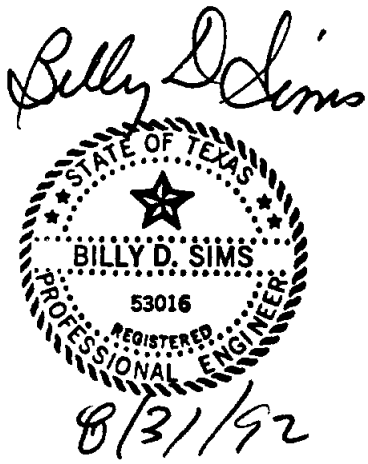
NACOGDOCHES COUNTY

WATER SUPPLY STUDY
FINAL REPORT

August 1992



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EXECUTIVE SUMMARY

This report identifies and evaluates current and future water supply needs for Nacogdoches County, current and future water supply sources for the County, and alternative plans for meeting these needs with the identified sources. It also recommends a plan to meet these needs.

Water needs for Nacogdoches County were projected for the years 2000, 2010, 2020, and 2040. Although the study was to cover a thirty year planning period, fifty year figures were also determined to better evaluate the alternative water supply sources.

Population in the county is projected to increase from 54,753 in 1990 to 83,561 in the year 2020 and 108,694 in 2040. Water use is projected to increase similarly from 11.4 million gallons per day in 1990 to 20.1 mgd in 2020 and 25.8 mgd in 2040. It is estimated that implementation of a water conservation and drought contingency plan could reduce these demands by about 15% in the year 2020 and 18% in 2040. Peak day demand, the demand which must be met by water production facilities such as wells or a treatment plant, is projected to grow from 22.3 mgd in 1990, to 36.0 mgd in 2020 and 47.5 mgd by the year 2040. Water conservation could reduce these numbers to 31.8 mgd in 2020 and 43 mgd in 2040.

Existing production facilities currently produce about 23 million gallons per day. By the year 2020, due to older wells failing, this production is estimated to drop to 16.4 mgd, assuming no new facilities are built. To meet the needs of Nacogdoches County, it was assumed that, for any alternative, existing production levels would be maintained by the individual entities. Additional demands would then be supplied through a regional solution.

Given this assumption, an additional 8.7 mgd of water supply and an additional 12.46 mgd of water production for the year 2020 is projected to be needed for Nacodgoches County, including the City of Nacogdoches.

To meet these increased demands, the following alternatives are presented and evaluated:

1. A conjuctive use of surface water from Lake Nacogdoches and groundwater from existing wells and additional wells in the Wilcox, Carrizo, Sparta, and Yegua formations. This option is an extention of current water supplies, as presently operated. Additional wells and well fields will be developed to provide the most cost effective arrangement of wells and surface water supplies to meet the needs of the county.

2. Conjunctive use of groundwater with surface water from Lake Nacogdoches and from Sam Rayburn Reservior. In this alternative, groundwater use would play a decreasing role in the county's water supply. Few new wells would be developed except in some areas where it may be unfeasible to extend a supply main from the regional system.

3. Conjunctive use of groundwater and surface water from Lake Nacogdoches and from Lake Eastex. This is essentially the same alternative as alternative (2) except that Lake Eastex would be used to supply additional needs.

4. Conjunctive use of groundwater and surface water from Lake Nacogdoches and from Lake Naconiche. This also is the same alternative as alternative (2) except that Lake Naconiche would supply future needs of the county.

In the analysis of the alternatives, it was determined that the City of Nacogdoches will require all of the water in Lake Nacogdoches for its own use by the year 2040. This being the case, it was assumed that water from Lake Nacogdoches was not available for other entities in the study and that the City would be provided for by Lake Nacogdoches.

Other than the City of Nacogdoches and D&M WSC, the largest demands in the county were observed to be in the northeast part of the county. Analyzing each alternative, it was found that each surface water alternative could supply the county's needs outside the City of Nacogdoches if current groundwater production levels are maintained. If federal regulatory agencies allow groundwater to be produced with total dissolved solids levels of greater than 500 parts per million, there is sufficient groundwater to meet the needs of the County outside of the City, but location and spacing can diminish access to the source. If the EPA Secondary Standard of 500 ppm becomes a requirement, adequate groundwater is not available.

It is recommended in this report that the Lake Naconiche alternative be selected. Of the four alternatives, the Lake Naconiche alternative is the least expensive and best situated to meet the needs of Nacogdoches County. For the 30 year planning period, this alternative involves the eventual construction of a 3.6 mgd water treatment plant and a piping network serving Appleby, Caro, Central Heights, D&M WSC, Libby, Lilly Grove, Melrose, and Nacogdoches Municipal Utilities District #1. The increased needs of other entities will be supplied through increased pumping capacity in existing wells or additional wells in the formation best suited to the entities' individual locations.

Implementation of this alternative will involve permitting of the project, mitigation

of environmental concerns, and financing, designing, and construction of the project. Construction of Lake Naconiche will require permits from the Texas Water Commission and U.S. Corps of Engineers. In the permitting process mitigation of the various environmental concerns will be addressed. It is recommended that construction of the water treatment facilities and the distribution system be accomplished in two phases. In Phase I all of the line work and a portion of the treatment facilities (2.6 mgd) will be constructed at a 1991 cost of $7,651,000. In Phase II, the water treatment facilities, in the year 2010, will be increased in capacity to treat the full 3.6 mgd at a 1991 cost of $1,332,000.

There is a definite need for new water supply sources in Nacogdoches County over the next thirty years and beyond. To meet these needs it is recommended that the City of Nacogdoches continue to move towards total use of Lake Nacogdoches while Appleby, Caro, Central Heights, D & M W.S.C., Libby, Lilly Grove, Melrose, and Nacogdoches Municipal Utilities District No. 1, form a regional system and move towards the combined use of Lake Naconiche and their current groundwater resources.

SECTION I

INTRODUCTION

SECTION I

INTRODUCTION

A. OBJECTIVE AND SCOPE

The purpose of this study and report is to evaluate the water supply currently available to Nacogdoches County, project future water supply needs of the county by decade through the year 2020, to evaluate water supply alternatives to meet these needs, and to develop a proposed plan to meet these needs. To better evaluate surface water alternatives, figures for a fifty (50) year projection were also determined and used. This report will present the results of the evaluation of the existing water supply, the population and water use projections for the county, discuss water supply alternatives, evaluate selected alternatives, propose the implementation of a specific alternative, and discuss issues related to the proposed alternative.

The following is a list of the active participants in this study:

1. Appleby Water Supply Corporation
2. Caro Water Supply Corporation
3. Central Heights Water Supply Corporation
4. Cushing, City of
5. D&M Water Supply Corporation
6. Etoile Water Supply Corporation
7. Garrison, City of
8. Libby Water Supply Corporation
9. Lilbert-Looneyville Water Supply Corporation
10. Lilly Grove Water Supply Corporation
11. Melrose Water Supply Corporation

12. Nacogdoches, City of
13. Nacogdoches, County of
14. Nacogdoches County Municipal Utility District No. 1
15. Sacul Water Supply Corporation
16. Swift Water Supply Corporation
17. Woden Water Supply Corporation

B. AUTHORIZATION OF REPORT

This study and report are being partially financed by a planning grant issued to the Angelina and Neches River Authority (ANRA) by the Texas Water Development Board. KSA Engineers, Inc. was authorized by contract with the Angelina and Neches River Authority dated May 15, 1990 to perform this Water Supply Study for Nacogdoches County.

