water conservation program for the BS/EACD area.

SECTION 4 REPORT

REGIONAL WATER PLAN
for the
BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

PRELIMINARY RECHARGE ENHANCEMENT STUDY

prepared for

BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT
Austin, Texas

and

TEXAS WATER DEVELOPMENT BOARD
Planning Grants Assistance Program
Austin, Texas

TWDB CONTRACT NO. 9-483-732

prepared by

R. J. BRANDES COMPANY
Austin, Texas
(PRINCIPAL INVESTIGATOR)
and
DONALD G. RAUSCHUBER & ASSOCIATES, INC.
Austin, Texas

SEPTEMBER 1990

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4.1 INTRODUCTION

4.1.1 BACKGROUND

The Barton Springs segment of the Edwards aquifer presently serves as the principal water supply for more than 30,000 people in northern Hays and southern Travis Counties. The aquifer also provides water for industrial and commercial users, as well as for some agricultural operations. These demands for water are projected to increase as the regional population continues to grow and expand, and pumpage from the Barton Springs segment of the Edwards aquifer to supply these demands undoubtably also will increase.

Historically, during hot, dry summer months and extended periods of low rainfall, water levels in the Barton Springs segment of the Edwards aquifer have significantly declined as discharge has exceeded the natural recharge of the groundwater system. Likewise, springflows from Barton Springs and other associated springs have been considerably reduced to critical levels.

As part of its ongoing activities to protect and manage the aquifer, the Barton Springs Edwards Aquifer Conservation District (BS/EACD) has undertaken a regional water supply planning study to consider water supply problems in the area and to develop programs and measures that will extend the life and utility of the groundwater system. With funding support from the Texas Water Development Board (TWDB), this planning effort has addressed solutions that include the formulation of an emergency interconnect program for the major public water supply systems that rely on the aquifer, lowering and modification of existing wells to increase their pumping capabilities during drought conditions, the development of water conservation and drought contingency plans, and the preliminary investigation of recharge enhancement measures that potentially can increase the available water supply of the groundwater system.

This component of the overall regional planning study has focused on the assessment of alternatives that are available for enhancing the recharge to the Barton Springs segment of the Edwards aquifer. A summary and description of the various artificial recharge measures that could be implemented and that have been considered in other previous studies is presented, along with a discussion of their recharge potential and implementation feasibility and an identification of special problems that may be encountered.

4.1.2 STUDY AREA

The Barton Springs segment of the Edwards aquifer includes that portion of the Edwards (Balcones Fault Zone) aquifer system that lies within northern Hays and southern Travis Counties in central Texas. The Edwards (Balcones Fault Zone) aquifer, which is comprised of massive, highly-fractured, vugular limestone, extends over a distance of about 250 miles along a narrow, arc-shaped band that crosses southwestern and central Texas in parts of ten counties from Kinney, near the Rio Grande, through Uvalde, Medina, Bexar, Comal, Guadalupe, Hays, Travis, Williamson and Bell Counties to the northeast [Klemt et al, 1981; Maclay & Small, 1984].

Generally, the areal extent of the Barton Springs segment of the Edwards aquifer is considered to be bounded on the north by Town Lake on the Colorado River, on the west by its contact with the Glenrose limestone formation of the Trinity Group, on the east by the dividing line between fresh and saline water, i. e. the "bad-water" line that distinguishes those parts of the aquifer with less than and more than 1,000 mg/L of total dissolved solids, and on the south by the groundwater divide (high water levels) near the Blanco River that has been established as the northern limit of the "San Antonio area" Edwards aquifer [Slade et al, 1986]. This area covers about 155 square miles, with most of the northern third generally developed and urbanized as part of the City of Austin and several other outlying communities. Figure 4.1 identifies the boundaries of the Barton Springs segment of the Edwards aquifer as delineated for purposes of this study.

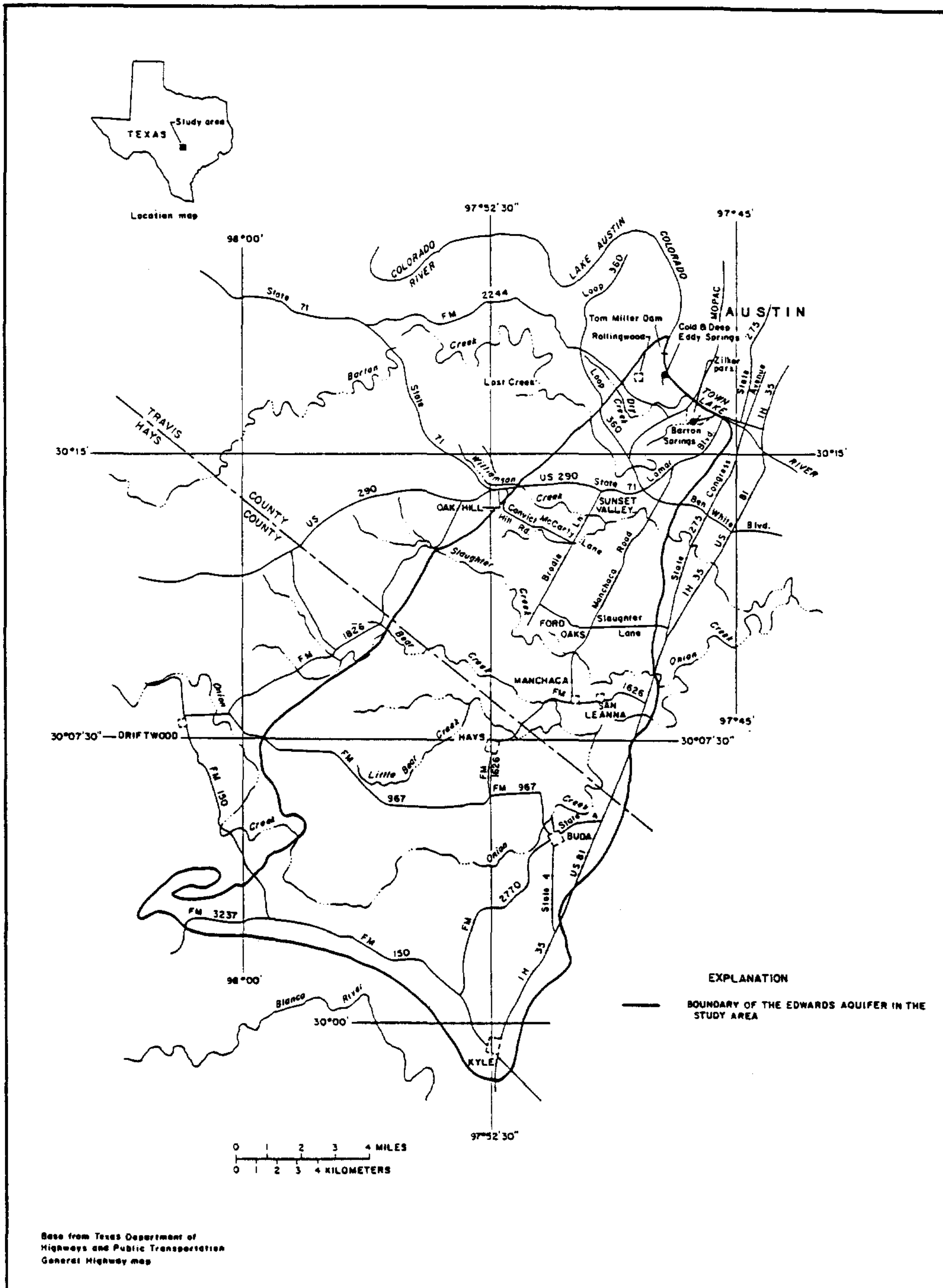
4.2 SYSTEM DESCRIPTION

4.2.1 GEOHYDROLOGY

The Edwards formation is comprised mostly of hard to soft limestone with some interbedded marl present both at the outcrop and in the subsurface. Zones with extensive fracturing, weathering and solution features such as honeycombing, sinkholes and caverns provide for rapid infiltration of water at the outcrop, as well as for rapid movement of groundwater within the aquifer. Extensive faulting both at the outcrop and throughout the formation, is an important feature of the Edwards. It creates variations in the physical characteristics and dimensions of the aquifer and provides conveyance mechanisms for surface water infiltration and groundwater movement, both of which enhance solution cavity development.

A narrow portion of the Edwards extending along most of the eastern boundary of the Barton Springs segment of the Edwards aquifer is overlain by the Del Rio Clay, which is a relatively impermeable formation that functions as a confining layer for groundwater within the underlying Edwards and associated limestones. In the areas west of this confining layer, particularly where the Edwards

FIGURE 4.1 DELINEATION OF BARTON SPRINGS/EDWARDS AQUIFER STUDY AREA BOUNDARIES



outcrops, the groundwater in the Barton Springs segment of the Edwards aquifer is under free-surface, water table conditions.

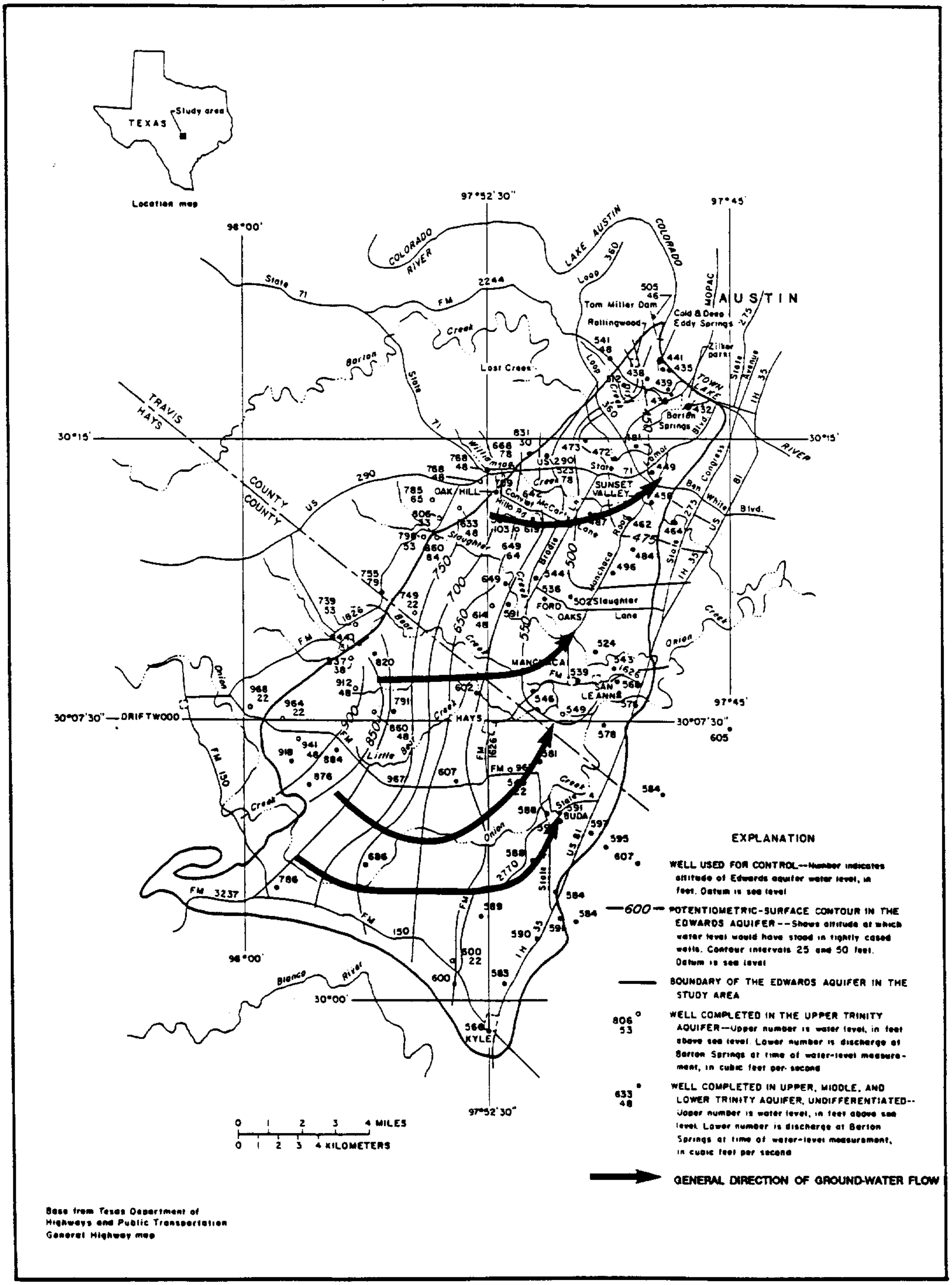
Groundwater movement within the Barton Springs segment of the Edwards aquifer is from areas with the highest water levels in the southwestern and western portions of the system eastward and northeastward to the point of primary discharge at Barton Springs on the lower reach of Barton Creek just upstream from Town Lake [Slade et al, 1985]. This generalized pattern of groundwater movement through the aquifer towards Barton Springs is illustrated in Figure 4.2.

Barton Springs, which has an average flow rate of about 50 cfs (cubic feet per second) and is currently the fourth largest spring in Texas, is located in Zilker Park near the center of Austin. These springs are not only a major recreational attraction for the region, but they also serve as a source of municipal water for the City of Austin's Green Water Treatment Plant on Town Lake. On the average, about 90 percent of the total discharge from the Barton Springs segment of the Edwards aquifer occurs through Barton Springs and other associated springs in the immediate vicinity (36,200 acre-feet per year), with the remainder being pumped from wells throughout the aquifer for water supply purposes.

4.2.2 NATURAL RECHARGE

The Barton Springs segment of the Edwards aquifer is recharged primarily by infiltration of surface runoff during storm events into fractures and openings in the outcrop area of the Edwards and associated limestones, principally along watercourses and streambeds. Direct infiltration of precipitation falling on the outcrop land surface and subsurface inflows from adjacent formations also contribute to the recharge of the Edwards groundwater system. Several ephemeral creeks that are tributary

FIGURE 4.2 GENERALIZED GROUNDWATER MOVEMENT THROUGH THE BARTON SPRINGS/EDWARDS AQUIFER



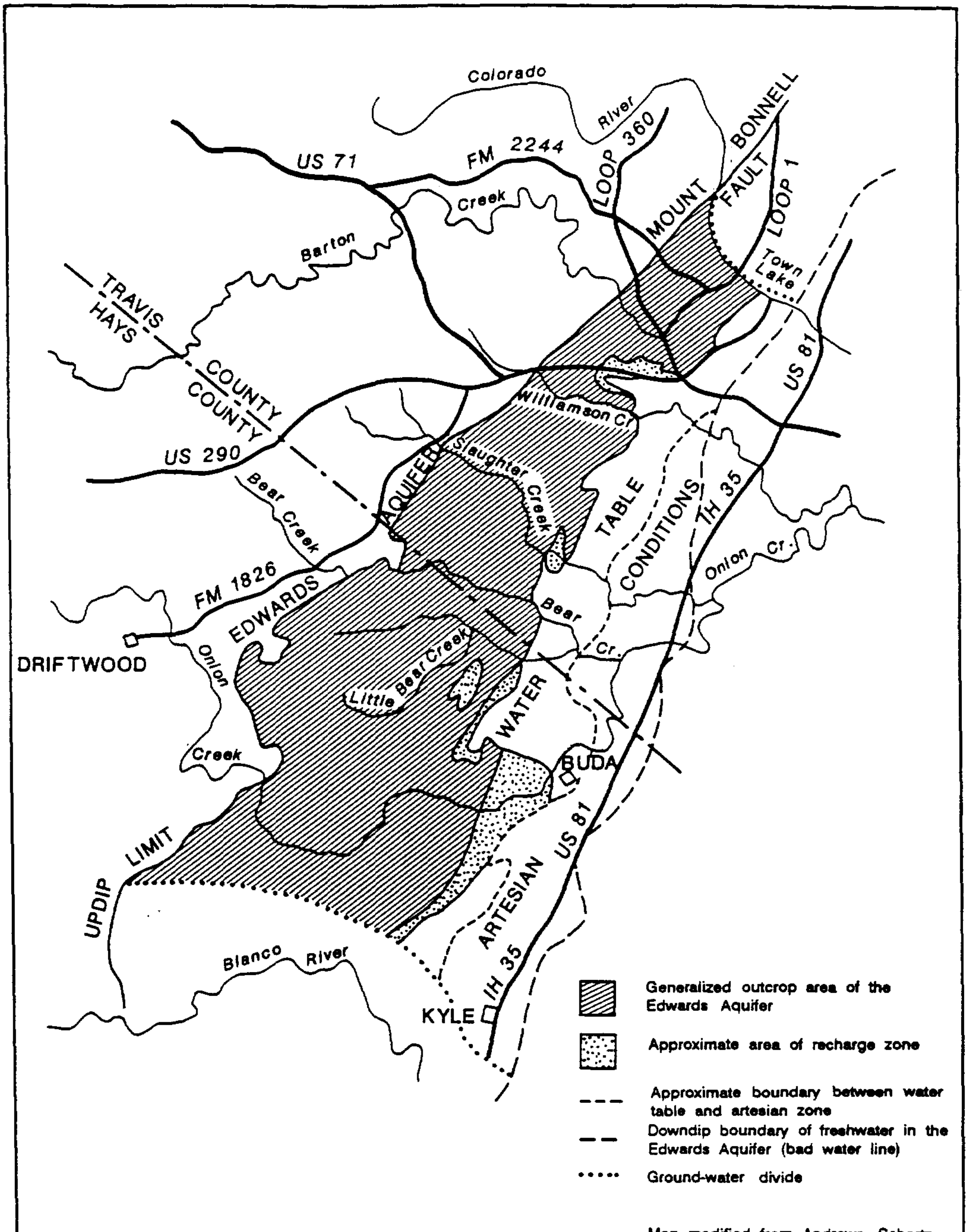
to the Colorado River cross the outcrop area generally from west to east and contribute the majority of the runoff that recharges the aquifer.

The recharge zone for the Barton Springs segment of the Edwards aquifer extends generally from the southwest to the northeast along the western half of the aquifer area; it is delineated on the map in Figure 4.3 along with other key hydrologic features of the aquifer. The recharge zone covers approximately 90 square miles [Slade et al, 1986].

Recent studies conducted by the USGS [Slade et al, 1986] and other investigators [Woodruff, 1986] have examined the historical hydrologic characteristics of the Barton Springs segment of the Edwards aquifer and its associated surface streams for the purpose of identifying the sources, magnitudes and locations of natural recharge. There are six principal streams that contribute surface recharge to the aquifer across the outcrop area. These include Barton Creek, Williamson Creek, Slaughter Creek, Bear Creek, Little Bear Creek and Onion Creek. These creeks are identified on the map in Figure 4.3, and the percentage distribution of their average recharge contributions, their maximum mean-daily recharge rates, as determined by the USGS [Slade et al, 1986], and their drainage areas above and within the recharge zone are listed in Table 4.1. The drainage area figures in the table have been derived from watershed areas reported by the USGS for streamflow gages located near the upstream and downstream boundaries of the recharge zone [Slade et al, 1982], adjusted based on visual inspections to account for deviations between these gaged areas and the actual recharge zone.

With the exception of Little Bear Creek, each of these streams has a contributing watershed that extends upstream beyond the recharge zone of the Barton Springs segment of the Edwards aquifer. The

FIGURE 4.3 DELINEATION OF BARTON SPRINGS/EDWARDS AQUIFER RECHARGE ZONE AND EDWARDS OUTCROP AREA



Source: Espey Houston & Associates, 1979

TABLE 4.1 WATERSHED RECHARGE CHARACTERISTICS FOR THE BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

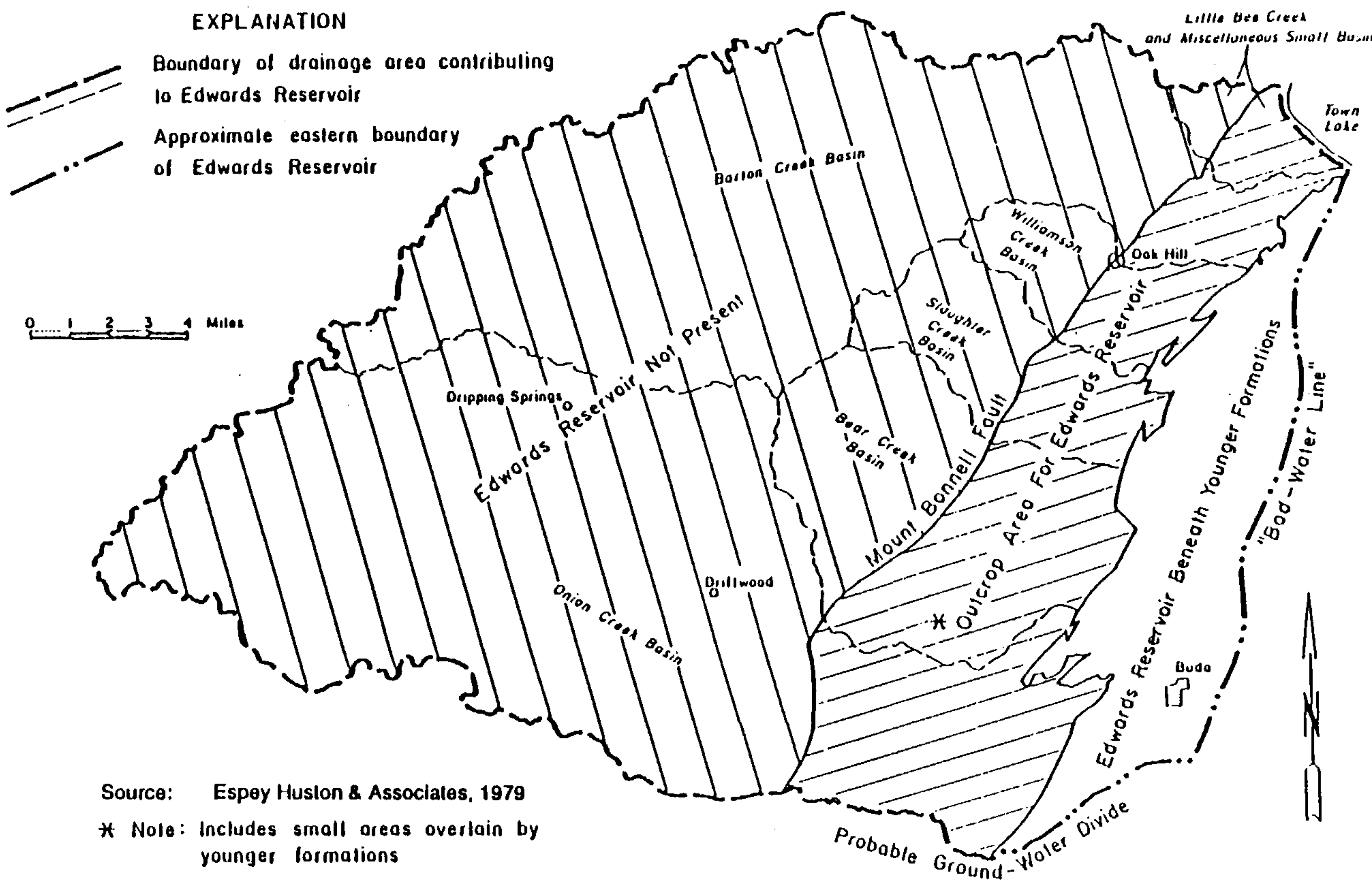
WATERCOURSE	RELATIVE RECHARGE CONTRIBUTION	MAXIMUM MEAN-DAILY RECHARGE RATE	DRAINAGE AREAS		
			ABOVE RECHARGE ZONE	WITHIN RECHARGE ZONE	TOTAL
	Percent	cfs	Sq. Mi.	Sq. Mi.	Sq. Mi.
Barton Creek	28	30 to about 70	111	9	120
Williamson Creek	6	13	6	7	13
Slaughter Creek	12	52	9	7	16
Bear Creek	10	33	14	6	20
Little Bear Creek	10	about 30	0	19	19
Onion Creek	34	about 120	124	42	166
Combined Watershed	100		264	90	354

headwaters of Little Bear Creek originate within the recharge zone. According to the USGS, the total contributing drainage area above the recharge zone encompasses 264 square miles. Including the 90 square miles of area within the recharge zone, there is a total of 354 square miles of drainage area that can contribute runoff that is potentially available for recharge. Of this total area, 166 square miles, or almost 47 percent, are contained within the Onion Creek basin; Barton Creek encompasses 120 square miles, or about 34 percent. The drainage area delineations identified on the map in Figure 4.4 illustrate the significant size of the Onion Creek and Barton Creek watersheds.

From USGS studies based on daily streamflow measurements on each of the six streams and on precipitation data collected throughout the drainage area over the 42-month period beginning in July, 1979, and ending in December, 1982, it has been determined through water budget analyses that an average of six percent of the precipitation that falls on the entire drainage area (354 square miles) results in surface recharge to the Barton Springs segment of the Edwards aquifer. For an average annual rainfall of 33 inches, this amounts to about 37,400 acre-feet of recharge per year. An average of nine percent of the precipitation, or about 56,100 acre-feet per year, occurs as surface streamflow that discharges past the downstream boundary of the recharge zone. The remaining 85 percent of the rainfall is lost to surface retention, shallow infiltration and soil storage, evapotranspiration and other surface processes. Based on 33 inches of annual rainfall, these losses represent an average of approximately 530,600 acre-feet of water that never reaches the groundwater system.

As indicated in Table 4.1, the Barton Creek and Onion Creek watersheds account for over 60 percent of the average surface recharge that enters the Barton Springs segment of the Edwards aquifer, which relates directly to the fact that these two

FIGURE 4.4 DRAINAGE AREAS OF PRINCIPAL STREAMS CROSSING THE BARTON SPRINGS/EDWARDS AQUIFER RECHARGE ZONE



Source: Espey Huston & Associates, 1979

* Note: Includes small areas overlain by younger formations

watersheds encompass over 80 percent of the total drainage area that contributes runoff to the recharge zone. When considering measures to enhance the recharge to the groundwater system, these two watersheds clearly offer the most potential, based on recharge volume, since they have an abundance of runoff available that normally flows out of the recharge zone as streamflow.

Using the nine-percent figure indicated above for the streamflow-to-rainfall fraction and considering 33 inches of average annual precipitation, the total quantity of runoff that would be available for recharge enhancement from the Barton Creek and Onion Creek watersheds is approximately 45,300 acre-feet per year. Certainly, this represents a sizable amount of water considering that only about 4,000 acre-feet per year are currently pumped from the Barton Springs segment of the Edwards aquifer. With this quantity of additional water potentially available and with future water demands in the aquifer area projected to substantially increase beyond current levels of pumpage, the need to develop and implement an effective recharge enhancement program is of paramount importance.

4.2.3 PRESENT GROUNDWATER WITHDRAWALS

At the present time, most of the water pumped from Barton Springs segment of the Edwards aquifer in northern Hays and southern Travis Counties is used for domestic and municipal uses [BS/EACD, 1988]. Much of this water, about 75 percent, is withdrawn through large capacity wells operated by public water supply systems. The remainder is pumped from individual household wells, which have been estimated to number on the order of 1,500 [RJB, 1988]. There also are additional industrial and commercial wells and some agricultural wells that withdraw water from the aquifer.

The approximate distribution of the total pumpage of groundwater from the Barton Springs segment of the Edwards aquifer for the various categories of use are as follows: municipal - 55 percent, domestic - 20 percent, industrial/commercial - 24 percent, and agricultural - 1 percent. The combined pumpage that has been required to meet water demands for these uses during recent years has been about 4,000 to 5,000 acre-feet per year [RJB, 1988]. The BS/EACD currently (as of February 27, 1990) has permits issued for 106 nonexempt wells in the Barton Springs segment of the Edwards aquifer. The combined annual permitted pumpage for these wells is 1,020 million gallons, or about 3,100 acre-feet per year. For various categories of use, the number of permitted wells and their combined annual permitted pumpage amounts are listed in Table 4.2.

4.2.4 PROJECTED PUMPAGE EFFECTS

On the average and over the long term, the quantity of discharge from the Barton Springs segment of the Edwards aquifer that occurs as springflows and pumpage generally is considered to be in "dynamic equilibrium" with the quantity of surface recharge that enters the aquifer [Slade et al, 1986]. Although the present level of pumpage represents only about ten percent of the average annual recharge to the aquifer, projections of population growth in the region over the next 10 to 20 years suggest that domestic and municipal water needs very likely will substantially increase and result in increased withdrawals from the Barton Springs segment of the Edwards aquifer. Since inflows and outflows generally are balanced for the aquifer, these increased withdrawals probably will cause a corresponding decrease in the flow of Barton Springs.

For the Barton Springs segment of the Edwards aquifer area, the projected increase in population by the year 2000 has been estimated to be 86,000 [Slade et al, 1986, based on City of Austin

TABLE 4.2 PERMITTED WELLS IN THE BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT (FEBRUARY 27, 1990)

TYPE OF USE	NUMBER OF WELLS	PERMITTED ANNUAL PUMPAGE Acre-Feet	PERCENT
Public Water Supply	70	2,824	90
Industrial	7	281	9
Commercial	13	5	< 1
Irrigation	11	19	< 1
Other	5	0	0

projections]. Considering expected growth trends with regard to population densities, the location and size of future groundwater service areas, and the anticipated future industrial and commercial groundwater needs, the increased pumpage from the Barton Springs segment of the Edwards aquifer necessary to meet the projected year-2000 water demands has been estimated, for evaluation purposes, to be on the order of 6,200 acre-feet per year [Slade et al, 1985]. As the aquifer is further developed to meet these additional demands, the increased pumpage very likely will cause reductions in the quantity of water stored in the aquifer and in the discharge from Barton Springs. These reductions will be most pronounced during extended periods of low rainfall when surface recharge will be minimal. During these times, it is likely that water levels in the aquifer will be drastically lowered, and the pumping potential in some areas may be severely limited.

Studies conducted by the U. S. Geological Survey (USGS) using a mathematical model to simulate the hydraulic behavior of the Barton Springs segment of the Edwards aquifer [Slade et al, 1985] have attempted to quantify the approximate magnitudes of the reductions in water levels and springflows that potentially could occur as a result of the increased pumpage required to meet the projected year-2000 water demands. Using the water levels measured in 1981 as an average, steady-state hydrologic baseline for the aquifer, output from the model simulations with the increased year-2000 pumpage requirement indicate that water levels could decline more than 100 feet in the southern portion of the aquifer near Kyle and that complete dewatering of the formation could occur in the western and southwestern portions of the aquifer. The computer model results also indicate that the flow of Barton Springs would be reduced from an average of 51 cfs for the baseline case to about 38 cfs for the increased pumpage condition. This reduction in springflow is equivalent to about 9,400 acre-feet per year less flow in the Colorado River downstream.

Obviously, the pumping capacity of wells under these significantly-lowered water level conditions would be drastically reduced, and water shortages very likely would be experienced by a large number of well owners. With the reduced springflows, less water also would be available for municipal use by the City of Austin, and the reduced flows in the Colorado River would exacerbate water quality problems in Town Lake and downstream of the City's wastewater treatment plant effluent discharges.

4.3 RECHARGE ENHANCEMENT MEASURES

4.3.1 OVERVIEW

The concept of aquifer recharge enhancement, or artificial recharge, as a means for augmenting the available supply of groundwater from an aquifer system has been studied and utilized across the country for many years. A variety of methods have been developed, including water spreading on the land surface, recharging through pits and channels, and well injection. The choice of a particular method for a given area is governed by local topographic, geologic and soil conditions; the quantity of water to be recharged; and the ultimate water use. Other factors that can influence the design and operation of an artificial recharge project include environmental considerations, climatic conditions, land values, water rights, legal constraints, and water quality.

For the Edwards aquifer, the most effective approach for recharge enhancement involves the use of dams and reservoirs on the recharging streams to capture and store stormwater runoff, which then can be infiltrated into the groundwater system either as seepage directly from the impoundments or, once released, as channel losses through the fractures and openings along the streambeds below the dams. In effect, these types of recharge facilities function to increase the volume of water that enters the aquifer naturally along the creeks and streams that cross the recharge zone.

During intense and/or extended rainfall periods, the quantity of stormwater runoff flowing down watercourses across the outcrop area often exceeds the available capacity for channel infiltration. For example, the peak discharge rates for streams in the area often exceed several hundred cubic feet per second during even the more frequent, smaller magnitude storm events, but, as indicated in Table 4.1, the maximum recharge rates of these streams generally are considerably less than these levels. Consequently, the excess runoff that cannot be infiltrated is discharged as streamflow past the downstream boundary of the recharge zone and, therefore, lost as a potential source of recharge water for the aquifer. By constructing dams on the watercourses either just upstream of or over the recharge zone, a portion of this excess runoff can be detained and, subsequently, allowed to infiltrate into the groundwater system. Releases from the impoundments can be made at prescribed rates that provide for maximum infiltration along the streambeds while minimizing the streamflow discharge downstream.

The use of off-channel reservoirs to capture stormwater runoff for direct infiltration into surface recharge features such as caves, sinkholes and fractures also offers some potential for recharge enhancement. The possibility of diverting either surface runoff or streamflows to these types of natural recharge features through channels or pipe systems may be an effective means for significantly increasing instantaneous recharge rates in local areas.

The various types of mechanisms that could be used for recharge enhancement of the Barton Springs segment of the Edwards aquifer and, in some cases, that already have been considered, are described and evaluated in the following sections. Generally, the information that is presented in the following sections has been obtained from reports and documents prepared as part of other previous investigations. When available, figures relating the recharge potential of specific projects are presented. For some projects, only the available developed supplies are indicated. For all of the projects considered, the additional quantity of water that would be recharged generally would be available within the aquifer for withdrawal by pumping. Additional recharge amounts in excess of pumping demands would flow naturally through the aquifer and ultimately be discharged at Barton Springs.

4.3.2 EUWD RECHARGE FACILITIES

Several on-channel recharge structures have been constructed by the Edwards Underground Water District (EUWD) for the specific purpose of increasing the available water supply of the San Antonio portion of the Edwards aquifer. Four such facilities presently are in operation on different streams that cross the recharge zone in Medina County west of the City of San Antonio.

One of these facilities, which is located on Parker Creek, is a floodwater retarding structure that originally was designed by the Soil Conservation Service and now provides dual flood control and recharge benefits. Two others, on Middle Verde Creek and San Geronimo Creek, are low-head dams that simply capture and detain floodwaters and provide for gradual releases downstream. Recharge from these facilities occurs directly through streambed fractures and openings within the impoundments and along the downstream channels. The fourth recharge facility is located on Seco Creek, and it not only impounds stormwater runoff, but also diverts these floodwaters approximately 700 feet through a channel into a large sinkhole where they are readily infiltrated into the Edwards formation. Since water rights provisions of the Texas Water Code require that these facilities recharge only "unappropriated stormwater and floodwater" into the aquifer, all of the structures have low-flow outlets installed that provide for complete dewatering of the impoundments following runoff events. All of the EUWD recharge facilities are permitted under provisions of the Texas Water Code for recharge purposes.

The EUWD, in cooperation with the U. S. Geological Survey, routinely monitors the performance of these recharge facilities. Each structure is equipped with a reservoir stage recorder, and these data are analyzed together with available streamflow measurements to estimate recharge quantities for each facility.

The annual quantities of additional recharge contributed by each of these facilities since 1983 are listed in Table 4.3 as reported by the EUWD [Bader, 1990]. Also presented is descriptive information for each structure. As shown, these facilities combined have contributed as much as 20,000 acre-feet of recharge water to the Edwards in a single year; however, there also have been years such as 1988 and 1989 when no recharge has been experienced because of low rainfall and runoff conditions. Overall, the annual recharge amount for these facilities has averaged about 4,000 acre-feet.

4.3.3 ONION CREEK MAINSTEM RECHARGE RESERVOIR

In the early to mid 1980's prior to creation of the BS/EACD several communities and governmental entities in the area undertook preliminary studies to investigate the feasibility of constructing a major dam and reservoir on Onion Creek for purposes of developing an additional surface water supply and enhancing the natural recharge of the Barton Springs segment of the Edwards aquifer [Ruiz, 1985; Slade et al, 1985 and Slade et al, 1986]. As originally planned, this facility was to be located on the mainstem of Onion Creek immediately upstream of the recharge zone in

TABLE 4.3 PHYSICAL CHARACTERISTICS AND HISTORICAL RECHARGE OF EDWARDS UNDERGROUND WATER DISTRICT PROJECTS

PROJECT FEATURE	EUWD RECHARGE PROJECTS			
	PARKER CREEK	MIDDLE VERDE CREEK	SAN GERONIMO CREEK	SECO CREEK
Dam Height, Feet	48	16	22	13
Dam Length, Feet	1,500	361	474	310
Max. Capacity, Ac-Ft	2,661	150	271	2
YEAR	ANNUAL RECHARGE AMOUNTS			
	Ac-Ft	Ac-Ft	Ac-Ft	Ac-Ft
1983	0	254	0	0
1984	251	246	0	143
1985	232	440	1,097	643
1986	217	889	963	1,580
1987	2,104	4,141	1,176	12,915
1988	0	0	0	0
1989	0	0	0	0
7-Yr. Average	401	853	462	2,183

northern Hays County about four miles southeast of the town of Driftwood and about eight miles west of the City of Buda. For purposes of this report, this project is referred to as Driftwood Dam and Reservoir.

This site also was considered by the Fort Worth District of the Corps of Engineers for a major regional stormwater detention pond to help alleviate flooding problems along the lower reaches of Onion Creek [Corps of Engineers, 1987]; however, hydrologic studies conducted by the Corps indicated that the flood benefits of this proposal were minimal. Consequently, this detention pond facility was not considered by the Corps in its final recommendations for flood control improvements along Onion Creek.

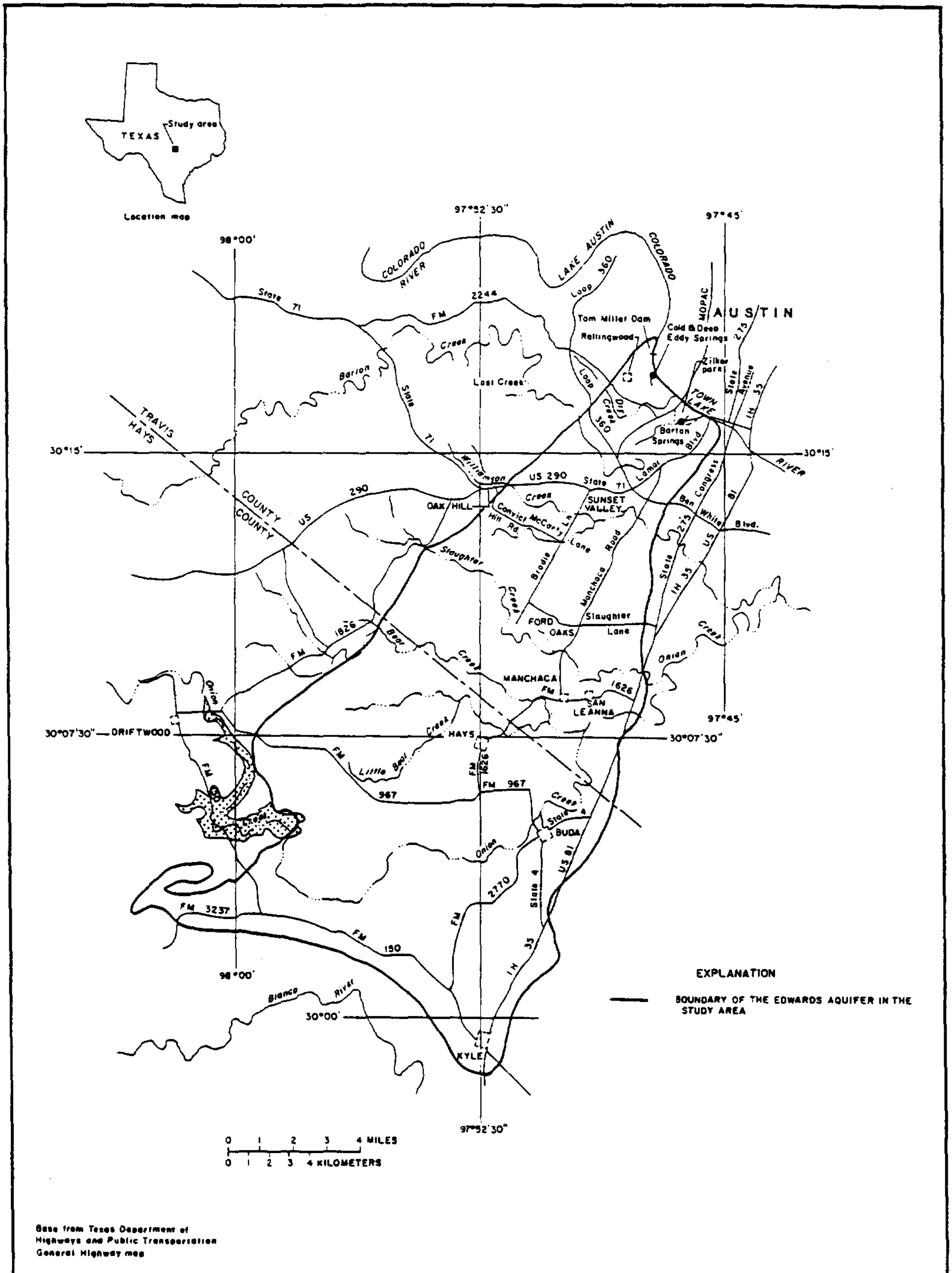
The Driftwood Reservoir water supply and recharge project was particularly controversial because of local landowner opposition and environmental concerns. Ultimately, the Texas Water Commission issued an Agreement and Stipulation, which was executed by the interested parties, stating that proceedings for the involuntary acquisition of land for the project would not be initiated for at least ten years and "only after thorough and appropriate cost/benefit, geological, hydrological, archeological and environmental analyses have performed and documented, and after all necessary permits for the project have been obtained". This agreement was executed on April 7, 1986.