C. ACKNOWLEDGEMENTS

The gathering of data for a study of this magnitude is not an easy task. We wish to thank the participating entities for providing the data contained herein. We also wish to thank the staff of ANRA and the individual participants for their assistance.

D. REFERENCES

The following is a list of references used in the development of this report:

1. Rules and Regulations for Public Water Systems - Texas Department of Health - Adopted 1988

2. City of Nacogdoches, Texas Water System Analysis - KSA Engineers, Inc. - June 1985

3. Groundwater Study for Lilly Grove Water Supply Corporation - SMD Drilling Company - January 1989

4. Groundwater Study for D&M Water Supply Corporation - SMD Drilling Company - June 1990

5. Draft Evaluation of the Groundwater Resources in the Vicinity of the Cities of Henderson, Jacksonville, Kilgore, Lufkin, Nacogdoches, Rusk, and Tyler in East Texas - Texas Water Development Board - November 1989

6. Groundwater Conditions in Angelina and Nacogdoches Counties, Texas - Texas Water Development Board, Report 110 - March 1990

7. Angelina County Water Study - Everett Griffith, Jr. & Associates, Inc. - July 1989

8. City of Nacogdoches Water Supply Study - KSA Engineers, Inc. - Phase I, January 1988 - Phase II, April, 1989.

9. Lake Eastex Regional Water Supply Planning Study - Lockwood, Andrews & Newnam, Inc. September 1991.

SECTION II

PROJECTIONS OF POPULATION AND WATER USE

SECTION II

PROJECTIONS OF POPULATION AND WATER USE

A. POPULATION PROJECTIONS

Historically the population of Nacogdoches County has grown at a rate varying from -1.4% per year during the 1950's to 3.0% per year during the 1970's, as shown in Table 1. Population projections for each individual entity are included in Appendix A.

For purposes of this report, exhaustive population projections were made and compared to the projections prepared and maintained by the Texas Water Development Board (TWDB). The projections of water consumption in this study will be based upon the high population projections of the TWDB and the low projections as presented in Table 2.

B. WATER CONSERVATION AND DROUGHT CONTINGENCY PLAN

To obtain financial assistance from the TWDB or Water Loan Assistance Fund by a political subdivision, it is necessary that a water conservation and drought contingency plan be developed and implemented. These requirements were set by the 69th Texas Legislature in 1985 by House Bill (HB) 2 and Joint Resolution (HJR) 6. Texas voters approved the amendment to the Texas Constitution implementing HB 2 on November 5, 1985.

A Water Conservation and Drought Contingency Plan has been developed as a part of this project. The plan is not included as a part of this report, but as a separate document.

The implementation of the plan is projected to have an effect on the future water supply requirements. This effect is taken into account by reducing the rate of per capita consumption in the water supply projections.

C. WATER USE PROJECTIONS

1. General

The projected water demands for this study were arrived at by multiplying population projections by projected per capita demands. As previously discussed, the TWDB high population projections were adopted for use in this study.

2. Per Capita Demands

Per capita demands were determined by using the Texas Water Development Board's Water Demand Projections for Nacogdoches County and their population projects for the same. These numbers were pro-rated among the individual entities based on historic data. Having calculated total use and population projects, the per capita demands could be calculated by dividing the volume of water by the projected population for each year.

Appendix A includes a worksheet for each entity which shows the projected population and per capita water demands. Population projections and per capita demands are summarized in Tables 3-A. and 3-B.

3. Average Daily Demands

Average daily water demands represent the average daily demand over a period of one year (i.e., annual water use/365 days). This value is considered the base demand for estimating minimum daily, maximum daily, and peak hour demands for water system analyses. The average daily demand

is also used to establish the required capacity of water supply sources, to provide a basis for water billing, and to evaluate opertional costs.

Projected average daily water demands for Nacogdoches County range from 15.64 mgd in 2000 to 32.06 mgd in 2020 and 52.63 mgd in 2040 as shown in Table 3-A.

The projections shown in Table 3-A were made utilizing the following assumptions:

(a) population growth in accordance with the projections given in Table 2;

(b) per capita treated water consumption as discussed in Section II.A. above;

(c) the Texas Water Development Board has included an average daily demand of 12 million gallons per day (mgd) in their projections for Nacogdoches County which would provide for the development of a steam powered generation plant. This assumption was included in the projections shown in Table 3-A and B.

(d) the projections of water use and existing water supply do not include the Champion well fields in south Nacogdoches County. The Texas Water Development Board has included these demands and production in their projections for Angelina County.

4. **Maximum Daily Water Demands**

The maximum daily demand is defined as the maximum water usage during any 24-hour period during the year. This demand would be expected to occur during the summer months when outdoor water uses are at their peak. This value is used to size raw water pumping facilities, treatment

plants, and distribution system high service pumps.

As shown in Tables 3.A. and B., the ratio of maximum daily demand to average daily demand varies among the different water purveyors within Nacogdoches County.

Projected maximum daily demands for the entire county are shown in Table 3.A. to vary from 30.23 mgd in 2000 to 54.97 mgd in 2020 and 87.67 mgd in 2040. These demands are projected based upon actual water use. However, water supply regulatory requirements may be higher than actual water use. The Texas Department of Health (TDH) requires that a public water purveyor be capable of supplying 0.6 gallons per minute (gpm) per connection to its customers. In some cases this requirement may be stricter than the projections of water use made in this study. As shown in the worksheets in Appendix A, the water supply needs of the individual entities are based upon the TDH requirement or the actual projected demands, whichever is greater.

A demand of 12.0 mgd has been projected by the TWDB in Nacogdoches County for the use of a future steam powered electric generation plant. This demand is shown in Tables 3.A. and B. and 4.A. and B. However, this highly speculative demand is high in comparison to the rest of the County's water use, and would have a dramatic impact on the planning for a public water supply. For purposes of this report, it is assumed that this demand will be satisfied by the electric company that requires the water. The water supply source for this demand might be Lake Eastex. For the balance of this report and the evaluation of the needs of the local entities, this demand will no longer be considered.

5. Water Conservation

The projected effects of water conservation are summarized in Table 5. It is assumed in Table 5 that water conservation will result in a 7.5% reduction of water use by the year 2000, a 12.5% reduction by the year 2010, 15% by 2020, and 18.5% by 2040.