Although the proposed Driftwood Dam and Reservoir project on Onion Creek has not been pursued since, it is important for purposes of this study that the key features of this project be understood and examined as part of the overall assessment of potential recharge enhancement alternatives for the Barton Springs segment of the Edwards aquifer. As proposed, the project was to consist of a rockfill dam about 100 feet in height and approximately 2,500 feet long, which would provide for an impoundment at the selected site on Onion Creek with a maximum capacity of about 55,000 acre-feet and a total surface area of 1,750 acres [Ruiz, 1985]. The proposed site for the project is identified on the map in Figure 4.5. As indicated, this site is just upstream of the Edwards recharge zone and is situated on the Glen Rose limestone outcrop.

At the proposed location for the Driftwood Dam, the contributing watershed upstream encompasses approximately 124 square miles. Using the 15-percent figure for the fraction of rainfall that occurs as runoff from the watershed above the recharge zone as derived from previous USGS studies [Slade et al, 1986] and assuming an average annual rainfall amount of 33 inches for the region, the average annual quantity of runoff from the Onion Creek basin that flows past the dam site is calculated to be about 32,700 acre-feet, and for normal lower and upper extremes in annual rainfall of 20 inches and 40 inches, respectively, this annual runoff volume ranges from 19,800 acre-feet to about 39,700 acre-feet. With the natural recharge along Onion Creek averaging only about 15,000 acre-feet per year based on USGS data, it is apparent that, on the average, considerable excess flow (> 18,000 acre-feet per year) would be available in Onion Creek for capture and storage in the Driftwood Reservoir for recharge enhancement purposes.

Studies conducted at the University of Texas at Austin (UTA) [Ruiz, 1985] involving a benefit-cost analysis of the proposed Driftwood Dam and Reservoir indicate that the firm annual yield of the impoundment during the occurrence of a seven-year critical drought would be 12,900 acre-feet. Operated to maximize recharge enhancement during this drought period, the reservoir would increase the recharge to the Edwards from a natural level of 3,600 acre-feet per year to about 12,900 acre-feet per year, an increase in the available annual groundwater supply of 9,300 acre-feet. Under normal flow conditions, the reservoir would increase the natural annual recharge from about 12,300 acre-feet to over 21,500

FIGURE 4.5 LOCATION OF DRIFTWOOD DAM AND RESERVOIR ON ONION CREEK



acre-feet. Certainly, these quantities of additional groundwater are significant in terms of the projected increases in water demands that are anticipated in the future for the Barton Springs segment of the Edwards aquifer area.

From the UTA studies, the total capital cost for designing and constructing the proposed Driftwood Dam and Reservoir was estimated to be $30,988,000. In as much as this estimate includes only $220,000 for the actual construction of the dam and spillway and does not provide for any permitting expenses, it probably is several million dollars low in terms of the actual total cost of the project. Considering the cost of other major reservoir projects in the state, a more reasonable estimate of the cost for the Driftwood project is probably on the order of $35,000,000. Assuming this capital cost figure for designing, permitting and constructing the project with financing over a 25-year period at an interest rate of 10 percent, the annual debt service cost would be approximately $3,900,000 (CRF=0.11017). Combining this amount with an estimated $100,000 annual operation and maintenance cost, the total annual project cost would be $4,000,000. Assuming that the project will produce 9,300 acre-feet of additional groundwater recharge that will be available for subsequent pumpage from the Barton Springs segment of the Edwards aquifer, the unit cost of water in the ground will be $1.32 per 1,000 gallons.

This unit cost figure for water from Driftwood Reservoir is consistent with that of other surface water development projects that are being proposed in other basins in the state. For example, raw water from the Lake Bosque project north of Waco on the Bosque River in the Brazos Basin is expected to cost an average of about $0.85/1,000 gallons under comparable financing terms. Considering the additional costs for treatment and transmission with similar financing, the Lake Bosque water will cost an average of approximately $1.75/1,000 gallons. For comparison purposes, the current standard rate for purchasing municipal and industrial water stored in the reservoir system of the Lower Colorado River Authority is $0.24/1,000 gallons.

Another water supply reservoir on Onion Creek, referred to as Lake Dripping Springs, also has been proposed by the Hays County Water Development Board to serve the City of Dripping Springs and the surrounding area [HDR Engineering Inc., 1989]. The proposed site for this dam is approximately five miles south-southeast of Dripping Springs at a point on Onion Creek that is about 12 stream miles upstream from the Driftwood Dam site. As proposed, Lake Dripping Springs would be considerably smaller than Driftwood Reservoir, and based on firm annual yield studies, it potentially could provide a dependable water supply of about 4,700 acre-feet per year if all of the runoff and streamflow in Onion Creek is captured and stored. If only "unappropriated" flows in Onion Creek are captured and stored, i. e. those that are considered by the Texas Water Commission to not be committed to existing downstream water rights in the Colorado Basin, then the firm annual yield of Lake Dripping Springs is projected to be about 3,100 acre-feet [HDR Engineering Inc., 1989].

The capital cost for constructing Lake Dripping Springs on Onion Creek has been estimated to be $10,870,000 [HDR Engineering Inc., 1989]. Based on this cost figure and an assumed annual operation and maintenance cost of $75,000, the unit cost for supplying 4,700 acre-feet per year of raw water with Lake Dripping Springs is about $0.80/1,000 gallons under the same financing terms used above for the water cost analyses of the Driftwood project. For treated water from the lake delivered to the distribution system of the City of Dripping Springs, the unit cost would be about $2.00/1,000 gallons, based on a total capital cost of $17,480,000, estimated annual O&M costs of $300,000 and a firm supply of 3,400 acre-feet per year [HDR Engineering Inc., 1989].

4.3.4 LOW-HEAD INSTREAM RECHARGE DAMS

Another approach to recharge enhancement that may be less controversial than the construction of a major mainstem project such as Driftwood Dam and Reservoir on Onion Creek would be to utilize a series of small channel dams to impound stormwater runoff along the length of one or more of the principal streams and/or their tributaries across the recharge zone of the aquifer. The stormwater runoff captured in these small reservoirs could be retained and slowly released to enhance infiltration through the natural fractures and openings along the impounded reaches of the streambeds and downstream.

Based on preliminary siting investigations, it appears that the combined storage capacity of these types of channel reservoirs would not be enough to provide an appreciable amount of firm annual yield in the groundwater system during an extended critical drought condition, but it would be sufficient to capture a significant portion of the runoff from the contributing watershed such that recharge to the Edwards during normal flow periods could be considerably increased.

The additional recharge from these channel reservoirs would tend to elevate normal water levels in the aquifer and would provide some additional storage in the groundwater system that would, at least, prolong the beginning of water shortage conditions at the beginning of a drought period. It has been estimated that the travel time for groundwater through the Barton Springs segment of the Edwards aquifer from the farthest limits of the system on the southwest to Barton Springs is on the order of two to five years; therefore, the additional recharge water from the channel reservoirs would be available for pumpage for the period of time during its movement through the formation to the outlet at the springs. Undoubtably, the additional recharge attributable to these channel reservoirs also would result in some increase in the Barton Springs discharges. This recharge which would contribute to the available surface water supply of the City of Austin in Town Lake and to the base flow of the Colorado River, helping alleviate existing water quality problems downstream of Austin, particularly below the City's wastewater treatment plant discharges.

These channel dams would be situated within the lower floodplain of the streams, i. e. 10-year floodplain, and they probably would not be more than 20 feet in height and a few hundred feet in length. They would be constructed of some form of concrete material, possibly roller-compacted concrete, and designed to be overtopped during major flood events. Low-flow pipe outlets would be required to pass minimum streamflows for environmental purposes and to satisfy downstream senior water rights.

4.3.4.1 ONION CREEK CHANNEL RESERVOIRS

Although the channel reservoir recharge structures could be located on any of the streams that cross the recharge zone, they undoubtably would be most effective on Onion Creek in terms of their ability to increase the available groundwater supply. Certainly, as already has been demonstrated with regard to the mainstem Driftwood Reservoir, the upper watershed of Onion Creek above the recharge zone contributes a substantial amount of runoff that potentially could be captured for recharge of the aquifer, i. e. on the average, more than 18,000 acre-feet per year. However, it is also important to recognize that Onion Creek is the watercourse across the recharge zone that is farthest removed from the principal discharge point of the aquifer at Barton Springs. Therefore, any recharge water that enters the aquifer from Onion Creek moves through the entire length of the groundwater system generally towards Barton Springs and, consequently, is available for pumpage by intermediate wells. According to measurements made by the USGS, the channel along Onion Creek also exhibits the highest mean daily recharge rate of any of the six principal recharging streams that cross the outcrop area. As indicated in Table 4.1, Onion Creek can infiltrate water into the aquifer at a mean-daily rate on the order of 120 cfs (cubic feet per second), which is equivalent to an average annual recharge amount of almost 87,000 acre-feet. The maximum recharge rate may be as high as 350 to 400 cfs [Slade dt al, 1986].

To demonstrate how a series of channel dams might be constructed on Onion Creek along the reach across the recharge zone, a profile plot of the Onion Creek streambed has been prepared and is shown in Figure 4.6. In this figure, the elevation of the Onion Creek streambed with respect to mean sea level is plotted against distance along the Onion Creek channel in the downstream direction beginning at the upstream boundary of the recharge zone. Superimposed on the streambed plot is a series of six low-head dams and reservoirs located in a stairstep fashion within limits of the recharge zone.

As indicated on the streambed profile plot, each of the low-head dams is assumed to impound water to a maximum depth of 20 feet. The water surface of each of the reservoirs is indicated by a horizontal line extending upstream from the top of the dams. The streambed elevation data used to construct this profile plot were extracted from contour information on existing USGS topographic maps of the area. A copy of a portion of these maps is presented in Figure 4.7 with the locations of the six channel dams and reservoirs identified.

Considering an assumed average channel cross-section for each of the dam sites along Onion Creek based on a bottom width of 25 feet and a top width of 150 feet and assuming that the impoundments have a depth of one foot and a top width of 30 feet at their upstream

FIGURE 4.6 STREAMBED PROFILE ALONG ONION CREEK SHOWING CHANNEL RESERVOIR LOCATIONS

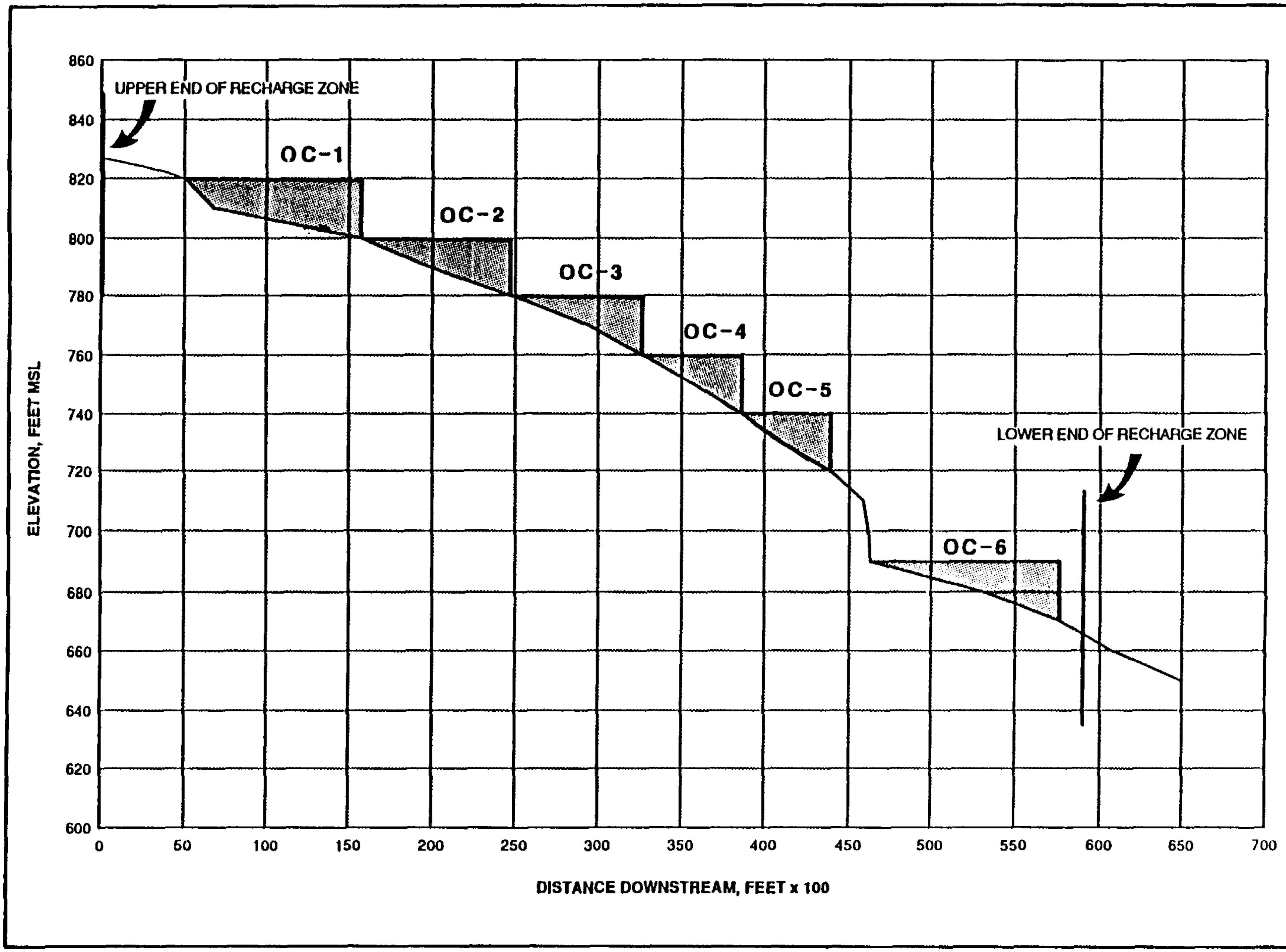
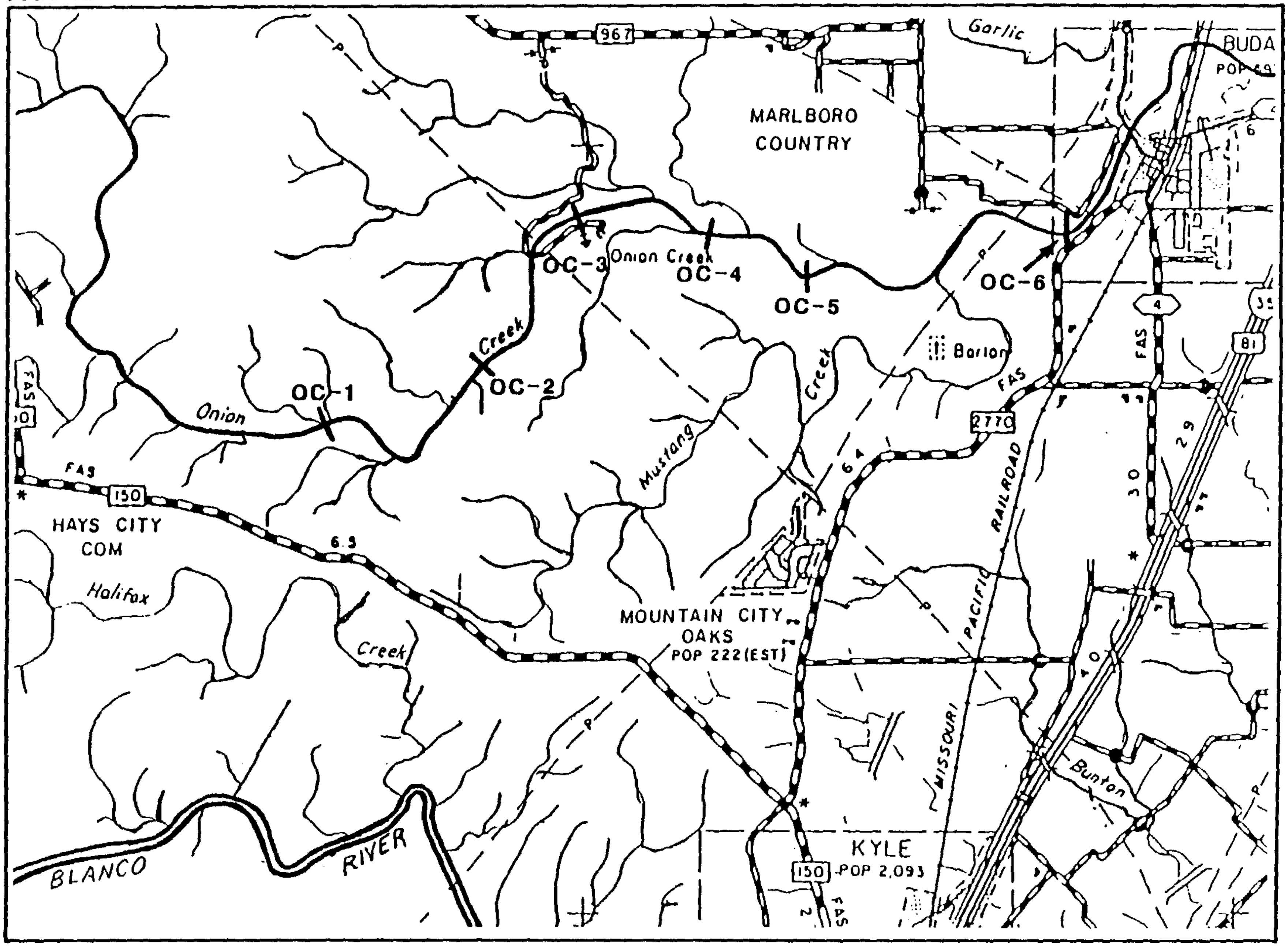


FIGURE 4.7 MAP OF ONION CREEK SHOWING CHANNEL RESERVOIR LOCATIONS



limits, a general relationship between the storage volume of the impoundments and their channel lengths has been derived. The results from applying this relationship using impoundment lengths determined from the profile plot in Figure 4.6 are presented in Table 4.4 for the six recharge dams and reservoirs. As indicated, the combined storage capacity of these structures has been determined to be approximately 815 acre-feet.

While this quantity of reservoir storage may not seem significant, particularly when compared to the 55,000 acre-feet of storage capacity provided in Driftwood Reservoir, its effectiveness for enhancing recharge can be demonstrated by considering how the associated series of small low-head dams might function during the occurrence of actual runoff events. Because of the significant size of the contributing watershed of Onion Creek above the recharge zone (124 square miles), only about 0.15 inches of runoff is required to completely fill the six channel reservoirs. For individual major storm events that produce significant runoff quantities, historical streamflow and rainfall records for gages in the total watershed above the recharge zone indicate that approximately 20 percent of the rainfall produces runoff that contributes to streamflow. Therefore, based on this figure, the amount of rainfall that is necessary to produce the 0.15 inches of runoff required to fill the reservoirs is only about 0.75 inches.

The frequencies and magnitudes of rainfall events that historically have occurred in the Austin area, based on daily measurements made at the Austin weather station during the 1949-1974 period [Hydroscience, 1976], are presented in Table 4.5 for selected frequently-occurring storms. These data suggest that, on the average, 12 storms with rainfall amounts equal or greater than 0.79 inches can be expected to occur in the Onion Creek watershed during any given year, i. e. storms with a one-month return period. Theoretically, since this amount of rainfall exceeds that required

TABLE 4.4 PHYSICAL DESCRIPTIONS OF ONION CREEK RECHARGE CHANNEL RESERVOIRS

RESERVOIR IDENTIFICATION	STATION	LENGTH Feet	CAPACITY Acre-Feet
OC-1	157+00	10,700	172
OC-2	245+00	9,400	151
OC-3	327+00	8,100	130
OC-4	385+00	5,700	91
OC-5	438+00	5,200	83
OC-6	577+00	11,700	188
		COMBINED CAPACITY	815

TABLE 4.5 RAINFALL AMOUNTS FOR SMALL, FREQUENTLY OCCURRING STORMS NEAR AUSTIN BASED ON 1949-1974 RECORDS

RETURN PERIOD OF STORM	RAINFALL AMOUNT PER STORM EVENT Inches
1 Month	0.79
3 Months	1.59
6 Months	2.28
1 Year	3.19
2 Years	4.12

Source: Hydroscience; 1976; "Water Quality Management Planning for Urban and Industrial Stormwater Needs"; Arlington, Texas.

to produce the necessary runoff from the upper Onion Creek watershed to fill the six channel reservoirs, i. e. > 0.75 inches, there should be 815 acre-feet of water captured and stored in the reservoirs, on the average, twelve times per year that would be available for enhancement of the recharge to the Barton Springs segment of the Edwards aquifer. Assuming 100-percent efficiency, this would be equivalent to about 9,800 acre-feet per year of additional groundwater supply. Actually, the total amount of runoff that could be captured by these reservoirs would be even more because of the numerous smaller magnitude rainfall events that would produce lesser amounts of runoff that would only partially fill the six impoundments, but still contribute to enhanced recharge.

Certainly, rainfall events in the Austin area typically do not occur uniformly over regions as large as the Onion Creek watershed, nor do they occur in a given amount the same number of times each year. Also, depending on rainfall intensities and areal distributions as well as storm movement patterns, the fraction of rainfall that contributes to runoff can vary appreciably over a given watershed for a particular storm event. Because of factors such as these, it is probably unreasonable to expect the six recharge structures on Onion Creek to fully capture and infiltrate the entire 9,800 acre-feet of runoff water. For planning and evaluation purposes, an average figure of 5,000 acre-feet per year, about half the total, has been assumed as a conservative estimate for the additional amount of recharge attributable to these channel reservoirs. All of the analyses conducted for this study have been based on the assumption that all six of the recharge channel reservoirs would be in place on Onion Creek. This would maximize the recharge potential for this type of project. Subsequent, more detailed studies should focus on the investigation of the relative benefits of constructing fewer numbers of channel dams, considering only the most favorable sites for recharge enhancement. Hydraulic ground water modeling of the aquifer for the different project configurations will need to be conducted to develop more definitive answers regarding the water supply benefits.

Although detailed cost figures for designing, permitting and constructing the channel reservoir recharge facilities have not been developed, preliminary estimates of these costs indicate that a project consisting of the series of six structures on Onion Creek probably could be implemented for about $3,000,000. The actual construction of the dams probably could be completed for about $250,000 each, with the remainder of the costs required for detailed engineering and hydrologic studies, facilities design, environmental impact assessments and mitigation, land acquisition and flood easements, state and federal permitting, general management and administrative activities, and contingencies.

Assuming that the six reservoirs on Onion Creek will provide an additional 5,000 acre-feet of recharge water to the Barton Springs segment of the Edwards aquifer and, therefore, will supplement the available groundwater supply by this amount, the unit cost of this water would be less than $0.25/1,000 gallons. This figure is based on a total capital cost of $3,000,000, with annual operation and maintenance costs of $30,000 and 10-percent, 25-year financing. Certainly, this unit cost of water compares favorably with that estimated for the recharge water provided by the mainstem Driftwood Reservoir project of $1.32/1,000 gallons, and it is slightly less that the rate that LCRA proposes to implement in 1992 for "firm" raw water from its reservoirs, i.e., $115 per acre-foot or $0.35 per 1,000 gallons.

4.3.4.2 SOUTH BRANCH WILLIAMSON CREEK CHANNEL RESERVOIR

A proposed regional stormwater detention pond that is to be constructed by the City of Austin at the new MOPAC Loop 1 crossing of the South Branch of Williamson Creek, in effect, will function as a recharge channel reservoir. This detention facility, which is to be located in the Dick Nichols District Park about one and a half miles south of the City of Oak Hill, will control runoff from about four square miles of drainage area that currently is partially developed primarily for single family residential purposes. Most of this development has occurred since the City's watershed ordinances have been in effect; therefore, most of the stormwater runoff is subject to treatment through sedimentation and filtration basins.

Although this facility has not been designed specifically for recharge enhancement of the Edwards, it, nevertheless, will function to increase the natural recharge to the aquifer. According to City personnel [Johns, 1990], the area of the pond where stormwater is to be impounded is highly fractured and contains a major cave, called District Park Cave, and several other small sinkholes. The streambed of the creek within the pond and downstream also is fractured and has several collapsed sinkholes. These features presently provide direct avenues for infiltration of streamflows into the Edwards formation. With the detention pond providing for the temporary storage of these streamflows and their subsequent release at lower discharge rates, recharge of the aquifer undoubtably will be increased. This facility illustrates how the overall benefits of routine drainage structures, that are normal components of development projects and highway construction activities, can be maximized to include recharge of the Barton Springs segment of the Edwards aquifer.

4.3.4.3 CIRCLE C RANCH CHANNEL RESERVOIR

As part of the Circle C Ranch development southwest of Oak Hill, another stormwater detention pond has been constructed that also serves to increase recharge to the Barton Springs segment of the

Edwards aquifer. This facility is located on the mainstem of Slaughter Creek at the Escarpment Lane crossing just west of the proposed southern extension of MOPAC Loop 1.

The Escarpment Lane bridge over Slaughter Creek functions as the control structure for this detention pond. Engineers for the Circle C Ranch project designed this structure with multiple port openings and a two-stage overflow weir in order to maximize the detention effects for lower streamflows, while allowing higher floodflows to pass at levels consistent with predevelopment watershed conditions. The discharge capacity of the multi-port outlets has been designed to maintain flow rates that generally are about the same magnitude as the maximum recharge rate for Slaughter Creek (Table 4.1).

By detaining stormwater runoff from the upstream watershed and controlling the rate at which it is released downstream, this facility provides for maximum infiltration along the streambed of the Slaughter Creek channel. The natural recharge through fractures and sinkholes along the creek is increased.

4.3.5 LAKE TRAVIS DIVERSIONS INTO ONION CREEK

As part of the Hays County Regional Water and Wastewater Study undertaken by the Hays County Water Development Board [HDR Engineering Inc., 1989], a variety of alternatives were considered for meeting the future water demands of users in northern Hays County that presently rely on groundwater from the Barton Springs segment of the Edwards aquifer, principally the towns of Hays and Buda. One of these options involved a plan to divert surface water from Lake Travis on the Colorado River above Austin, pipe it across southwestern Travis and northern Hays Counties, and then discharge it into a tributary of Onion Creek so that it could flow downstream and recharge the Barton Springs segment of the Edwards aquifer.

The point of discharge into the Onion Creek watershed was to be on Pier Branch about four miles east of Dripping Springs just south of Highway 290. A portion of the water also was to be used by the City of Dripping Springs to supply their water supply.

Although this alternative was considered to be attractive from a cost standpoint for Hays and Buda, it was not recommended for further consideration in the Hays County Regional Plan because of uncertainties regarding the availability of the water to the intended users once it was recharged to the aquifer since it would then be available for withdrawal by any of the existing aquifer users. Potential problems and risks associated with the possible need to change state law in order to implement this alternative in a manner that would provide water supply protection to the intended users also was a concern.

4.3.6 BLANCO RIVER DIVERSIONS INTO ONION CREEK

Because of the close proximity of the Blanco River to Onion Creek in northern Hays County, it may be possible to develop a plan to increase the recharge to the Barton Springs segment of the Edwards aquifer by diverting a portion of the floodflows from the Blanco River into Onion Creek. These floodwaters would have to be discharged into Onion Creek near the upstream boundary of the recharge zone, or they possibly could be discharged into one or more of the natural recharge features in the area, i. e. caves and major sinkholes.

This scheme would require careful consideration of surface water rights in the Blanco and Guadalupe River Basins and close coordination with and approval from the Texas Water Commission. Only unappropriated flows in the Blanco could be diverted, and, in accordance with the Texas Water Code, it would have to be demonstrated that none of the diversion water would be needed in the basin of origin for a 50-year period. With current water shortage conditions threatening to severely diminish or even eliminate springflows into the San Marcos and Comal Rivers from the Edwards aquifer, it is highly unlikely that surface waters from the Blanco River will not be needed in the lower reaches of the basins during the next 50 years.

Still, there may be some possibility if it could be shown that certain portions of the floodflows in the Blanco River never contribute to the lower streamflows because of significant losses that occur across the Edwards recharge zone. It should be noted, however, that the Blanco River has been identified as one of the principal streams where recharge structures would be particularly effective for enhancing recharge to the San Antonio portion of the Edwards aquifer. The Technical Advisory Panel to the Special Committee on the Edwards Aquifer, a joint committee of the Texas Senate and House of Representatives, has reported that recharge enhancement along the Blanco across the recharge zone of the Edwards would be especially beneficial with regard to maintaining flows in San Marcos Springs [Fisher et al, 1990].

4.3.7 RUNOFF DIVERSIONS INTO NATURAL RECHARGE FEATURES

Although the large majority of the natural recharge of the Barton Springs segment of the Edwards aquifer occurs through openings and fractures along streambeds that tranverse the Edwards outcrop area, additional quantities of surface runoff also enter the groundwater system through such surface features as caves, sinkholes, fracture zones, faults and other openings. Studies by the USGS have determined that about 15 percent of the total surface recharge that enters the Barton Springs segment of the Edwards aquifer flows through these surface features.

Because of the extremely limited and localized nature of the drainage areas that contribute runoff to these surface features, the quantity of recharge water that enters the groundwater system through any one of these features generally is not appreciable. However, in many instances, the capacity of these features to accept and infiltrate runoff is considerable. Their ability to contribute recharge to the aquifer simply is limited by the source of water from the land surface.

There are some cases, however, where surface runoff that is concentrated in swales, draws, creeks, streams and other drainageways could be diverted into one of these recharge features and provide a substantial amount of additional recharge to the aquifer. One potential example of this type of recharge facility is the proposed stormwater detention pond that is planned for the South Branch of Williamson Creek at the crossing of the southern extension of MOPAC Loop 1. Certainly, there are other areas where runoff can be directed to existing surface recharge features.

The BS/EACD has had a program underway to locate, classify and map these surface recharge features. Considerable data and information has been compiled and reviewed. Most of the major caves and sinkholes over the recharge zone have been identified and catalogued. Detailed geologic maps of the area showing major fault lines and fracture zones are available. Maps identifying significant karst features and lineaments have also been assembled.

With the information base that is available at the BS/EACD regarding surface recharge features, future plans for drainage improvements, new stormwater detention ponds or roadway modifications in the vicinity of the recharge zone should be examined for the purpose of identifying potential measures that might be incorporated into the projects that could provide for increased recharge to the aquifer. This program should be initiated jointly with the City of Austin and Travis and Hays Counties to assure that all future plans for new developments are included in this recharge enhancement review process.

4.4 IMPLEMENTATION CONSIDERATIONS

4.4.1 AGENCY COORDINATION

There are several local, state and federal agencies with offices in Austin that have specific interests regarding recharge enhancement of the Barton Springs segment of the Edwards aquifer. These include, of course, the BS/EACD, as well as the City of Austin, the several communities that rely on the Edwards for their municipal supplies, Travis County, Hays County, the Lower Colorado River Authority (LCRA), the Texas Water Commission, the State Department of Highways and Public Transportation (SDHPT), and the U. S. Geological Survey (USGS). Efforts to implement recharge programs need to be coordinated among these entities.

The USGS has extensive data and information regarding the hydrogeologic characteristics of the aquifer, and its staff are particularly knowledgeable with respect to the behavior and recharge features of the groundwater system. Plans from the City of Austin, Travis County, Hays County, and the SDHPT for proposed development projects and drainage improvements should be routinely reviewed for potential measures that could increase recharge to the Edwards.

4.4.2 WATER RIGHTS

Any major efforts to increase surface recharge to the Barton Springs segment of the Edwards aquifer will require approval by the Texas Water Commission (TWC) because of the potential impacts on downstream senior water rights. Determinations of available unappropriated surface water for the streams that cross the recharge zone will have to be made with assistance from the TWC.

The Texas Water Code includes provisions for issuing water rights permits for the use of surface waters for recharge purposes; however, as presently written, the law applies only to the San Antonio portion of the Edwards. This provision of the Water Code may have to be changed before a permit could be issued by TWC.

The BS/EACD has entered into a Memorandum of Understanding with the LCRA to establish a "cooperative framework within which they both may work toward their common goal of conservation and protection of the Barton Springs segment of the Edwards Aquifer". This agreement specifically mentions the need to pursue recharge projects jointly, and it states that LCRA will "assist the District in obtaining the necessary water and/or water rights associated with such projects". Certainly, this agreement could provide the basis for utilizing a portion of LCRA's interruptible water supplies for recharge enhancement purposes.

4.4.3 STATE AND FEDERAL PERMITTING

Besides the state water rights permits from the Texas Water Commission, there are other permits that may be required for implementing recharge enhancement projects. Of special note are the Section 404 and Section 9 and 10 permits from the Corps of Engineers. The 404 permit addresses the placement of materials in the nation's waters so as to minimize impacts on wetlands and instream uses. Section 9 and 10 permits deal with obstructions to stream flow and navigation. These permitting processes can require considerable time and effort, and they must be factored into the cost and scheduling for implementing any recharge enhancement projects.

4.4.4 ENVIRONMENTAL IMPACTS

All of the permitting process will require careful consideration of the environmental consequences of implementing a proposed recharge enhancement project. Both terrestrial and aquatic issues involving the biologic and hydrologic resources of the project area must be addressed, as well as, secondary impacts. Alternatives to recharge enhancement projects also must be identified and evaluated.

4.4.5 FACILITIES OPERATION AND MAINTENANCE

A specific program for operating and maintaining any recharge enhancement projects that might be implemented will need to be developed. Personnel will have to be available for these purposes, and budgets will have to be allocated accordingly.

4.4.6 FACILITIES OWNERSHIP

For major recharge projects such as the Driftwood Reservoir, substantial land and facilities will be involved. These will have to purchased and owned by some governmental entity, or entities, that can assume responsibility for repayment of loans and operation and maintenance activities. For the smaller instream channel reservoirs, probably only a few acres of land may actually need to be purchased for the dam sites, with flood easements acquired for the impoundments. For these facilities, the BS/EACD could be the local sponsoring agency with responsibilities for project ownership and financing.

4.4.7 PROJECT FINANCING

The most likely source for funding of these recharge enhancement projects is the loan program administered by the Texas Water

Development Board. These funds could be made available for implementing specific projects with attractive financing terms. These loans will require local participation and a guaranteed payback. The BS/EACD could serve as the local sponsoring entity for these projects with financing responsibility. Certainly the ground water users within the BS/EACD would be direct beneficiaries of any recharge enhancement project, and it would be appropriate for these users to pay their proportionate share of the project implementation and operation costs. Other entities that will use the ground water resulting from the recharge enhancement project, including the City of Austin since it diverts water from Barton Springs through Town Lake at the Green Water Treatment Plant, also should pay for a portion of the project costs.

4.5 CONCLUSIONS AND RECOMMENDATIONS

This study of recharge enhancement for the Barton Springs segment of the Edwards aquifer has identified the following specific conclusions and recommendations regarding the potential for implementing projects to increase the available water supply of the groundwater system.

1. There is substantial surface water runoff available in the watersheds that drain to and across the recharge zone of the Barton Springs segment of the Edwards aquifer that could be captured and used to increase the natural recharge of the aquifer;

2. Successful recharge enhancement projects have been implemented for other portions of the Edwards aquifer, particularly west of San Antonio in Medina County by the Edwards Underground Water District;

3. Preliminary cost estimates for implementing large-scale mainstem dam and reservoir projects for enhancing the recharge of the Barton Springs segment of the Edwards aquifer indicate that the unit costs of water developed by these projects generally would be consistent with those of other large reservoir projects in Texas;

4. Based on preliminary studies, the construction of small channel dams and reservoirs on the creeks and streams that cross the recharge zone appears to be the most attractive alternative for recharge enhancement, with affordable unit costs of water and reduced environmental impacts. It is recommended that the BS/EACD proceed with more detailed studies to develop a specific channel dam recharge enhancement project on one or more of the contributing creeks and streams;

5. Onion Creek offers the most potential for increasing the available groundwater supply through recharge enhancement because it has the largest drainage area upstream of and over the recharge zone, its streambed exhibits high rates of infiltration capacity, and it is the farthest removed from the principal outlet of the aquifer at Barton Springs, such that any additional recharge from the creek must move through the entire length of the groundwater system where it would be available for pumpage;

6. It is recommended that more detailed geologic, hydrologic, siting, and cost analyses of a recharge enhancement channel dam and reservoir facility be undertaken to develop a specific project for implementation on Onion Creek;

7. With results available from the detailed studies, it is recommended that the BS/EACD undertake preparation of an

Engineering Report for the recharge enhancement project using guidelines in Section 363.55 of the Texas Water Code titled "Required Engineering Feasibility Data for Water Supply Projects";

8. Following preparation of the Engineering Report, it is recommended that the BS/EACD submit an application to the Texas Water Development Board for financing assistance for construction of the recharge enhancement project; and

9. The BS/EACD should initiate efforts to coordinate the development of a comprehensive recharge enhancement and management program for the Barton Springs segment of the Edwards aquifer with the LCRA, the City of Austin, Travis County, Hays County, and the USGS.

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SECTION 5 REPORT

REGIONAL WATER PLAN
for the
BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

DROUGHT CONTINGENCY PLAN

prepared for

BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT
Austin, Texas

and

TEXAS WATER DEVELOPMENT BOARD
Planning Grants Assistance Program
Austin, Texas

TWDB CONTRACT NO. 9-483-732

prepared by

DONALD G. RAUSCHUBER & ASSOCIATES, INC.
Austin, Texas
(PRINCIPAL INVESTIGATOR)
and
R. J. BRANDES COMPANY
Austin, Texas

SEPTEMBER 1990

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5.0 INTRODUCTION

The Barton Springs/Edwards Aquifer Conservation District (BS/EACD) was created by the 70th Texas Legislature, under Senate Bill 988. This legislation mandated the BS/EACD to preserve and protect the Barton Springs - Edwards Aquifer. The Drought Contingency Plan (DCP) presented herein is a critical element in the fulfillment of the BS/EACD's statutory charge. This effort is one of several water protection and conservation strategies that will be implemented by the BS/EACD. This DCP compliments other BS/EACD plans, such as, the emergency interconnection of water systems, water conservation planning, and development of ground water enhancement projects.

This DCP establishes guidelines and procedures by which the groundwater resources of the Barton Springs - Edwards Aquifer can be managed during a drought.

5.1 DCP GUIDELINES

The BS/EACD Conservation/Drought Committee adopted the following guidelines for the development and establishment of the DCP.

GOALS AND OBJECTIVES

1. Assure that adequate quantity and quality of water is available to all wells used to supply basic human and animal needs, including economic activity, in the Barton Springs segment of the Edwards Aquifer.
2. Assure that flows at Barton Springs do not fall appreciably below historic low levels.