TABLE 1

HISTORICAL POPULATION OF NACOGDOCHES COUNTY

Year	Population	Percent Growth Per Year
1930	30,290	
1940	35,392	1.7%
1950	30,326	-1.4%
1960	28,046	-0.8%
1970	36,362	3.0%
1980	46,786	2.9%
1990	54,753	1.7%

TABLE 2

POPULATION PROJECTIONS FOR NACOGDOCHES COUNTY

Year	Low	High
1990	54,753	54,753
2000	62,143	64,274
2010	70,470	73,582
2020	79,363	83,561
2040	83,139	108,694

TABLE 3-A
NACOGDOCHES COUNTY
WATER USE PROJECTIONS
HIGH PROJECTIONS W/O CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED GALLONS PER DAY PER CAPITA																			
1990	178	137	155	114	100	60	181	140	70	142	115	235	127	65	134	121	468		
2000	213	173	169	131	119	76	216	164	78	156	135	279	161	80	156	150	654		
2010	211	175	163	132	118	73	216	164	75	150	133	278	155	77	150	150	672		
2020	217	182	163	138	121	73	224	168	75	150	136	284	155	77	150	156	656		
2040	217	185	159	140	121	71	227	168	73	146	136	286	161	75	146	160	679		

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED POPULATION																			
1990	2762	1744	884	1257	2246	1204	1827	425	334	1778	2436	30872	187	363	1891	1616	2938		54753
2000	3247	2038	973	1289	3019	1557	1965	479	363	2198	2928	37266	220	393	2236	1944	2161		64276
2010	3782	2365	1088	1371	3787	1915	2088	545	403	2641	3458	42701	255	419	2615	2294	1863		73580
2020	4336	2705	1212	1470	4549	2273	2197	614	445	3090	4001	48529	293	437	3005	2653	1752		83561
2040	5711	3562	1536	1766	6340	3124	2470	793	569	4167	5330	63161	385	474	3967	3537	1821		108692

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED WATER USE IN GAL/DAY																			
1980	323034	211468	60392	102222	102391	53293	245398	30173	0	94446	175948	7036054	22333	13778	171123	103260	1396251		10141564
1987	451251	199871	119173	128635	190588	66058	306368	52936	20532	206477	233704	6878826	22406	30262	248880	194783	1110100		10460850
1990	491636	238928	137020	143298	224600	72240	330687	59500	23380	252476	280025	7254920	23749	22945	253394	195536	1376027		11380361
2000	692248	353026	164556	169114	358953	118096	424973	78555	28277	342442	396151	10389580	35403	31420	348363	290915	1413465		15635537
2010	799726	413629	177386	181530	445296	140025	451836	89394	30264	396660	461280	11856336	39559	32293	392765	344543	1244930	12000000	29497442
2020	939473	492420	197851	202154	549069	166411	491235	103269	33460	464679	542301	13779525	45511	33723	451897	414711	1149984	12000000	32057673
2040	1240526	658894	243590	247675	767794	222192	560266	133382	40833	608769	722323	18090494	58096	35535	579550	564324	1054890	26800000	52629132

TABLE 3-A
NACOGDOCHES COUNTY
WATER USE PROJECTIONS
HIGH PROJECTIONS W/O CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED PEAK DAY WATER USE IN GAL/DAY																			
PEAK DAY TO AVG DAY RATIO	2.2	1.71	2.2	1.34	1.91	2.2	1.61	2.2	2.2	2.31	1.94	1.9,1.87,1.	2.2	2.21	2.2	2.2	2.2	1.5	
1990	1081599	408567	301444	192019	428986	158928	532406	130900	51436	583220	543249	13784348	62248	50708	567467	430179	3027260	0	22314964
2000	1522946	603675	362023	226613	685600	259812	684206	172820	62210	791042	768534	19428514	77886	69438	766398	640012	3109624	0	30231352
2010	1759398	707305	390249	243250	850515	308056	727456	196668	66581	916284	894884	21815668	87030	71369	864060	767994	2738846	18000000	51395601
2020	2066841	842039	435272	270887	1048721	366104	790889	227191	73612	1073409	1052063	24114170	100125	74528	994173	912364	2529964	18000000	54972350
2040	2729166	1126708	535899	331886	1466487	488822	902028	293440	89832	1406256	1401307	31658364	127811	78533	1275010	1241512	2320758	40200000	87673808

TABLE 3-B

NACOGDOCHES COUNTY

WATER USE PROJECTIONS

HIGH PROJECTIONS WITH CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED GALLONS PER DAY PER CAPITA																			
1990	178	137	155	114	100	60	181	140	70	142	115	235	127	65	134	121	468		
2000	197	160	156	121	110	70	200	152	72	144	125	258	149	74	144	138	605		
2010	185	153	143	116	103	64	189	144	66	131	117	243	136	67	131	131	588		
2020	184	155	139	117	103	62	190	143	64	128	115	241	132	66	128	133	558		
2040	177	151	129	114	99	58	185	137	60	119	110	233	123	61	119	130	472		

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED POPULATION																			
1990	2762	1744	884	1267	2246	1204	1827	425	334	1778	2435	30872	187	353	1891	1616	2938		54753
2000	3247	2038	973	1289	3019	1557	1965	479	363	2198	2928	37266	220	393	2236	1944	2161		64276
2010	3782	2365	1088	1371	3787	1915	2088	545	403	2641	3458	42701	255	419	2615	2294	1853		73580
2020	4336	2705	1212	1470	4549	2273	2197	614	445	3090	4001	48529	293	437	3005	2653	1752		83561
2040	5711	3552	1536	1765	6340	3124	2470	793	559	4167	5330	63161	385	474	3967	3537	1821		108692

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED WATER USE IN GAL/DAY																			
1980	323034	211468	60392	102222	102391	53293	245398	30173	0	94446	175948	7036054	22333	13778	171123	103260	494812		9240125
1987	461261	199871	119173	128635	190588	66058	306368	52936	20532	206477	233704	6878826	22406	30262	248880	194783	374286		9725036
1990	491636	238928	137020	143298	224600	72240	330687	59500	23380	252476	280025	7264920	23749	22945	263394	195536	1376027		11380361
2000	640330	326549	152214	156430	332031	109239	393100	72663	26156	316759	366440	9610361	32748	29063	322236	269096	1307455		14462872
2010	699761	361925	155213	158839	389634	122522	395356	78220	26481	347077	403620	10374294	34614	28257	343660	301475	1089314	12000000	27310262
2020	798552	418557	168173	171831	466709	141449	417550	87778	28441	394977	460956	11712597	38685	28665	384112	352504	977486	12000000	29049022
2040	1011028	536998	198526	201855	625752	181086	456617	108706	33279	496146	588693	14743752	47348	28961	472333	459924	859735	26800000	47850743

TABLE 3-B
NACOGDOCHES COUNTY
WATER USE PROJECTIONS
HIGH PROJECTIONS WITH CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED PEAK DAY WATER USE IN GAL/DAY																			
PEAK DAY TO AVG DAY RATIO	2.2	1.71	2.2	1.34	1.91	2.2	1.61	2.2	2.2	2.31	1.94	1.9,1.87,1.	2.2	2.21	2.2	2.2	2.2	1.6	
1990	1081599	408667	301444	192019	428986	158928	532406	130900	51436	583220	543249	13784348	52248	50708	557467	430179	3027260		22314964
2000	1408725	558399	334871	209617	634180	240326	632891	159859	57544	731714	710894	17971375	72045	64230	708918	592011	2876402		27964001
2010	1539473	618892	341468	212844	744200	269549	636524	172084	58258	801748	783023	19088701	76161	62448	756053	663245	2396490	18000000	47221151
2020	1756815	715733	369981	230254	891413	311189	672255	193112	62570	912397	894254	20497044	85106	63349	845047	776509	2150470	18000000	49426498
2040	2224263	918267	436758	270486	1195187	398390	736153	239153	73213	1146098	1142065	25801667	104166	64004	1039133	1011832	1891417	40200000	78891154