3. Protect this natural resource and provide a legacy for future generations.

DROUGHT CONDITION TRIGGERS

1. Establish trigger conditions for area monitor wells based on historical low for each monitor well.
2. Water level must be at or below trigger level for 21 consecutive days prior to raising level of drought condition.
3. Water level must above trigger level for 21 consecutive days prior to decreasing level of drought condition.
4. Quality and discharge of water from Barton Springs must be related to trigger levels

DROUGHT CONDITION STAGES

1. Alert Status - Each year beginning on May 1 and ending on September 30 (unless other trigger conditions exist) this status will automatically go into effect. Due to groundwater pumpage, the BS/EACD is in a mild drought condition during this period of each year. The following activities shall occur while in this status:

    A. Public awareness and conservation
    B. Voluntary lawn watering curtailment
    C. Monitoring of wells and BS/EACD to watch for trigger conditions

2. Alarm Status - Requirements:

    A. Monitor wells more frequently
    B. Mandatory curtailment for industrial users
    C. Advisable curtailment for water suppliers
    D. Voluntary curtailment for individuals

3. Critical Status - Requirements:

A. Daily monitoring of wells and springs
B. Mandate more restrictive curtailments for all users

5.2 QUANTITY, QUALITY AND BARTON SPRINGS DISCHARGE INFORMATION

5.2.1 GENERAL AQUIFER CHARACTERISTICS

It is estimated that there are approximately 1,500 Edwards aquifer wells located within the boundaries of the BS/EACD. Figure 5.1 shows the locations of selected wells where water level measurements and geologic data have been collected.

Using geologic data for the wells shown in Figure 5.1, Slade and others (USGS 1986) developed hydrogeologic sections of the Edwards aquifer. A strike section of the Edwards developed by Slade is shown in Figure 5.2. This section approximately follows the outcrop of the Edwards aquifer from the Blanco River in Hays County, to north of the Colorado River in Travis County. The faults shown on this figure indicate how the elevation of the top of the Edwards aquifer can change rapidly within a short distance. The faults also effect the rate ground water moves through the aquifer.

A delineation of the Edwards aquifer within the boundaries of the BS/EACD is shown in Figure 5.3. The extensive outcrop area shown on this map approximates the recharge zone. Water table conditions prevail in an area adjacent and east of the recharge zone. As water moves eastward and downdip in the aquifer it becomes confined and artesian conditions prevail.

FIGURE 5.1 LOCATION OF WELLS WHERE WATER-LEVEL MEASUREMENTS HAVE BEEN COLLECTED

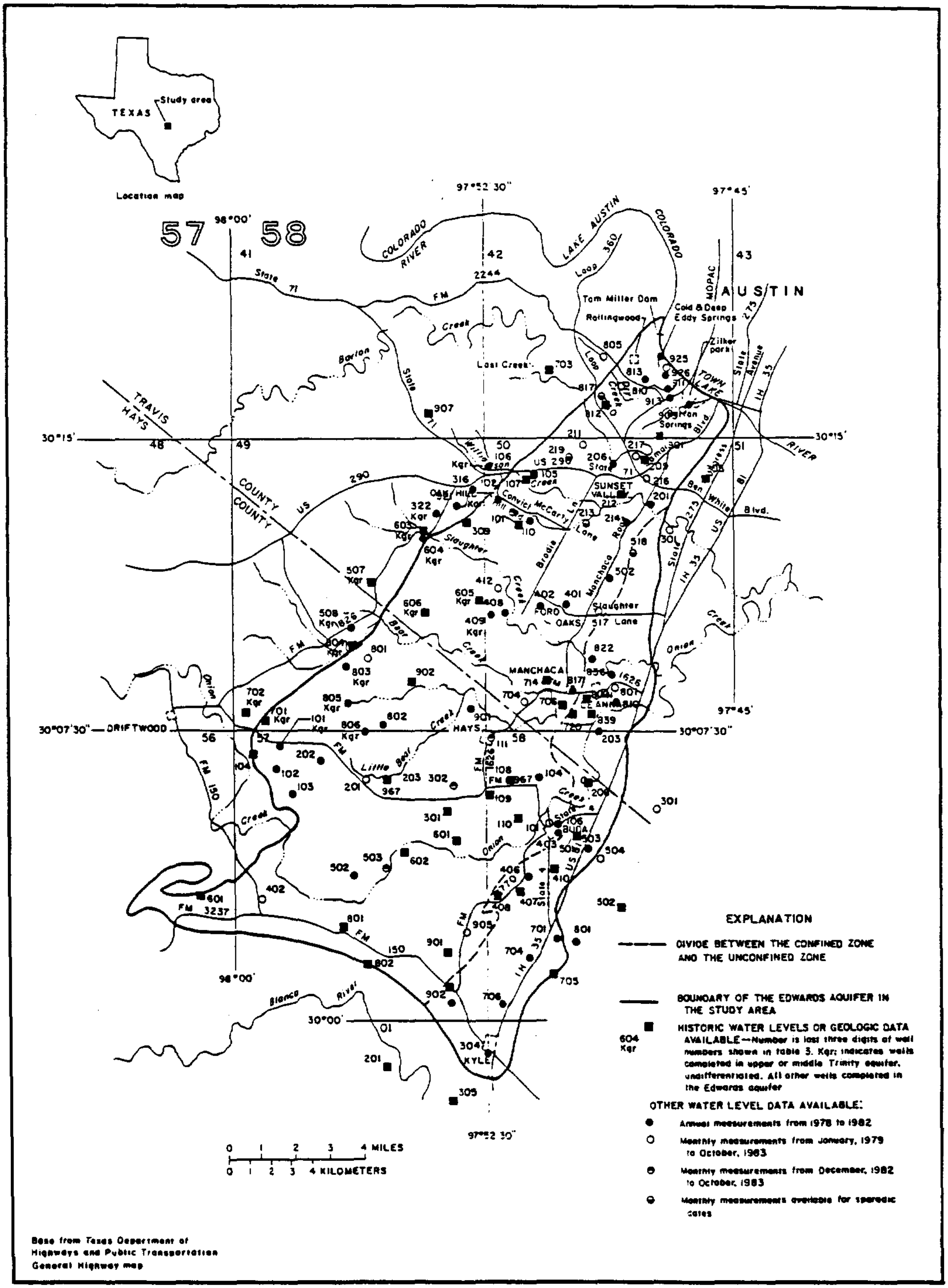


FIGURE 5.2 HYDROGEOLOGIC SECTION OF EDWARDS AQUIFER ALONG STRIKE, A-A'

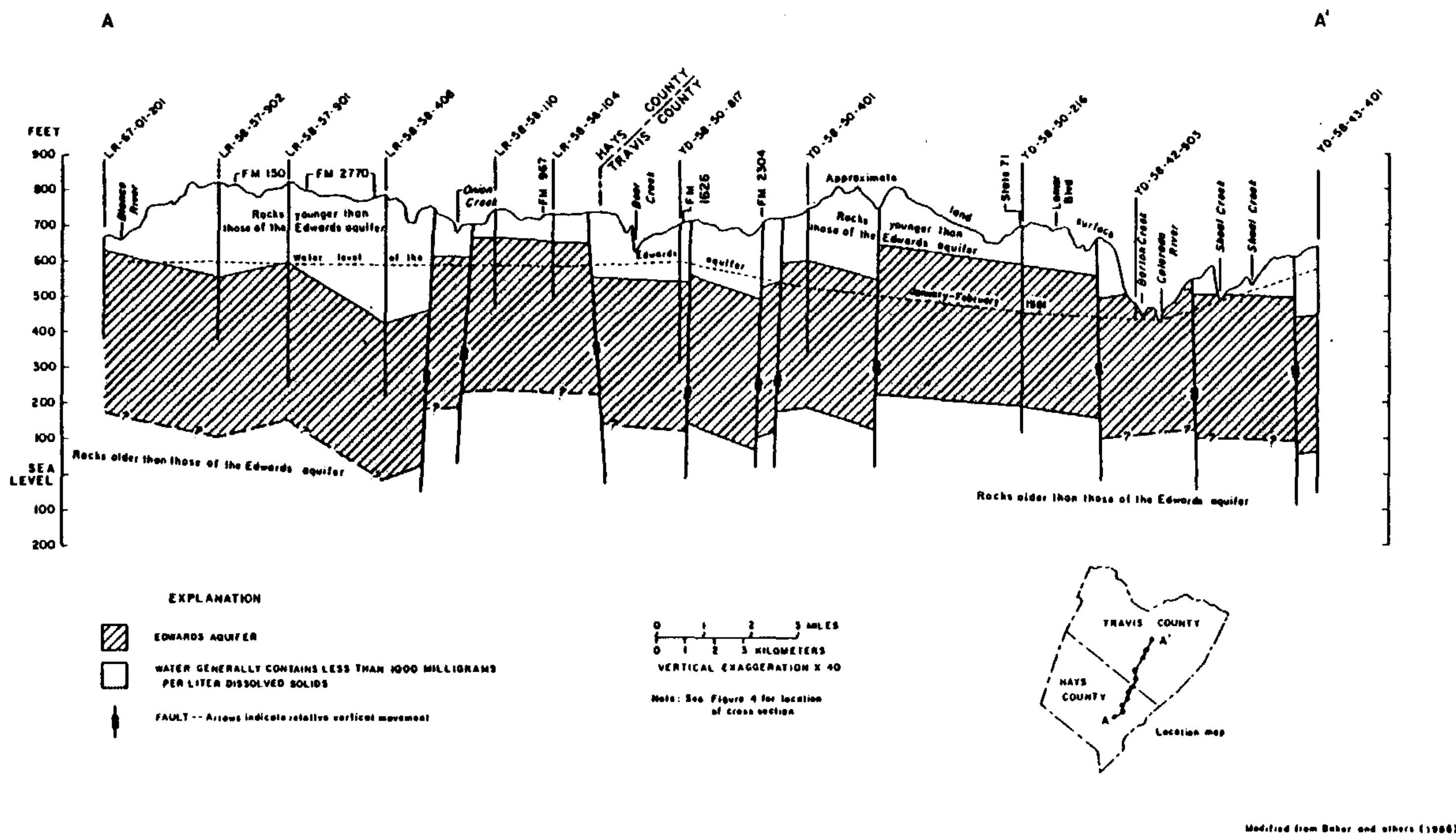
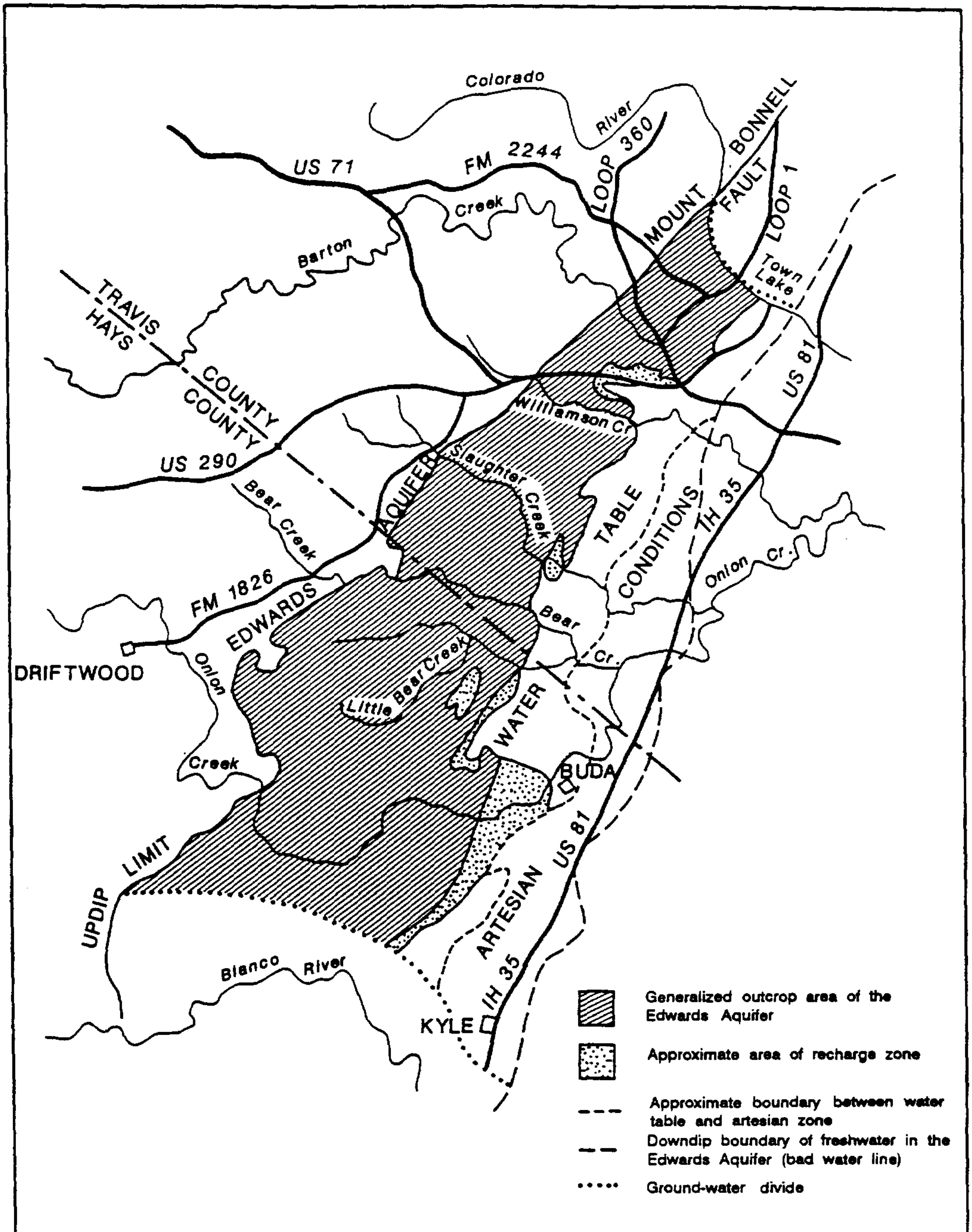


FIGURE 5.3 DELINEATION OF BARTON SPRINGS/EDWARDS OUTCROP AREA



Map modified from Andrews, Schertz, Slade, and Rawson, 1984.

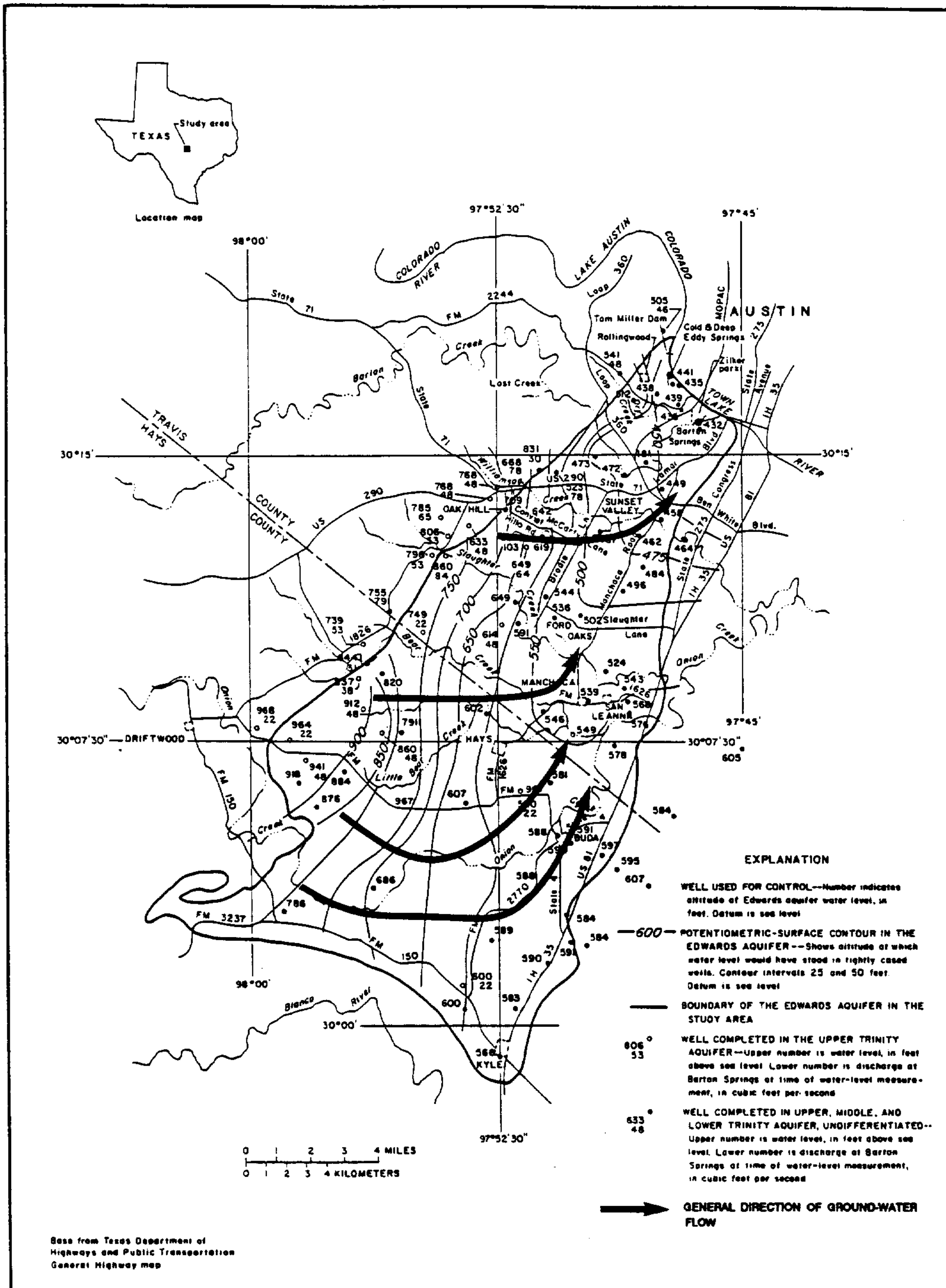
Source: Espey Houston & Associates, 1979

The source of the water which recharges the Edwards aquifer is from precipitation that falls both on and upstream from the recharge zone. The major drainage areas that provide the majority of the recharge to the aquifer are Onion, Bear, Little Bear, Slaughter, Williamson, and Barton Creeks. As these creeks transverse the recharge zone, surface runoff is recharged through numerous faults (see Figure 5.2) and joints. These faults and joints have been enlarged by solution and often are characterized by sinkholes, crevices, cracks, and caves, especially in stream channels (TWDB 1986). Streamflow enters these sinkholes and moves downward into the aquifer.

Generalized groundwater movement within the Edwards is shown in Figure 5.4. The direction of movement is from areas of high water levels in the southwestern and western portions of the system eastward and northeastward to the point of primary discharge at Barton Springs (Slade et al, 1985). Since ground water in the Edwards and associated limestones moves under turbulent flow conditions in underground channels, it travels relatively fast (TWDB 1986). Historically, hydraulic gradients of the potentiometric surface have ranged from less than 20 to 200 feet per mile. It is estimated that, under "normal" conditions, water recharged at Onion Creek would move downdip for about 3 to 5 years before being discharged through Barton Springs.

Water levels in the Edwards aquifer respond rapidly to changes in the amount of water recharged to and discharged from the aquifer. During above normal rainfall years, aquifer recharge exceeds discharge, causing water levels to rise. In below normal rainfall years, aquifer discharge (spring and pumpage) is greater than recharge causing the amount in storage to decrease and water levels to decline. The amount of water pumped from the Edwards aquifer

FIGURE 5.4 GENERALIZED GROUNDWATER MOVEMENT THROUGH THE BARTON SPRINGS/EDWARDS AQUIFER



greatly effects water levels. This effect is easily observed by rapidly declining water levels when periods of heavy pumping are accompanied by periods of deficient rainfall (TWDB 1986).

5.2.2 EVALUATION OF KEY MONITOR WELLS

Figure 5.1 illustrates wells used by previous researchers to investigate the hydrogeologic characteristics of the Edwards aquifer. Only a few wells of those shown on Figure 5.1 have had water level measurements recorded over sufficient periods of time to evaluate historical drought stages, especially the 1950's drought of record. This drought resulted in the lowest-long term water levels ever recorded in the Barton Springs-Edwards Aquifer. It also resulted in the lowest discharges recorded for Barton Springs. For the purposes of this DCP, the 1950's drought is used to determine drought stages and trigger conditions for responses.

Examination of reports and records from the Texas Water Development Board and the U.S. Geological Survey indicates that the following Edwards wells have records dating from the 1940's:

Well No.	General Location	County	Period of Record
LR58-57-903	Mountain City Ranch	Hays	1949 - 1981
LR58-58-101	City of Buda	Hays	1937 - Present
YD58-58-301	IH35 & FM 1327	Travis	1943 - Present
YD58-50-801	Near San Leanna	Travis	1941 - Present
YD58-50-502	Near Manchaca Rd and Riddle Lane	Travis	1949 - 1981
YD58-50-301	Near Congress Ave. and Ben White	Travis	1949 - Present
YD58-42-911	Near Barton Springs	Travis	1941 - Present

These wells lie on a general line from the southerly updip section of the Edwards aquifer to its most downdip section at Barton Springs. In addition, these wells are situated both in the water table and artesian portion of the Edwards aquifer. Table 5.1 presents a physical description of these wells.

The first four wells shown in Table 5.1 are situated south of Slaughter Creek, in the "sole source" portion of the Edwards aquifer. Water elevations in these wells are indicative of localized water level conditions available to the majority of users of the Edwards aquifer. The remaining three wells would be indicative of "down gradient" water level conditions and would be influenced to a lesser degree by localized pumpage.

A hydrograph of water level of each of these wells is shown in Figures 5.5 through 5.11. Examination of these hydrographs shows that water levels fluctuate widely due to hydrologic conditions and pumpage. Well No. LR58-57-903, a water table well located near Mountain City Ranch, had a record low in 1956 with a water level elevation of 554.02 ft msl, based on the 1949 through 1981 period of record. The highest water level measured for this well was 639.70 ft msl in 1975 (see Figure 5.5).

The water elevation in Well No. LR58-58-101 (Figure 5.6), a water table well located near Buda, ranged from a low of 550.66 ft msl in 1984 to a high of 654.15 ft msl in 1973. The lowest record level for this well during the 1950's drought was 558.44 ft msl, which occurred in 1956. The drought of 1983 through 1984 was shorter than the 1950's drought, but was more severe in terms of lower water levels. This is due to higher rate of pumpage in the 1980's as compared to the 1950's.

TABLE 5.1 PHYSICAL DESCRIPTION OF SELECTED EDWARDS AQUIFER WELLS

WELL NO.	OWNER	AQUIFER CONDITION	DATE COMP.	WELL DEPTH	ALT. (MSL)	PURPOSE OF WELL
LR58-57-903	MOUNTAIN CITY RANCH	WATER TABLE	1943	400	822	TWDB OBSERVATION WELL
LR58-58-101	FRANKLIN	WATER TABLE	1907	243	707.2	TWDB OBSERVATION WELL
YD58-58-301	UNITED GAS PIPELINE	ARTESIAN - BAD WATER ZONE	1943	703	734	USGS OBSERVATION WELL
YD58-50-801	C. H. BIRD	ARTESIAN	1939	277	662	TWDB OBSERVATION WELL
YD58-50-502	R. W. HERNDON	ARTESIAN	1937	300	740	TDWB OBSERVATION WELL
YD58-50-301	JOHN LOVELADY	ARTESIAN	1949	388	640	TWDB OBSERVATION WELL
YD58-42-911	BEE CAVE PROPERTIES	ARTESIAN	1920's	135	517	USGS OBSERVATION WELL

FIGURE 5.5 HYDROGRAPH OF WATER LEVEL FOR EDWARDS WELL NO. LR58-57-903 - MOUNTAIN CITY

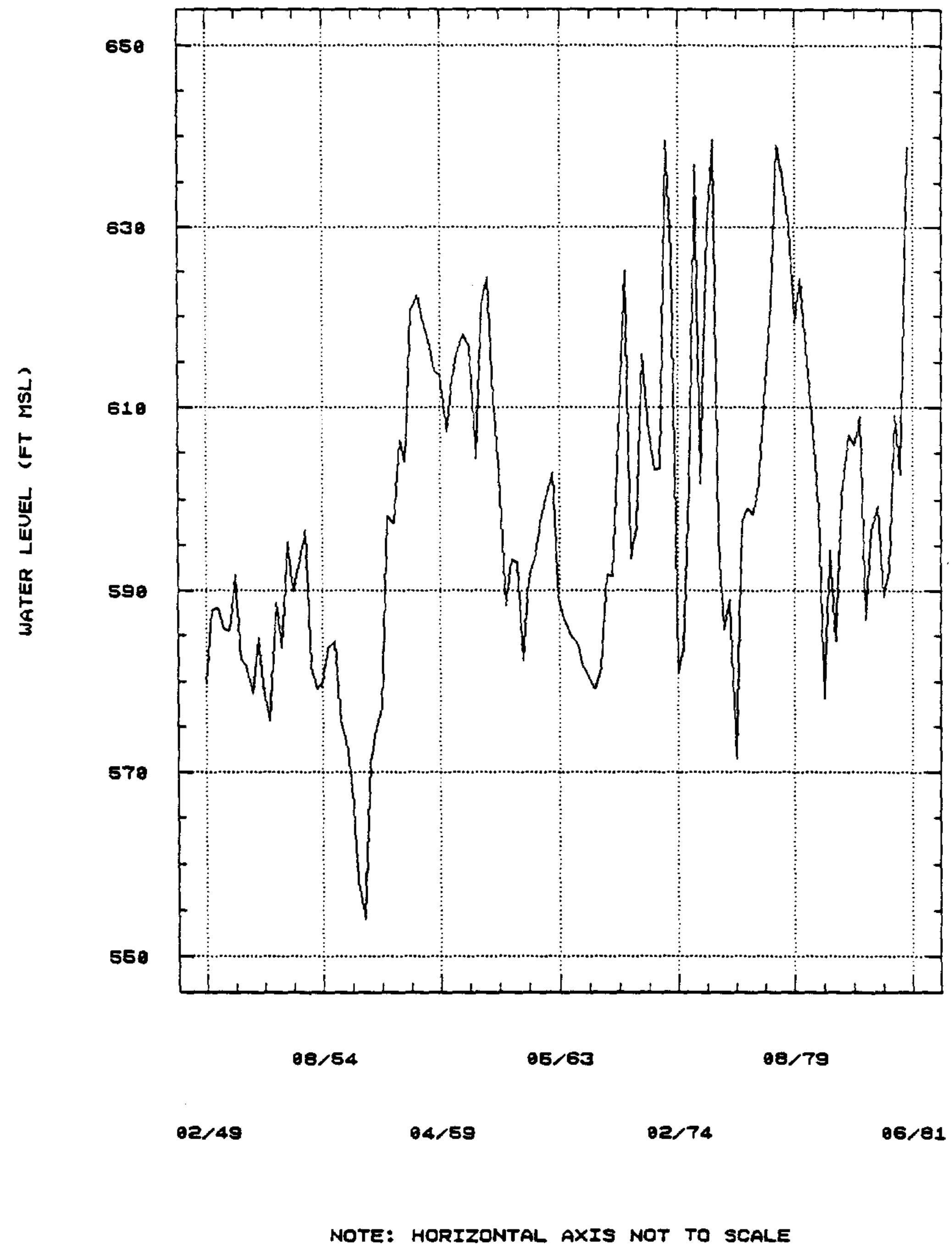
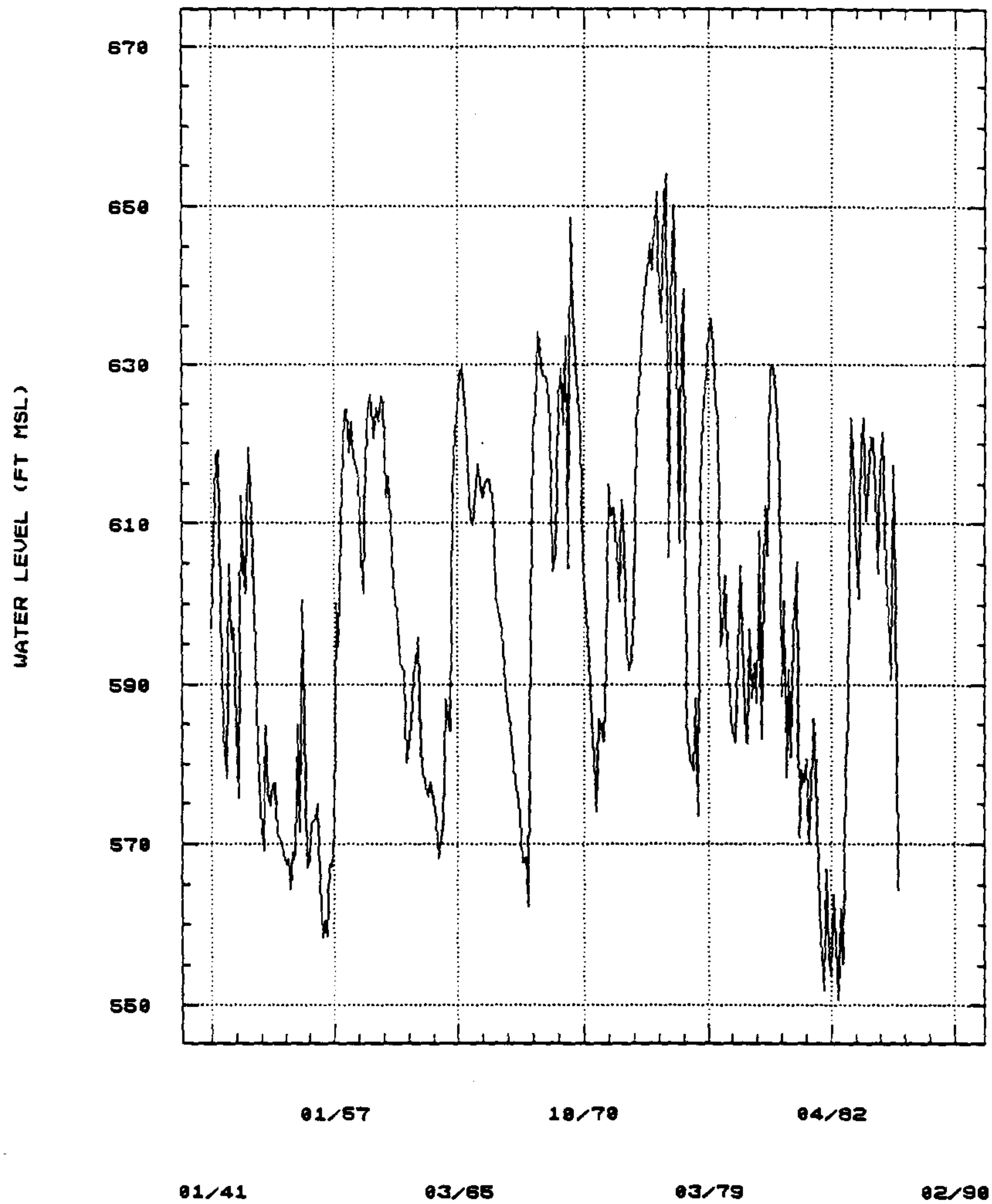


FIGURE 5.6 HYDROGRAPH OF WATER LEVEL FOR EDWARDS WELL NO. LR58-58-101 - BUDA



NOTE: HORIZONTAL AXIS NOT TO SCALE

FIGURE 5.7 HYDROGRAPH OF WATER LEVEL FOR EDWARDS WELL NO. YD58-58-301 - NEAR IH35 & FM1327

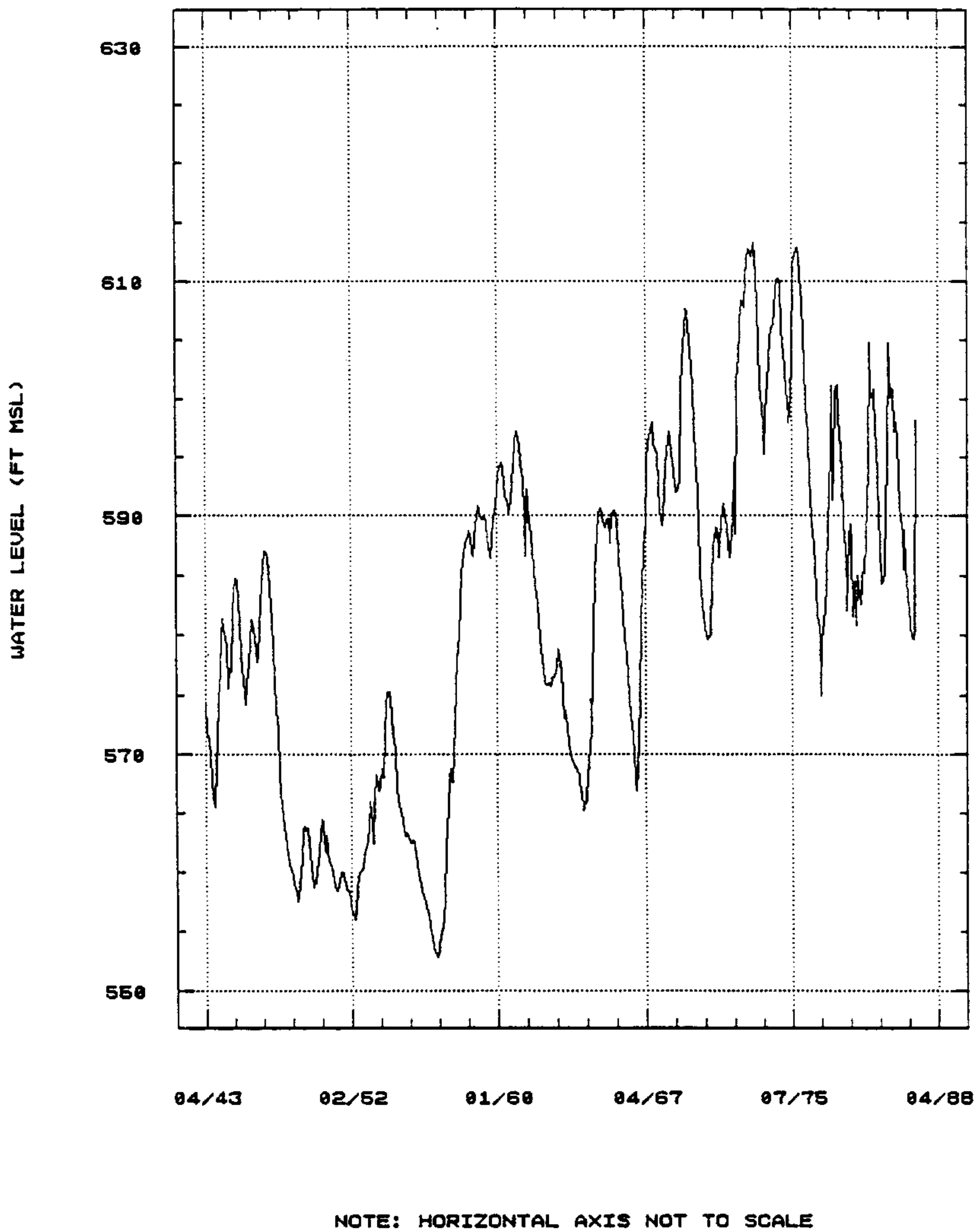
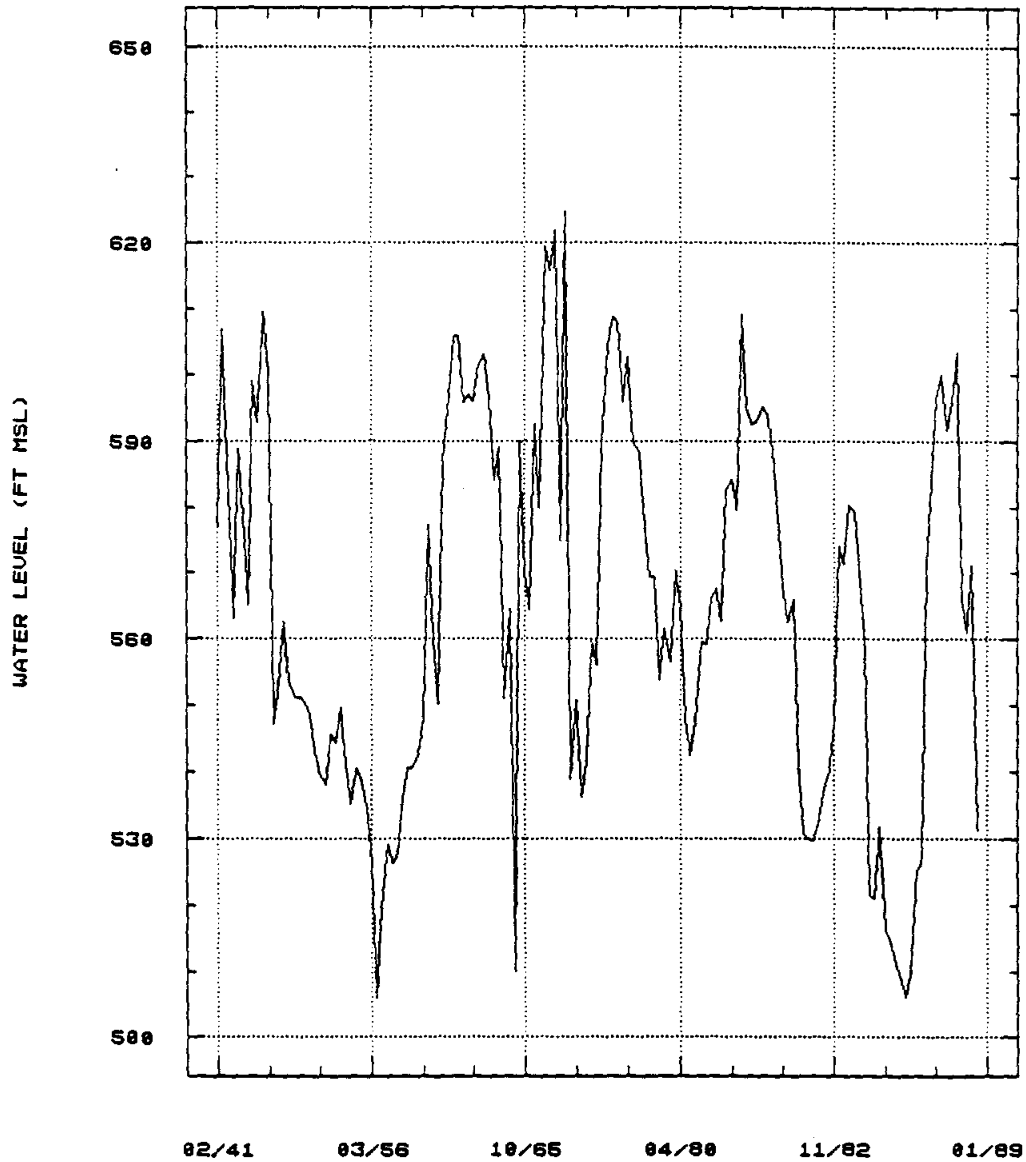
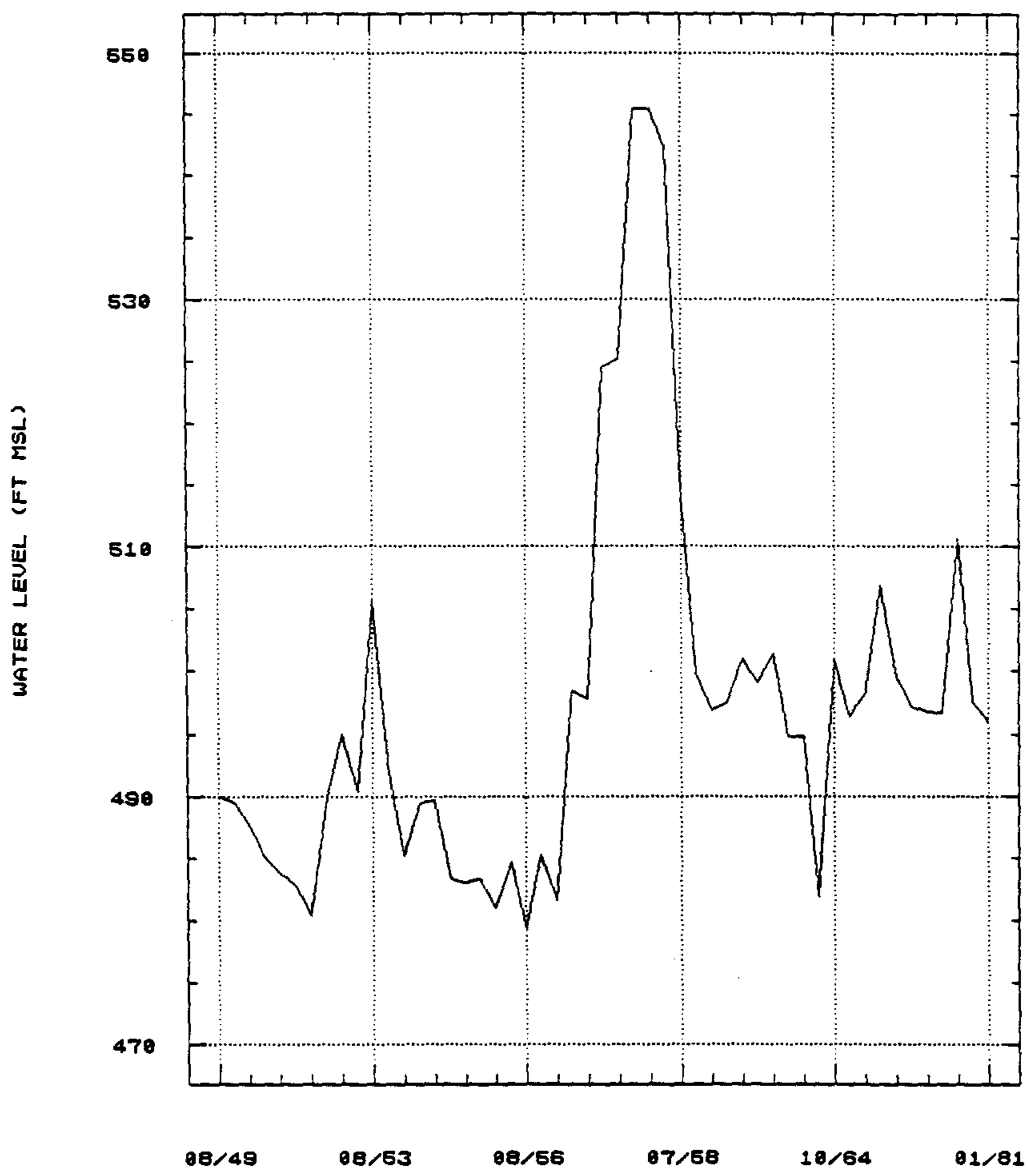