TABLE 4-A

NACOGDOCHES COUNTY

WATER USE PROJECTIONS

LOW PROJECTIONS W/O CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER LOONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS
PROJECTED GALLONS PER DAY PER CAPITA																	
1990	178	137	155	114	100	60	181	140	70	142	115	235	127	65	134	121	468
2000	248	188	217	173	138	69	254	200	96	197	161	326	145	78	173	172	942
2010	262	203	219	183	144	70	269	212	97	200	168	344	147	79	176	185	1027
2020	266	210	216	188	146	69	276	215	96	197	169	356	145	78	173	190	1005
2040	301	244	236	216	166	75	317	242	104	215	190	397	158	85	189	221	1165

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER LOONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS
PROJECTED POPULATION																	
1990	2762	1744	884	1257	2246	1204	1827	425	334	1778	2435	30872	187	353	1891	1616	2938
2000	2943	1847	882	1168	2737	1411	1809	433	328	1992	2654	33802	200	346	2026	1762	1960
2010	3301	2064	950	1197	3306	1672	1840	476	352	2305	3019	37268	222	346	2283	2002	1617
2020	3712	2316	1037	1268	3894	1946	1918	525	381	2645	3424	41568	250	355	2573	2271	1501
2040	4305	2678	1158	1330	4779	2365	2313	598	421	3141	4018	48311	290	393	2990	2666	1393

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER LOONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS
PROJECTED AVERAGE DAY WATER USE IN GAL/DAY																	
1980	323034	211468	60392	102222	102391	53293	245398	30173	0	94446	175948	7036054	22333	13778	171123	103260	1396251
1987	451251	199871	119173	128635	190588	66058	306368	52936	20532	206477	233704	6878826	22406	30262	248880	194783	1110100
1990	491636	238928	137020	143298	224600	72240	330687	59500	23380	252476	280025	7264920	23749	22945	253394	195536	1376027
2000	730271	347918	191142	202530	376344	97021	459639	86818	31413	392993	428468	11014936	28974	26909	351377	302869	1845271
2010	864287	418636	208401	219136	475263	116364	495701	100800	34075	460454	507080	12805343	32646	27255	400801	369703	1661144
2020	986484	487479	224540	236720	569728	133618	529803	112969	36412	521198	577687	14791418	36262	27527	445519	430586	1508265
2040	1294434	652885	272905	287500	792268	176069	733070	144818	43792	673871	764066	19158910	45720	33215	563721	589297	1623403

TABLE 4-A

NACOGDOCHES COUNTY

WATER USE PROJECTIONS

LOW PROJECTIONS W/O CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER LOONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS
PROJECTED PEAK DAY WATER USE IN GAL/DAY																	
PEAK DAY TO AVG DAY RATIO	2.20	1.71	2.20	1.34	1.91	2.20	1.61	2.20	2.20	2.31	1.94	1.92,1.89 1.87,1.82	2.20	2.21	2.20	2.20	2.20
1990	1081599	408567	301444	192019	428986	158928	632406	130900	51436	583220	643249	13929446	52248	60708	657467	430179	3027260
2000	1606595	694941	420513	271390	718818	213447	740019	190999	69109	907815	831227	20818229	63743	59468	773029	666312	4059597
2010	1901431	715867	458481	293642	907753	256002	798078	221761	74964	1063648	983735	23946991	71820	60234	881763	813347	3664617
2020	2170265	833589	493988	317205	1088181	293959	852983	248532	80107	1203967	1120712	26920380	79777	60836	980143	947290	3318182
2040	2847754	1116434	600391	385250	1513232	387353	1180242	318599	96343	1556642	1482288	34869217	100584	73405	1240186	1296453	3571487

TABLE 4-B

NACOGDOCHES COUNTY

WATER USE PROJECTIONS

LOW PROJECTIONS WITH CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER LOONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC
PROJECTED GALLONS PER DAY PER CAPITA																		
1990	178	137	155	114	100	60	181	140	70	142	115	235	127	65	134	121	468	
2000	230	174	200	160	127	64	235	185	88	183	149	301	134	72	160	159	871	
2010	229	177	192	160	126	61	236	185	85	175	147	301	128	69	154	162	899	
2020	226	179	184	160	124	58	235	183	81	168	143	302	123	66	147	161	854	
2040	245	199	192	176	135	61	258	197	85	175	155	323	128	69	154	180	950	

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER LOONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED POPULATION																			
1990	2762	1744	884	1257	2246	1204	1827	425	334	1778	2436	30872	187	353	1891	1616	2938		54753
2000	3137	1969	940	1245	2917	1504	1928	462	350	2123	2829	36030	213	369	2160	1878	2089		62143
2010	3622	2266	1042	1313	3627	1834	2019	522	386	2529	3312	40898	244	380	2505	2197	1774		70469
2020	4062	2534	1136	1377	4261	2129	2099	575	417	2894	3747	46529	274	388	2815	2485	1642		79363
2040	4305	2678	1158	1330	4779	2366	2313	598	421	3141	4018	48311	290	393	2990	2666	1393		83139

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER LOONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED AVERAGE DAY WATER USE IN GAL/DAY																			
1980	323034	211468	60392	102222	102391	53293	245398	30173	0	94446	175948	7036054	22333	13778	171123	103260	494812		9240125
1987	451251	199871	119173	128635	190588	66058	306368	52936	20532	206477	233704	6878826	22406	30262	248880	194783	374286		9725036
1990	491636	238928	137020	143298	224600	72240	330687	59500	23380	252476	280026	7254920	23749	22945	253394	195536	1376027.5		11380361
2000	720032	343040	188463	199690	371068	95661	453195	85600	30973	387483	422460	10860394	28568	26531	346450	298622	1819400		16677631
2010	829707	401886	200063	210368	456248	111709	475868	96767	32711	442031	486792	12296039	31339	26165	384765	354912	1594683		18432055
2020	917509	453394	208840	220168	529893	124275	492759	105070	33866	484756	537295	14073215	33727	25603	414368	400480	1402806	6700000	27158023
2040	1054964	532101	222418	234313	645698	143496	597452	118027	35691	549205	622714	15614512	37262	27070	459433	480277	1323074	6700000	29397704