FIGURE 5.8 HYDROGRAPH OF WATER LEVEL FOR EDWARDS WELL NO. YD58-50-801 - NEAR SAN LEANNA



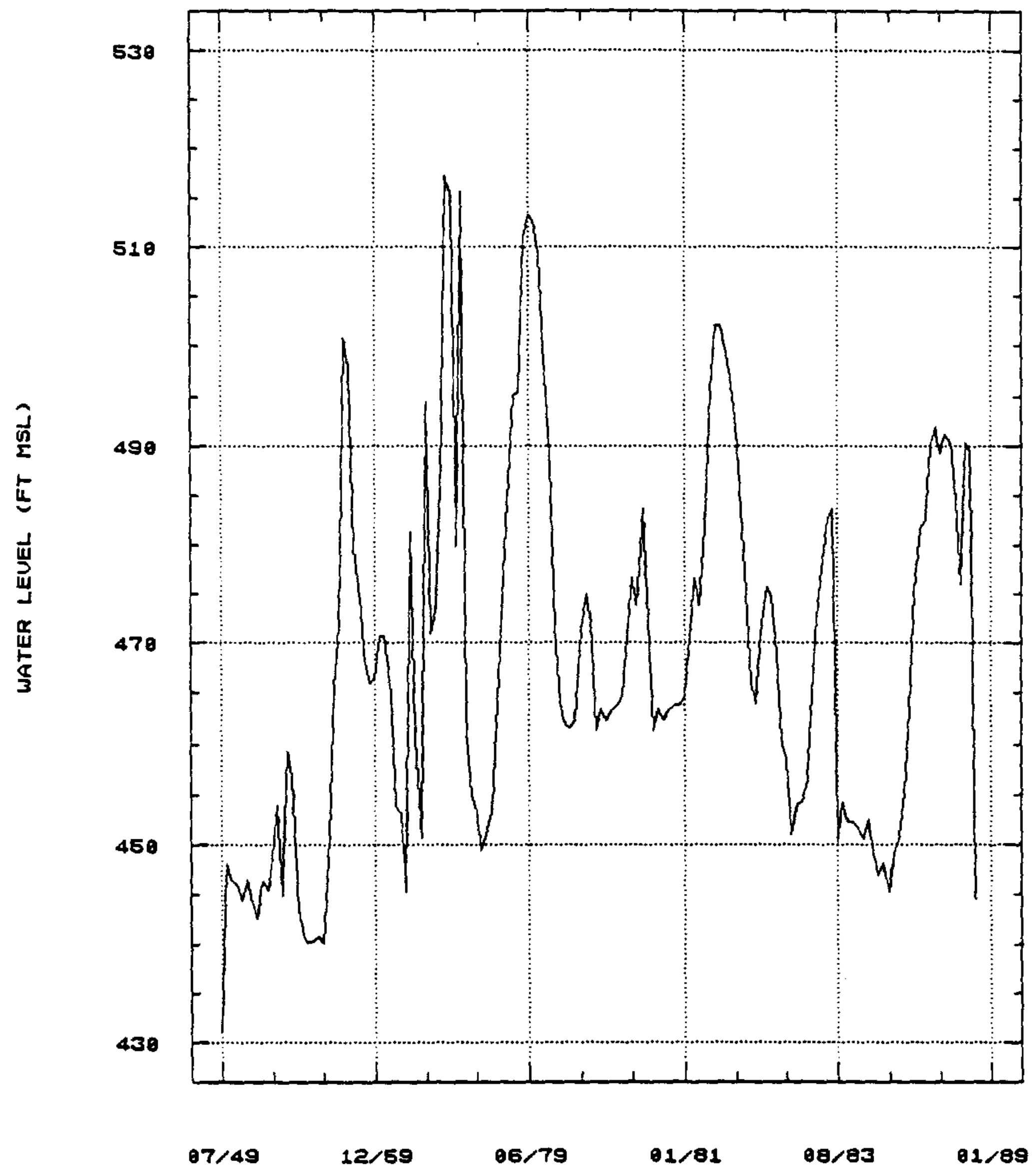
NOTE: HORIZONTAL AXIS NOT TO SCALE

FIGURE 5.9 HYDROGRAPH OF WATER LEVEL FOR EDWARDS WELL NO. YD58-50-502 - MANCHACA RD & RIDDLE LANE



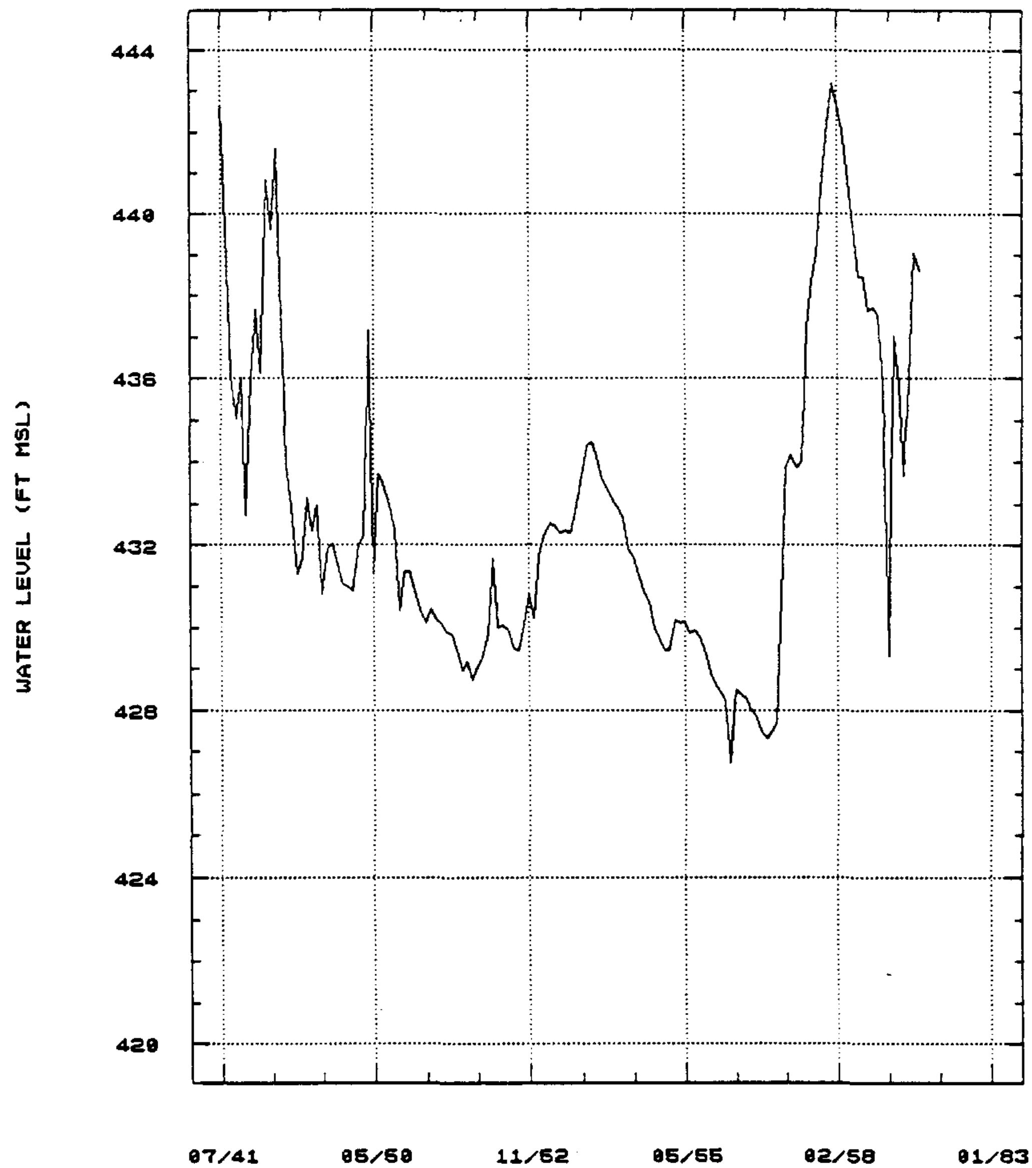
NOTE: HORIZONTAL AXIS NOT TO SCALE

FIGURE 5.10 HYDROGRAPH OF WATER LEVEL FOR EDWARDS WELL NO. YD58-50-301 - NEAR CONGRESS AVE & BEN WHITE BLVD



NOTE: HORIZONTAL AXIS NOT TO SCALE

FIGURE 5.11 HYDROGRAPH OF WATER LEVEL FOR EDWARDS WELL NO. YD58-42-911 - NEAR BARTON SPRINGS



NOTE: HORIZONTAL AXIS NOT TO SCALE

A similar trend is observed by examining the hydrograph for Well No. YD58-50-801 (artesian condition), located near San Leanna (Figure 5.8). This well experienced three lows of almost the same magnitude. These occurred in drought years of 1956, 1964 and 1984. The lowest measured water level was 505.88 ft msl in 1954. The highest water level recorded in this well was 624.63 ft msl in 1974. At that time, the potentiometric level was within 40 feet of the land surface.

The hydrograph for Well No. YD58-58-301 (Figure 5.7), located near IH35 and FM 1327 did not show similar lows during the 1964 and 1984 droughts as those observed during the 1950's drought. This artesian well, located east of IH35, is in the "bad water zone" of the Edwards. The well, used by the U.S. Geological Survey as an observation well, is remote and down-dip (easterly) from heavy pumping centers. Therefore, the well is less affected by area pumpage and discharge from Barton and other springs.

Water level changes for the three artesian wells located north of Slaughter Creek were not as great as those wells located over the sole source portion of the aquifer. The hydrograph for Well No. YD58-50-502 (Figure 5.9), located near Manchaca Road and Riddle Lane, exhibits a relatively stable water level. With the exception of the 1957 floods that ended the 1950's drought, the water levels ranged only about 30 feet from the maximum to the minimum observations.

Well No. YD58-50-301 (Figure 5.10), located near Congress Avenue and Ben White Boulevard, is a TWDB and USGS observation well. Water elevations in this well varied from a low in 1956 of 440.00 ft msl to a high of 517.21 ft msl, a range of 77.21 ft. Similarly, Well No. YD58-42-911 (Figure 5.11), located near Barton Springs, exhibits little variation.

A statistical summary of historical water elevations for the seven wells discussed above is presented in Table 5.2. Figure 5.12 illustrates plots of historical water level statistics for six of the seven wells shown in Table 5.2. Well No. YD58-58-301 is not plotted on Figure 5.12, since it is located in the "bad" water zone and is remote from major pumping centers.

Five statistical calculations for each well considered are plotted in Figure 5.12. These include the following parameters:

1. Highest Potentiometric Surface Measured (ft msl) - The highest observed water elevation, which generally occurred in the mid 1970's.
2. Upper Quartile of Potentiometric Surface Measurements (ft msl) - The water elevation above which 25% of the historical elevations lie and below which 75% of the data occur.
3. Median of Potentiometric Surface Measurements (ft msl) - The mid-point of the potentiometric surface measurements when ranked in an ordered array.
4. Lower Quartile of Potentiometric Surface Measurements (ft msl) - The water elevation above which 75% of the historical elevations lie and below which 25% of the data occur.
5. Lowest Potentiometric Surface Measured (ft msl) - The lowest observed water elevation, which generally occurred in 1956.

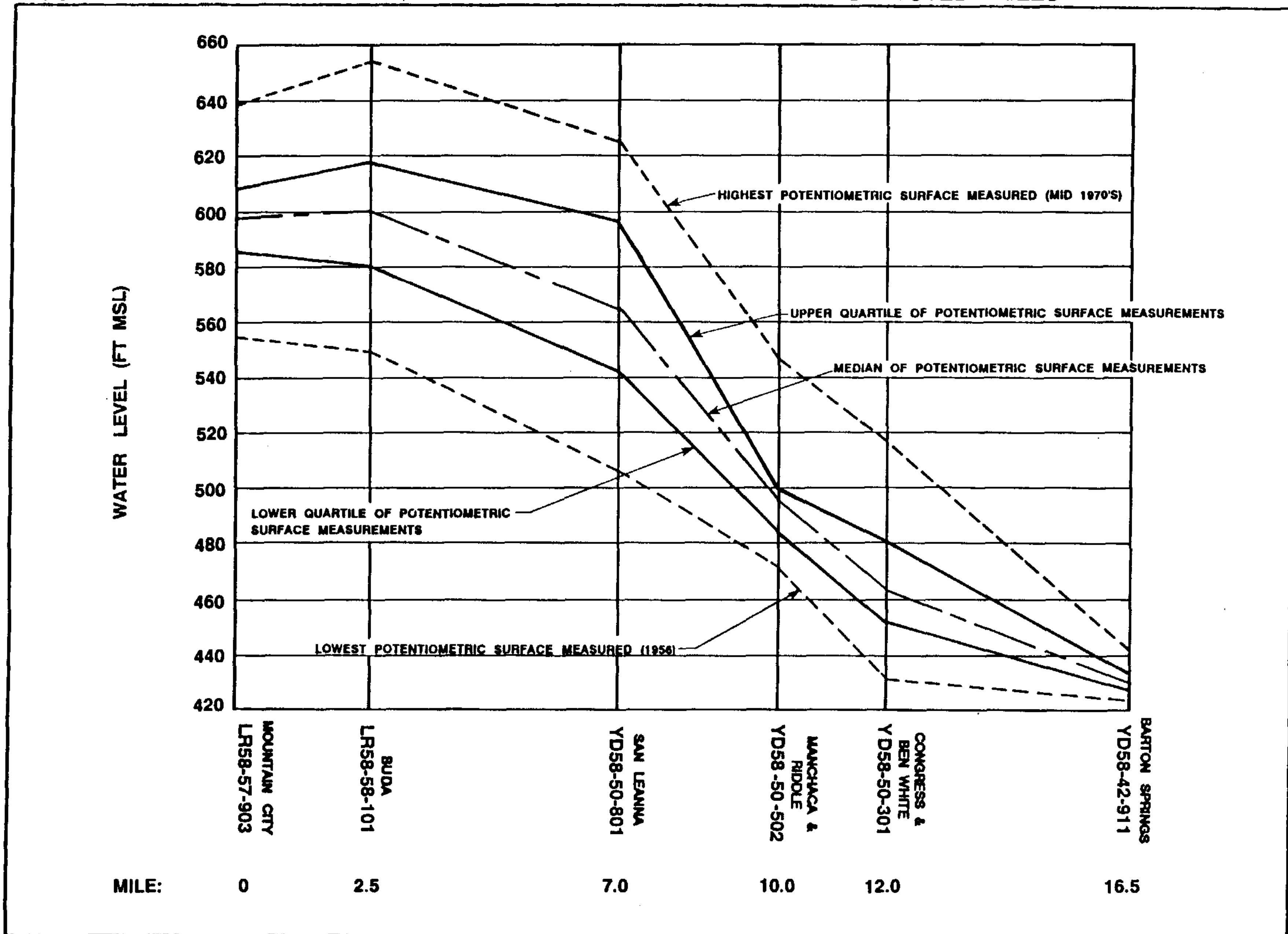
5.2.3 WATER QUALITY CONSIDERATIONS

The quality of water in the Edwards aquifer is related to the geology of the formation, as well as, to the origin of recharge water. Most of the dissolved matter in the ground water is from the solution of substances in the rocks that compose the aquifer (TWDB 1986).

TABLE 5.2 STATISTICS FOR SELECTED EDWARDS WELLS

WELL NO.	HIST. AVERAGE FT MSL	HIST. MEDIAN FT MSL	HIST. LOW FT MSL	HIST. HIGH FT MSL	RANGE FT	LOW QUARTILE FT MSL	HIGH QUARTILE FT MSL	NO. OBSER.
LR58-57-903	598.220	596.77	554.02	639.70	85.68	584.44	609.48	120
LR58-58-101	599.730	599.81	550.66	654.15	103.49	580.19	619.10	278
YD58-58-301	581.845	583.80	552.77	613.29	60.52	568.41	592.03	486
YD58-50-801	564.612	564.55	505.88	624.63	118.75	541.22	589.60	149
YD58-50-502	497.141	495.90	479.27	545.41	66.14	485.20	499.70	51
YD58-50-301	468.511	463.40	431.00	517.21	77.21	452.82	481.48	148
YD58-42-911	432.852	431.92	426.73	443.20	16.49	429.99	434.48	137

FIGURE 5.12 PLOT OF HISTORICAL WATER LEVEL STATISTICS FOR SELECTED WELLS



The quality of water from the Edwards aquifer varies throughout the BS/EACD area. Mineralization of water increases from the recharge areas on the west to the downdip areas on the east. Dissolved solids concentration increases from typically 200 to 400 mg/l in the recharge zone to 1,000 mg/l on the east side of the "fresh water" artesian zone.

The increase in mineralization with distance from the recharge area is predominant in the BS/EACD area. This may be due to intensive faulting, which creates numerous barriers to ground water movement in an easterly direction. This retardation of movement causes the dissolved solids concentration of the water to reach over 1,000 mg/l on the east boundary of the artesian zone (TWDB 1986).

Data published by the TWDB (1986) indicates that the total dissolved solids (TDS) concentrations for the Edwards aquifer in Hays County averages about 343 mg/l. TDS concentrations for Well No. LR58-58-105, located about 2 miles northwest of Buda, averaged approximately 372 mg/l for 1978 through 1981 . In Travis County, TDS concentrations average about 363 mg/l (TWDB 1986). TDS concentrations for Well No. YD58-50-810, located near FM1626 and Old San Antonio Highway, averaged approximately 461 mg/l, during the 1978 through 1981 period.

In addition to mineralization, the USGS (1986) reports that lower quality Trinity Formation water may be leaking into the Edwards aquifer. The wells that are suspected of leakage are near faults, which may be the major conveyers of leakage. Natural differences in hydrostatic head are probably responsible for most of the leakage. The Walnut Formation, which lies between the Edwards and upper Trinity aquifers, may have sufficient vertical permeability to allow water movement between the aquifers. If the hydrostatic pressure of the Edwards aquifer is lowered below a threshold value, vertical migration of poorer quality water from the Trinity and other aquifers will lower the water quality of Edwards water.

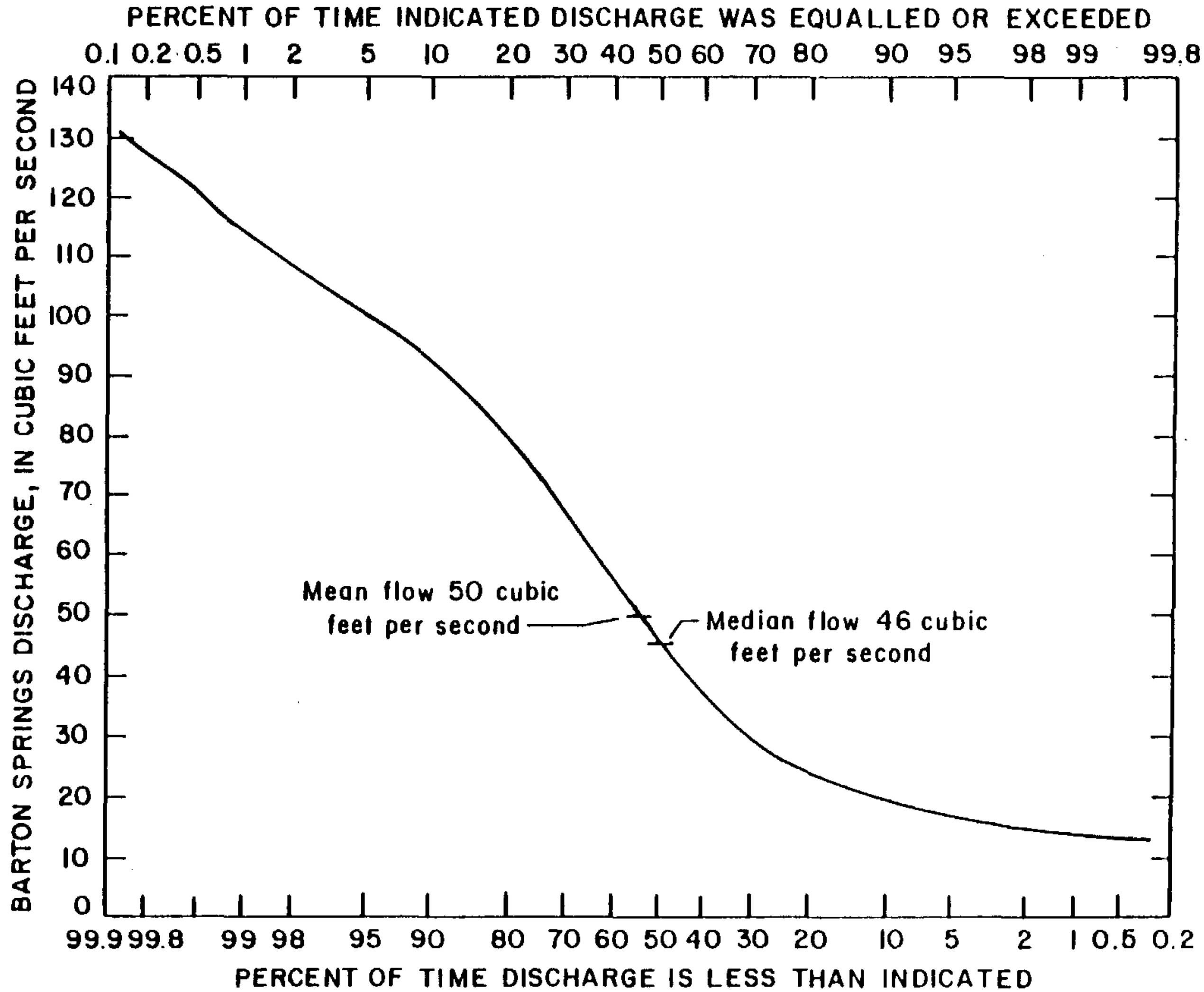
5.2.4 BARTON SPRINGS DISCHARGE

Barton Springs discharges to Barton Creek, which flows into Town Lake. Beginning in 1917, frequent measurements of discharge from Barton Springs have been made. Barton Springs include five major springs. Three discharge directly into the Barton Springs pool, while two others discharge downstream of the pool (USGS 1986).

Based on monthly mean discharges for the period 1917 through 1982, the mean flow for Barton Springs was 50 cubic feet per second (cfs). The median discharge for this period was 46 cfs. The minimum spring discharge was measured in 1956 at a flow rate of 10 cfs. Barton Springs has never gone dry during its recorded history. The maximum discharge ever recorded was 166 cfs.

A flow-duration curve for Barton Springs discharges is presented in Figure 5.13. This curve was developed by the USGS (1986) using monthly-mean discharges. The curve presents percentages of time that a given monthly-mean discharge are equaled or exceeded. Figure 5.13 indicates that 25% percent of the time the monthly-mean discharge from Barton Springs is greater than 72 cfs, or 75% of the time the discharge in less than 72 cfs. Likewise, the monthly-mean flow is greater than 30 cfs 75% of the time. Conversely, the mean discharge is less than 30 cfs 25% of the time.

FIGURE 5.13 FLOW-DURATION CURVE FOR BARTON SPRINGS DISCHARGE



5.3 DROUGHT STAGES AND REQUIRED RESPONSES

This DCP provides recommended standards for determining the extent and duration of drought conditions, including stages of drought severity. Severity stages are defined by hydrologic and water level parameters for wells and springs to be monitored by the BS/EACD. The recommended actions and demand reduction measures discussed in the remaining sections of this report generally followed the BS/EACD Conservation/Drought Committee guidelines set-forth in Section 5.1.

Upon declaration of a drought, users should be encouraged and, possibly, required to initiate demand reduction measures to reduce aquifer pumping. Minimum demand reduction measures are defined herein. Additional measures may be identified and implemented by the BS/EACD, as needed, to ensure the fulfillment of the goals of this DCP.

The goals and objectives set-forth by the BS/EACD Conservation/Drought Committee requires that the following criteria be addressed and achieved:

1. Assure an adequate quantity of water is available at all wells;
2. Assure that a suitable quality of water is available for supply; and
3. Assure that Barton Springs discharges do not fall appreciably below historic low levels.

Each of these criteria are addressed in the following sections.

5.3.1 STAGES AND TRIGGERS

There are three defined stages of drought severity and associated triggers. The stages are as follows:

1. Alert Status
2. Alarm Status
3. Critical Status

Implementation of demand reduction measures will always begin with the requirements of the Alert Status. Each subsequent drought management stage will be declared by the BS/EACD in progression. When management conditions are not prescribed with those outlined in the section, the BS/EACD will exercise discretion in determining when to declare respective stages.

5.3.1.1 ALERT STATUS

The Alert Status should commence when the following conditions are observed on 14 consecutive days[1] (moving average) at any or all of the following wells and in the opinion of the BS/EACD and its Board of Directors aquifer conditions warrant the execution of this status:

For Well Nos:	Water Levels Decline Below Historic Median Values:
LR58-57-903	596.77 ft msl
LR58-58-101	599.81 ft msl

[1] If hydrologic events unfold more rapidly than within 14 days, the BS/EACD may respond as necessary.

YD58-50-801	564.55 ft msl
YD58-50-502	495.90 ft msl
YD58-50-301	463.40 ft msl

The observation wells shown above represent different (1) portions of the Edwards aquifer, (2) water use sectors, and (3) localized recharge conditions. Therefore, it is possible that one or more wells may trigger an Alert Status, while others will not. In this case, localized Alert Status could be issued in accordance with the provision described below.

During this stage, the BS/EACD could provide bi-weekly (every two weeks) press releases to local newspapers and electronic media notifying the public of the Alert Status. The BS/EACD may request voluntary lawn watering curtailment and a reduction in irrigation. In addition, the BS/EACD could commence weekly water level monitoring of the wells listed above.

This trigger could be discontinued when water levels rise in the observation wells for more than 14 consecutive days (moving average), or in the judgement of the BS/EACD that this condition no longer exists.

5.3.1.2 ALARM STATUS

The Alarm Status should commence when any or all of the following conditions are observed for 14 consecutive days[2] and in the opinion of the BS/EACD and its Board of Directors aquifer conditions warrant the execution of the status:

---

[2] If hydrologic events unfold more rapidly than within 14 days, the BS/EACD may respond as necessary.

I. Observation Wells

For Well Nos:	Water Levels Decline Below Historic Lower Quartile:
LR58-57-903	584.44 ft msl
LR58-58-101	580.19 ft msl
YD58-50-801	541.22 ft msl
YD58-50-502	485.20 ft msl
YD58-50-301	452.82 ft msl

II. Water Quality

A. As aquifer water levels approach historical lows, public supply wells along and near the bad water line, and in the water table zone should be monitored for total dissolved solids (TDS) on a weekly basis. This monitoring program should begin when water level conditions shown above prevail and/or Barton Springs monthly-mean discharge falls below 30 cfs. The BS/EACD should maintain a high degree of flexibility in using these conditions for initiating a more intensive monitoring program.

B. The District should verify that the quality changes observed in the impacted public water supply are a result of decreased water levels.

C. The District should review data from the monitor wells along the saline water line and other public water supply wells to determine if other wells are exhibiting increased TDS concentrations which correlate to decreasing water levels.

In this stage, the BS/EACD could provide weekly press releases to local newspapers and electronic media. The BS/EACD could publish water level, quality information, and projections of ground water declines. Forecast of remaining local supplies should be made available to the public.

In addition, the BS/EACD should monitor observation wells at a minimum of three times per week. Mandatory curtailment of outside water use for industrial and commercial should be enforced. All major water suppliers should be advised that mandatory curtailments in water usage are forth-coming if "system" water use is not reduced. Voluntary curtailment for individual well supplies could be requested.

The Alarm Status could cease when the above described conditions do not exist for 14 consecutive days or in the judgement of the BS/EACD that an emergency condition no longer exists.

5.3.1.3 CRITICAL STATUS

The Critical Status should commence when any or all of the conditions presented herein are observed for 14 consecutive days[3] and in the opinion of the BS/EACD and its Board of Directors aquifer conditions warrant the execution of this status.

I. Observation Wells

For Well Nos:	Water Levels Decline Below Historic Low:
LR58-57-903	554.02 ft msl
LR58-58-101	550.66 ft msl
YD58-50-801	505.88 ft msl
YD58-50-502	479.27 ft msl
YD58-50-301	431.00 ft msl

[3] If hydrologic events unfold more rapidly than within 14 days, the BS/EACD may respond as necessary.

II. Water Quality

The BS/EACD could declare an Aquifer Emergency Warning when the concentration of TDS or conductivity in any public water supply well increases to 30% above the historical average and exceeds previous maximum concentrations. An Aquifer Emergency Warning does not signify that unacceptable deterioration of water quality has actually occurred. The purpose of the Warning is to initiate further detailed analyses to determine whether significant changes in water quality are occurring in the aquifer and, if so, appropriate responses to those changes.

The BS/EACD should also monitor wells along and near the bad water line, artesian zone and water table zone at a minimum of three times a week. This monitoring program should begin when water level conditions shown above prevail and/or Barton Springs monthly-mean discharge falls below 10 cfs. The BS/EACD should maintain a high degree of flexibility in using these conditions for initiating a more intensive monitoring program.

If the water level and quality analyses indicate that supplies will be depleted or water quality is deteriorating to a point of being non-potable, the BS/EACD should identify emergency supply options and develop a schedule for implementation. If an Aquifer Emergency Warning is declared, the BS/EACD should identify additional measures that may include a maximum per capita allotment for utilities, and reduction or cessation of industrial output and agricultural irrigation. In the most critical situation, the BS/EACD may instigate the interconnect of public water systems to prevent localized water shortages or depletions.

The Critical Status should cease when the above described conditions do not exist for 14 consecutive days or in the judgement of the BS/EACD that an emergency condition no longer exists.

5.3.2 WATER USER'S RESPONSES

Upon declaration of each drought management stage, water users should be expected to reduce their water use. To this end, two mechanisms could be used. The first mechanism is to achieve recommended water use reduction goals established for each stage. The goals define percentage reductions in base usage. The second recommended mechanism is to require each user to implement specific minimum demand reduction measures. Users could develop individual User Drought Contingency Plan (UDCP), which describe how each of these two mechanisms could be implemented within their respective service areas or operations.

5.3.3 REDUCTION GOALS

Reduction goals of 10%, 20%, and 30% should be established for each drought management stage, respectively. All water purveyors (BS/EACD permittees) should be required to achieve these reductions, or at a minimum these reductions should be achieved on an aquifer-wide basis. Each of these entities should be required to develop UDCPs which achieve the recommended reduction goals.

5.3.4 TARGET PUMPAGE VOLUME

The reduction goal percentage should be applied to the volume pumped by each user based on a fixed three year pumping average (useage). The target pumpage volume should be the total amount which can be used during any successive 12-month period, unless either a more restrictive or a less restrictive drought management stage is declared. The target pumpage volume may be prorated over the coming year by the user in accordance with the user's requirements. A monthly water budget may be established by the BS/EACD for each permitted in each drought stage. Use in excess of the water budget could be subject to a "punitive" water rate or other penalty. Excess revenues derived from any punitive water rate could be dedicated to water conservation programs.

If no pumpage data are available for a user, the user could calculate the average annual use per connection for similar users in the area. The target pumpage volume could be this per connection average, minus the reduction goal for the applicable stage.

5.4 USER DROUGHT CONTINGENCY PLANS

The BS/EACD's DCP could require the development of User Drought Contingency Plan (UDCP). Each permittee could be required to prepare, adopt, and implement UDCPs consistent with this DCP.

Upon receiving notification from the BS/EACD that drought response measures are needed, users could be required to initiate action according to their approved UDCPs. They could also be required to enforce use restrictions in their respective service areas.

5.4.1 Required UDCP Content

UDCPs developed by BS/EACD permittees could, at a minimum, include the following:

1. Those demand reduction measures specified above;
2. Additional demand reduction measures developed by the permittee which, when combined with the required measures achieve the reduction goals of this plan;
3. Financial measures which encourage compliance with the DCP and maintain financial stability of the permittee during a drought;

4. Provision for the ordinances, regulations or contractual requirements necessary for the permittee to enforce the DCP and the UDCP; and
5. Provisions for reporting water pumpage.

5.4.2 UDCP Implementation

For Alert Status, the reduction goal of 10% could be met through voluntary compliance with restrictions achieved through increased public awareness. If a 10% reduction goal is not achieved, the BS/EACD may implement non-voluntary reduction measures. Water waste could be prohibited. Waste is defined as any use which allows water to run off into a gutter, ditch or drain, or the failure to repair a controllable leak. This definition includes, hosing down sidewalks and driveways and allowing a hose to run while washing vehicles.

Beginning with Alarm Status, mandatory compliance could be required to achieve the reduction goals of 20%. Water purveyors could consider technical assistance programs, which encourage, alternative and/or supplemental water supply sources, and adjustments in water rates to offset lost revenues. Industrial users could be encouraged to consider alternative and/or supplemental water supply sources.

During the Critical Status stage, a 30% reduction in water use could be required. Water purveyors may need to establish allocations for customers, enact penalties for exceeding the allocations and place flow restrictors on meters of customers who repeatedly exceed their allocation. Industrial users could consider alternative and/or supplemental water supply sources.

5.4.3 REPORTING

Users should report volumes pumped from the aquifer during both drought and non-drought conditions. The frequency of reporting should increase upon declaration of Alert Status, and continue at the increased frequency until drought conditions cease to exist. Larger users should report more frequently than smaller users. Recommended reporting frequency requirements for each category of user are shown in Table 5.3.

5.5 RECOMMENDED BS/EACD ACTIONS

The BS/EACD could adopt rules to implement this recommended DCP. The BS/EACD could also review and approve variances from the requirements of this plan. It could monitor the hydrologic parameters used as trigger conditions, notify news media and permittees of water resource conditions and appropriate drought management responses, enforce the DCP, and review and revise the plan as necessary.

The BS/EACD should perform forecasts of water level and water quality changes. If drought conditions or changes in stages are projected, the BS/EACD should notify all permittees by mail at least 20-days in advance, whenever possible. Notification should include a description of pending drought or non-drought conditions (stages) and expected user response.

The BS/EACD could assist non-exempt well permittees and water users by providing concise descriptions of TWC's rules and regulations concerning water tariffs/rates and emergency water rationing programs. The BS/EACD could make available educational materials on rate structure and related tariff changes that may be necessary

TABLE 5.3 REQUIRED FREQUENCY OF PUMPAGE REPORTING

USER	NON DROUGHT	ALERT STATUS	ALARM STATUS	CRITICAL STATUS
Incorporated Cities	Annual	Quarterly	Monthly	Weekly
Water Purveyors with more than 35 connections	Annual	Quarterly	Monthly	Weekly
Water Purveyors with less than 35 connections, Industrial/Commercial users of less than 50,000 gpd, and irrigators of less than 25 acres	Annual	Quarterly	Monthly	Monthly
Industrial/Commercial users of more than 50,000 gpd	Annual	Quarterly	Monthly	Weekly
Irrigators of more than 25 acres	Annual	Quarterly	Monthly	Weekly

to successfully implement this recommended DCP and UDCPs. The BS/EACD could submit this DCP and associated rules, if developed, to the TWC for review and comment.

5.5.1 RULES

The BS/EACD should begin the procedure to adopt rules for implementing the DCP. The BS/EACD could conduct public hearings to receive comments on the proposed rules.

5.5.2 VARIANCES

The BS/EACD could institute a mechanism whereby variances can be obtained to this plan or adopted rules. Any user seeking a variance could file the appropriate request or include the variance request in its UDCP in accordance with procedures established by the BS/EACD. The user should be required to identify the requirement(s) for which the variance(s) is sought, to justify the variance and to identify the demand reduction measures which may be implemented. A variance request should be justified by a unique economic or financial hardship which is not experienced by other similar users. The user could also provide the BS/EACD with information and data supporting the request.

The BS/EACD should evaluate each variance request on the merits described in the application. In evaluating a request, the BS/EACD should consider factors such as the user's water use efficiency, demonstrated health and safety concerns, and economic/financial considerations. The BS/EACD may conduct a public hearing on variance requests, and it could approve or disapprove each request in accordance with established procedures. The approval should specify the period of time that the variance will be in effect. The user should receive written notification of the BS/EACD's action.

5.5.3 MONITORING

The BS/EACD should monitor the hydrologic parameters used as trigger conditions. Data should be collected and analyzed as frequently as necessary to provide advance information about trends.

The BS/EACD could be responsible for monitoring aquifer pumpage and developing report forms for users required to report pumpage.

5.6 REFERENCES

Slade, R. M., Jr., Ruiz, Linda, and Slagle, Diana, 1985, Simulation of the flow system of Barton Springs and associated Edwards aquifer in the Austin area, Texas: U.S. Geological Survey Water-Resources Investigations Report 85-4299, 49p.

U.S. Geological Survey, 1986, Hydrology and water quality of the Edwards aquifer associated with Barton Springs in the Austin area, Texas: Water-Resources Investigations Report 86-4036, 117p.

Texas Water Development Board, 1986, Geohydrology of the Edwards aquifer in the Austin area, Texas: Report 293, 216p.

SECTION 6 MAPS

REGIONAL WATER PLAN
for the
BARTON SPRINGS SEGMENT OF THE EDWARDS AQUIFER

FACILITY PLANNING MAPS

prepared for

BARTON SPRINGS/EDWARDS AQUIFER CONSERVATION DISTRICT
Austin, Texas

and

TEXAS WATER DEVELOPMENT BOARD
Planning Grants Assistance Program
Austin, Texas

TWDB CONTRACT NO. 9-483-732

prepared by

DONALD G. RAUSCHUBER & ASSOCIATES, INC.
Austin, Texas

in association with

FISHER, HAGOOD, HAMILTON & HEJL
Round Rock, Texas
(PRINCIPAL INVESTIGATOR)

SEPTEMBER 1990

Regional Water plan
For the
Barton Springs Segment Of The Edwards
Aquifer

Contract No. 9-483732

The following maps are not attached to this report. They are located in the official file and may be copied upon request.

Barton springs/Edwards Aquifer
Conservation District

Map No. 1 Exhibit No. 1

Map No. 2 Exhibit No. 2

Map No. 3 Exhibit No. 3

Please contact Research and Planning Fund Grants Management Division At (512) 463-7926 for copies.