TABLE 4-B

NACOGDOCHES COUNTY

WATER USE PROJECTIONS

LOW PROJECTIONS WITH CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER LOONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED PEAK DAY WATER USE IN GAL/DAY																			
PEAK DAY TO AVG DAY RATIO	2.2	1.71	2.2	1.34	1.91	2.2	1.61	2.2	2.2	2.31	1.94	1.92,1.89 1.87,1.82	2.2	2.21	2.2	2.2	2.2	1.5	
1990	1081599	408566.9	301444	192019	428986	158928	532406.1	130900	51,436	583,220	543,249	13929446	52248	50708	557466.8	430179.2	3027260.4		22460063
2000	1584070	586699.2	414617.5	267585	708739.6	210454	729643.8	188321	68,140	895,086	819,573	20526145	62850	58634	762190.5	656969.5	4002679.4		32542297
2010	1825366	687225.6	440137.8	281894	871434.5	245769	766147.6	212888	71,965	1,021,092	944,377	22993593	68947	67824	846483.8	780805.4	3508302		35624231
2020	2018519	775304.2	459448.5	295026	1012095	273405	793341.8	231155	74,506	1,119,785	1,042,351	25613251	74199	66582	911610.6	881055.1	3086173.7	10050000	48767807
2040	2320920	909893.4	489318.7	313979	1233284	315692	961897.2	259659	78,619	1,268,663	1,208,064	28418412	81976	69825	1010752	1056609	2910762.2	10050000	52948225

TABLE 5

SUMMARY OF PROJECTED WATER USE
FOR NACOGDOCHES COUNTY

Year	Projected Water Use Without Water Conservation (mgd)	Projected Water Use With Water Conservation (mgd)
	AVERAGE DAY	
1990	11.38	11.38
2000	15.64	14.46
2010	17.50	15.31
2020	20.06	17.05
2040	25.83	21.05
	PEAK DAY	
1990	22.31	22.31
2000	30.23	27.96
2010	33.40	29.22
2020	36.97	31.43
2040	47.47	36.69

Notes:
1. Projections are based upon TWDB high population projections and average day per capita demands.
2. Projections do not include the projected 12.0 mgd for steam powered electricity generation.
3. Assumes 7.5% reduction due to water conservation by the year 2000, 12.5% for the year 2010, 15% for 2020, and 18.5% for 2040.

SECTION III

EXISTING WATER SUPPLIES

SECTION III

EXISTING WATER SUPPLIES

A. GROUNDWATER SOURCES

Currently, the water purveying entities of Nacogdoches County obtain water from a combination of surface water and groundwater. The two major groundwater sources currently being used for water supply in Nacogdoches County are the Wilcox Group and Carrizo Sand. In addition to the Wilcox and Carrizo, the Sparta Sand and the Yequa formation are also used as water supply sources.

1. Wilcox Group

The Wilcox Group consists of interbedded gravel, sand, clay, and shale, with lignite deposits in some areas. In Nacogdoches County the total thickness of the Wilcox varies from 800 feet to about 2000 feet. About 40-60 percent of the total thickness is sand. Recharge to the Wilcox aquifer enters in outcrop areas of Van Zandt, Henderson, Anderson, Panola, Shelby, Rusk and Nacogdoches Counties. The recharge area located within Nacogdoches County is in the northeast portion of the County.

The quality of water available from the Wilcox aquifer is relatively good. The water is characteristically soft, mildly alkaline and has little or no iron. A slight odor due to hydrogen sulfide is commonly present. The odor is usually removed by chlorination and aeration. In isolated areas, water from the aquifer may contain concentrations of dissolved iron in excess of the recommended limit (0.3 milligrams per liter). But within most of the area, the quality of ground water is within the recommended limits for concentrations

of both secondary and primary constituents. As a general rule, water quality deteriorates with depth within the aquifer.

The Texas Water Development Board, in a draft report entitled "Evaluation of the Groundwater Resources in the Vicinity of Henderson, Jacksonville, Kilgore, Lufkin, Nacogdoches, Rusk, and Tyler in East Texas" dated November 1989 estimated that a total of 34,398 acre-feet of water was produced in Nacogdoches and Angelina Counties from the Wilcox and Carrizo in 1985. This is equal to an average day withdrawal rate of 30.7 million gallons per day.

According to the Texas Water Development Board Report 110 entitled "Groundwater Conditions in Angelina and Nacogdoches Counties, Texas", the estimated yield of the Wilcox formation is approximately 8.0 mgd for water containing less than 1000 ppm total dissolved solids. Estimated pumpage is 2.7 mgd for all wells currently drawing on the Wilcox. Most of the remaining yield should be available in Nacogdoches County.

The estimated maximum individual well yield from the Wilcox Group is 200 to 500 gpm in the northern part of the county (north of the City of Nacogdoches) and less than 300 gpm in the southern portion of the County. There are problems, however, in attaining these pumping rates. The spacing of wells in relation to one another is critical to minimize the local effects of one well on another.

2. **Carizzo Sand**

The Carizzo Sand directly overlies the Wilcox Group and outcrops immediately south of the Wilcox outcrop in a band 1 to 8 miles wide trending

northwest-southeast across northeastern Nacogdoches County. The thickness of the Carrizo Sand varies from 20 to 170 feet.

The quality of water in the Carrizo Sand in Nacogdoches County is good. The dissolved solids range from 100 ppm in the outcrop area to 300 ppm in the southern portion of the county. The hardness of the fresh Carrizo water is low everywhere south of the City of Nacogdoches, generally being less than 20 ppm. North of Nacogdoches toward the outcrop the hardness is somewhat spotty, ranging up to 150 ppm. In wells north, east, and west of the City of Nacogdoches, iron contents of water from most wells are higher than 0.3 ppm. The approximate southern limit of water containing less than 1000 ppm of dissolved solids is 2 miles south of FM 103, South of Etoile.

The estimated maximum individual well yield from the Carrizo Sand is 500 to 1000 gpm in the southwestern half of the County and less than 500 gpm in the northeastern half of the County.

The Carrizo Sand has been heavily pumped for many years. In 1985 pumpage from the Aquifer was approximately 29.6 mgd. The estimated yield of the aquifer by the previously mentioned TWDB Report 110 is 32 mgd. In 1988 the Champion Paper Mill was supposed to have reduced its pumpage from 17 mgd to 12 mgd. Most of the remaining yield will probably be absorbed in Angelina County. In a recently completed county wide study, it was determined that most of the future needs of Angelina County for the next 15 years would come from the Carrizo Aquifer. There is also more available drawdown in Angelina County since it is further down dip of Nacogdoches County. This greater allowed drawdown will allow for more pumping.

3. Sparta Sand

In addition to the Wilcox and the Carrizo, the Sparta Sand is available as a water source in the southern portion of Nacogdoches County. The total thickness of the Sparta Sand varies from 36 to 260 feet in Nacogdoches County. About half of this thickness is sand. Its outcrop varies in width from 2 to 15 miles and is exposed in a belt trending nearly east-west across the Central portion of the County.

The water in the Sparta Sands contains varying amounts of hardness and iron. The hardness ranges from 2 to 150 ppm, and the iron ranges from 0.02 to several ppm or more. There does not appear to be any relationship between depths of wells and the hardness and iron.

The Sparta Sand is relatively unused. The TWDB Report 110 estimates approximately 8 mgd of yield with less than 1000 ppm total dissolved solids is available from the Aquifer in both Angelina and Nacogdoches County. Almost half of this yield, or 3.0 mgd, would be available in southern Nacogdoches County along State Highway 103. In 1985 only about 0.1 mgd was being pumped from the Sparta formation in Nacogdoches County.

The estimated maximum individual well yield from the Sparta Sand is 200 to 500 gpm in the vicinity of FM 103 in southern Nacogdoches County.

B. SURFACE WATER SOURCE

Currently only one water purveying entity within Nacogdoches County produces water from a surface water source. The City of Nacogdoches receives water from Lake Nacogdoches for treatment and sale to its water customers.

1. **Lake Nacogdoches**

According to a draft report entitled "Evaluation of the Groundwater Resources in the Vicinity of the Cities of Henderson, Jacksonville, Kilgore, Lufkin, Nacogdoches, Rusk, and Tyler in East Texas' published by the Texas Water Development Board in November 1989, Lack Nacogdoches can supply about 22,000 acre-feet of water annually. The City of Nacogdoches has a permit authorizing annual diversions of up to 22,000 acre-feet/year and a maximum diversion rate of 56 cubic feet per second (cfs) or 36 mgd.

In 1988 when the spring and summer was relatively dry and hot, the City used 4,000 acre/feet for the year and had a peak diversion rate of 14.2 mgd for one 24 hour period. Water quality in the lake is excellent.

SECTION IV

EXISTING WATER SUPPLY FACILITIES

SECTION IV

EXISTING WATER SUPPLY FACILITIES

A. WATER PURVEYING ENTITIES

The following is a list of the water purveying entities in Nacogdoches County:

1. Appleby Water Supply Corporation
2. Central Heights Water Supply Corporation
3. Caro Water Supply Corporation
4. Cushing, City of
5. D&M Water Supply Corporation
6. Etoile Water Supply Corporation
7. Garrison, City of
8. Libby Water Supply Corporation
9. Lilbert-Looneyville Water Supply Corporation
10. Lilly Grove Water Supply Corporation
11. Melrose Water Supply Corporation
12. Nacogdoches, City of
13. Nacogdoches County Municipal Utility District No. 1
14. Sacul Water Supply Corporation
15. Swift Water Supply Corporation
16. Woden Water Supply Corporation

During the data collection phase of this study, a questionnaire was mailed to each of these entities. A copy of the questionnaire is attached in Appendix B. The response included the quantity of water available, the quality of that water, the

capacity of the entity's ground storage tank, and the location of the entity's service area.

Tables 6 and 7 show the existing water wells producing water in Nacogdoches County. For purpose of water supply projection, it has been assumed that the useful life of these wells is 50 years. As shown in Tables 6 and 7, the total water supply available to the County in the year 2020 utilizing existing wells and the existing City of Nacogdoches 11 mgd Water Treatment Plant is 16.43 mgd.

Included in Appendix A is a worksheet for each of the participating entities which shows projected population, projected per capita demand, projected average and maximum daily water demands, projected Texas Department of Health water supply requirements, and projected Texas Department of Health ground storage tank requirements. For the three cities, projected ground storage requirements were based upon State Board of Insurance requirements to account for fire protection. Table 8 is a summary of the projected ground storage tank capacities for Nacogdoches County. The data shown on this table assumes that the useful life of a ground storage tank is 50 years.

In general, the quality of the groundwater being produced in Nacogdoches County is good with some exceptions. High iron content and high and low pH values are a problem in isolated areas.

B. APPLEBY WATER SUPPLY CORPORATION

Appleby WSC receives water from five wells with capacities of 200 gpm, 100 gpm, 250 gpm, 200 gpm, and 400 gpm. They maintain ground storage in 3 tanks with capacities of 10,000 gallons, 50,000 gallons, and 125,000 gallons. They also have a 41,000 gallon standpipe.

Table 6

Projected Water Well Capacities

(exclusive of City of Nacogdoches wells)

Entity	Well No.	Well Capacity (g.p.m.)	Year Drilled	Projected Well Capacities in G.P.M. 1990	2000	2010	2020
Appleby W.S.C.	1	200	1964	200	200	200	0
	2	100	1975	100	100	100	100
	3	250	1978	250	250	250	250
	4	200	1982	200	200	200	200
	5	400	1986	400	400	400	400
Subtotal		**1150**		**1150**	**1150**	**1150**	**950**
Caro W.S.C.	1	98	1965	98	98	98	0
	2	inactive	1973	inactive	inactive	inactive	inactive
	3	71	1980	71	71	71	71
	4	156	1985	156	156	156	156
Subtotal		**325**		**325**	**325**	**325**	**227**
Central Heights W.S.C.	none	none	none				
Cushing, City of	1	100	1936	100	0	0	0
	2	100	1939	100	0	0	0
	3	100	1979	100	100	100	100
Subtotal		**300**		**300**	**100**	**100**	**100**
D&M W.S.C.	1	**235**	1991	**235**	**235**	**235**	**235**
Etoile W.S.C.	1	50	1964	50	50	50	0
	2	400	1979	400	400	400	400
Subtotal		**450**		**450**	**450**	**450**	**400**
Garrison, City of	2	110	1952	110	110	0	0
	3	195	1964	195	195	195	0
	4	175	1981	175	175	175	175
Subtotal		**480**		**480**	**480**	**370**	**175**
Libby W.S.C.	1	aban.	n/a	aban.	aban.	aban.	aban.
	2	90	1984	90	90	90	90
Subtotal		**90**		**90**	**90**	**90**	**90**
Lilbert-Looneyville W.S.C.	1	aban.	1965	aban.	aban.	aban.	aban.
	2	40	1989	40	40	40	40
	3	75	1989	75	75	75	75
Subtotal		**115**		**115**	**115**	**115**	**115**

Table 6 (cont.)

Projected Water Well Capacities

(exclusive of City of Nacogdoches wells)

Entity	Well No.	Well Capacity (g.p.m.)	Year Drilled	Projected Well Capacities in G.P.M. 1990	2000	2010	2020
Lilly Grove W.S.C.	1	132	1965	132	132	132	0
	2	132	1969	132	132	132	0
Subtotal		**264**		**264**	**264**	**264**	**0**
Melrose W.S.C.	1	50	1965	50	50	50	0
	2	125	1974	125	125	125	125
	3	75	1967	75	75	75	0
	5	150	1977	150	150	150	150
	6	165	1985	165	165	165	165
	7	50	1964	50	50	50	0
	9	50	1990	50	50	50	50
Subtotal		**665**		**665**	**665**	**665**	**490**
Nacogdoches County M.U.D. #1	none	none	none				
Sacul W.S.C.	1	**50**	1982	**50**	**50**	**50**	**50**
Swift W.S.C.	1	100	1967	100	100	100	0
	2	140	1967	140	140	140	0
	4	140	1970	140	140	140	140
	5	150	1982	150	150	150	150
	6	180	1985	180	180	180	180
Subtotal		**710**		**710**	**710**	**710**	**470**
Woden W.S.C.	1	68	1965	68	68	68	0
	2	88	1965	88	88	88	0
	3	170	1979	170	170	170	170
	4	140	1985	140	140	140	140
	5	160	1985	160	160	160	160
Subtotal		**626**		**626**	**626**	**626**	**470**
Total (g.p.m.)		5,460		5,460	5,260	5,150	3,772
Total (m.g.d.)		**7.86**		**7.86**	**7.57**	**7.42**	**5.43**

Table 7

Projected Water Supply Capacity

(for City of Nacogdoches wells and treatment plant)

Entity	Well No.	Well Capacity (g.p.m.)	Year Drilled	Projected Well Capacities in G.P.M. 1990	2000	2010	2020
Nacogdoches Water Wells	1	500	1929	500	0	0	0
	4	480	1949	480	0	0	0
	5	550	1957	550	0	0	0
	6	400	1964	400	400	400	0
	7	300	1964	300	0	0	0
	8	500	1964	500	500	500	0
	9	980	1967	980	980	980	0
	11	830	1973	830	830	830	830
Subtotal (g.p.m.)		4,540		4,540	2,710	2,710	830
Subtotal (m.g.d.)		6.54		6.54	3.90	3.90	1.20
Reliable Yield (m.g.d.)		4.41		4.41	2.49	2.49	0.00
Nacogdoches Water Treatment Plant							
Capacity (m.g.d.)		11.00		11.00	11.00	11.00	11.00
Total (m.g.d.)		15.41		15.41	13.49	13.49	11.00

Notes:

1. The reliable yield for wells is equal to the sum of all well capacities assuming the largest well out of service.
2. Well No. 5 was assumed to be abandoned at the same time as Well No. 4 because it is will not be cost effective to operate the Powers Street High Service Pump Station for one well.

Table 8

Projected Ground Storage Capacities

Entity	Tank No.	Tank Capacity (gal.)	Year Constructed	Projected Ground Storage Capacity (gal.) 1990	2000	2010	2020
Appleby W.S.C.	3	10,000	1975	10,000	10,000	10,000	10,000
	4	50,000	1982	50,000	50,000	50,000	50,000
	5	125,000	1984	125,000	125,000	125,000	125,000
Subtotal		**185,000**		**185,000**	**185,000**	**185,000**	**185,000**
Caro W.S.C.	1	75,000	1965	75,000	75,000	75,000	0
	2	inactive	1973	inactive	inactive	inactive	inactive
	3	10,000	1973	10,000	10,000	10,000	10,000
	4	80,000	1980	80,000	80,000	80,000	80,000
Subtotal		**165,000**		**165,000**	**165,000**	**165,000**	**90,000**
Central Heights W.S.C.	1	30,000	1962	30,000	30,000	30,000	0
	2	30,000	1962	30,000	30,000	30,000	0
	3	60,000	1969	60,000	60,000	60,000	0
Subtotal		**120,000**		**120,000**	**120,000**	**120,000**	**0**
Cushing, City of	1	100,000	1939	100,000	0	0	0
	2	100,000	1978	100,000	100,000	100,000	100,000
	3	35,000	1986	35,000	35,000	35,000	35,000
	4	12,000	1987	12,000	12,000	12,000	12,000
Subtotal		**247,000**		**247,000**	**147,000**	**147,000**	**147,000**
D&M W.S.C.	1	150,000	1982	150,000	150,000	150,000	150,000
	2	20,000	1964	20,000	20,000	20,000	0
	3	20,000	1966	20,000	20,000	20,000	0
	4	20,000	1988	20,000	20,000	20,000	20,000
Subtotal		**210,000**		**210,000**	**210,000**	**210,000**	**170,000**
Etoile W.S.C.	1	40,000	1964	40,000	40,000	40,000	0
	2	50,000	1979	50,000	50,000	50,000	50,000
	3	40,000	1979	40,000	40,000	40,000	40,000
Subtotal		**130,000**		**130,000**	**130,000**	**130,000**	**90,000**
Garrison, City of	1	200,000	1981	200,000	200,000	200,000	200,000
	2	50,000	1952	50,000	50,000	0	0
Subtotal		**250,000**		**250,000**	**250,000**	**200,000**	**200,000**
Libby W.S.C.	1	20,000	1968	20,000	20,000	20,000	0
	2	30,000	1984	30,000	30,000	30,000	30,000
Subtotal		**50000**		**50000**	**50000**	**50000**	**30000**

Table 8 (cont.)

Projected Ground Storage Capacities

Entity	Tank No.	Tank Capacity (gal.)	Year Constructed	Projected Ground Storage Capacity (gal.) 1990	2000	2010	2020
Lilbert-Looneyville W.S.C.	1	**50,000**	1965	**50,000**	**50,000**	**50,000**	**0**
Lilly Grove W.S.C.	1	**30,000**	1981	**30,000**	**30,000**	**30,000**	**30,000**
Melrose W.S.C.	1	20,000	1965	20,000	20,000	20,000	0
	2a	30,000	1974	30,000	30,000	30,000	30,000
	2b	50,000	1985	50,000	50,000	50,000	50,000
	3	20,000	1967	20,000	20,000	20,000	0
	4	20,000	n/a	20,000	20,000	20,000	20,000
	5	100,000	1985	100,000	100,000	100,000	100,000
	6a	40,000	1985	40,000	40,000	40,000	40,000
	6b	40,000	1985	40,000	40,000	40,000	40,000
	7	30,000	1964	30,000	30,000	30,000	0
	8	20,000	n/a	20,000	20,000	20,000	20,000
Subtotal		**370,000**		**370,000**	**370,000**	**370,000**	**300,000**
Nacogdoches, City of	1	1,500,000	1949	1,500,000	0	0	0
	2	2,000,000	1964	2,000,000	2,000,000	2,000,000	0
	3	4,000,000	1975	4,000,000	4,000,000	4,000,000	4,000,000
	4	3,000,000	1978	3,000,000	3,000,000	3,000,000	3,000,000
Subtotal		**10,500,000**		**10,500,000**	**9,000,000**	**9,000,000**	**7,000,000**
Nacogdoches County M.U.D. #1	n/a	n/a	n/a				
Sacul W.S.C.	n/a	n/a	n/a				
Swift W.S.C.	1	20,000	1967	20,000	20,000	20,000	0
	2	20,000	1967	20,000	20,000	20,000	0
	3	30,000	1980	30,000	30,000	30,000	30,000
Subtotal		**70,000**		**70,000**	**70,000**	**70,000**	**30,000**
Woden W.S.C.	1	20,000	1965	20,000	20,000	20,000	0
	2	30,000	1965	30,000	30,000	30,000	0
	3	20,000	1979	20,000	20,000	20,000	20,000
	4	30,000	1979	30,000	30,000	30,000	30,000
	5	50,000	1985	50,000	50,000	50,000	50,000
		30,000	n/a	30,000	30,000	30,000	30,000
Subtotal		**180,000**		**180,000**	**180,000**	**180,000**	**130,000**
Total (gallons)		12,557,000		12,557,000	10,957,000	10,907,000	8,402,000

Information provided by Appleby WSC indicates that the quality of water produced by the five wells is good.

C. CARO WATER SUPPLY CORPORATION

Caro WSC receives water from three active wells. The capacities of the wells are 98 gpm, 71 gpm, and 164 gpm. The total active ground storage capacity is 165,000 gallons. Caro WSC also has an inactive well and two inactive ground storage tanks totaling 40,000 gallons.

D. CENTRAL HEIGHTS WATER SUPPLY CORPORATION

Central Heights WSC receives treated water from the City of Nacogdoches for resale to its customers. It maintains ground storage in three tanks totaling 195,000 gallons.

E. CITY OF CUSHING

The City of Cushing receives water from its three wells, each with a capacity of 100 gpm. Two of the wells are quite old having been drilled in 1936 and 1939. The City maintains ground storage in 4 tanks totalling 247,000 gallons. The quality of water in the City's distribution system is generally good, with a high pH. The flouride content was above the TDH limit on the day of the reported test.

F. D & M WATER SUPPLY CORPORATION

D & M WSC receives treated water from the City of Nacogdoches for subsequent resale to its customers. They have also recently drilled a well which

produces 235 gpm. The WSC maintains ground storage in four tanks totalling 210,000 gallons. They also have a 78 ft. tall standpipe totalling 40,000 gallons.

G. ETOILE WATER SUPPLY CORPORATION

Etoile WSC pumps groundwater from two wells totaling 450 gpm One of these wells is rated at 50 gpm while the other is rated at 400 gpm. It maintains ground storage in three tanks totaling 130,000 gallons. The quality of water reported is generally good.

H. CITY OF GARRISON

The City of Garrison pumps ground water from three wells, with capacities of 110 gpm, 195 gpm, and 175 gpm. The City maintains ground storage in two tanks totaling 250,000 gallons. The reported quality of the City's water is generally good.

I. LIBBY WATER SUPPLY CORPORATION

Libby WSC has one well which produces 90 gpm and two ground storage tanks with a total capacity of 50,000 gallons.

J. LILBERT-LOONEYVILLE WATER SUPPLY CORPORATION

Lilbert-Looneyville WSC receives groundwater from two wells with capacities of 40 gpm and 75 gpm. They have one ground storage tank with a capacity of 50,000 gallons.

K. LILLY GROVE WATER SUPPLY CORPORATION

Lilly Grove WSC receives treated water from the City of Nacogdoches and from two wells, each with capacities of 132 gpm. They maintain ground storage in one tank totaling 30,000 gallons. They also have three standpipes with capacities of 60,000, 100,000, and 60,000 gallons. The reported quality of Lilly Grove's water is good.

L. MELROSE WATER SUPPLY CORPORATION

Melrose WSC receives groundwater from seven wells with capacities of 50 gpm, 125 gpm, 75 gpm, 150 gpm, 165 gpm, 50 gpm, and 50 gpm. The WSC maintains eight ground storage tanks with a total capacity of 370,000 gallons. The reported water quality from the wells is high in iron and has a high pH.

M. CITY OF NACOGDOCHES

The City of Nacogdoches receives groundwater from eight wells and surface water from Lake Nacogdoches. The total capacity of the City's wells is 4,675 gpm (assuming 24 hour per day production). The City treats water from Lake Nacogdoches in its treatment plant located approximately 9 miles west of the City. The plant is currently rated at 11 mgd. As previously mentioned, the City has a permit to withdraw 22,000 acre-feet from the lake at a maximum diversion rate of 56 CFS or 36 MGD.

The City maintains ground storage at four locations throughout the City. The total ground storage capacity is 10.5 million gallons.

The quality of water produced by the City's wells is good except that Wells 1, 4, and 5 have high iron content and have to be treated to sequester the iron.

N. NACOGDOCHES COUNTY MUNICIPAL UTILITY DISTRICT NO. 1

The Nacogdoches County Municipal Utility District No. 1 receives treated water from the City of Nacogdoches for subsequent resale to its customers.

O. SACUL WATER SUPPLY CORPORATION

Sacul WSC receives groundwater from one well with a pumping capacity of 50 gpm. This well produces water which is high in iron and has a pH of 5.93, which is below the lower limit of 6.5.

P. SWIFT WATER SUPPLY CORPORATION

Swift WSC produces groundwater from five wells with pumping capacities of 100 gpm, 140 gpm, 140 gpm, 150 gpm, and 180 gpm. The WSC maintains ground storage in 3 tanks totalling 70,000 gallons. They also have four standpipes with capacities of 40,000, 100,000, 100,000, and 50,000 gallons. The reported water quality of Swift's wells is good.

Q. WODEN WATER SUPPLY CORPORATION

Woden WSC receives groundwater from five wells with capacities of 68 gpm, 88 gpm, 170 gpm, 140 gpm, and 160 gpm. They maintain ground storage in 6 tanks totalling 180,000 gallons. They also have an 80 ft. tall standpipe with a capacity of 50,000 gallons.

SECTION V

FUTURE WATER SUPPLY NEEDS

SECTION V

FUTURE WATER SUPPLY NEEDS

A. WATER SUPPLY

As was summarized in Table 5 water supply requirements are expected to grow from 10.46 mgd in 1987 to 11.38 mgd in 1990, to 15.64 mgd in 2000, to 17.50 mgd in 2010, to 20.06 mgd in 2020, and to 25.83 mgd in 2040, assuming no reduction due to water conservation. Therefore, the County's water supply will almost have to double in the next 30 years. A concerted water conservation program could have a significant impact on these needs.

Approximately 6.5 mgd of the projected 8.7 mgd increase is expected to be for the City of Nacogdoches. Lake Nacogdoches can easily supply this projected increase for the next 30 years. Total estimated demand for the City is only 13.8 mgd while total yield of the Lake is 19.6 mgd.

The water supply study done by KSA Engineers, Inc. has shown that the City of Nacogdoches will require full use of their currently available water rights within the next 50 years. Therefore, this water should not be considered available to other entities, except possibly for short term emergency supply. It may be available to the western part of the County as a tradeoff with a new supply in the eastern part of the County.

The remaining increase of 2.2 mgd for the rest of the County will either have to come from development of new wells or a surface water supply. Additional supplies may be needed as older wells fail or wells lose their yield.

B. WATER SUPPLY FACILITIES

The calculation of future water supply needs was made by projecting the water supply facility requirements for Nacogdoches County for the years 2000, 2010, 2020 and 2040 and subtracting the water supply available from existing water supply facilities of the county. All existing water wells were assumed to have a useful life of 50 years, and therefore were eliminated from consideration as water supply sources when they became 50 years old.

Tables 9, 10 and 11-A and B are presentations of the projected future water facility needs for Nacogdoches County. As shown in Table 10 the projected additional water supply needs are 7.86 mgd by 2000, 11.28 mgd by 2010, and 19.26 mgd by 2020 if current supplies are allowed to play out without replacement. If current supplies are held constant the projected additional water supply needs are 1.66 mgd by 2000, 2.51 mgd by 2010, 3.76 mgd by 2020, and 7.23 mgd by 2040 as shown in Table 11, excluding the City of Nacogdoches. This need must be filled from the development of additional groundwater or surface water resources, as described in the next section.

A review of Table 10 indicates that 2 entities currently need additional water supply facilities, 8 will need additional water facilities in 2000, 11 will need additional water facilities in 2010 and 14 will need additional facilities in 2020. By maintaining existing supplies, these numbers can be reduced to 6 entities currently needing additional water facilities in 2000, 9 in 2010, 12 in 2020, and all entities requiring additional water facilities in 2040.

Table 9

Future Water Supply Needs

Description	Projected Water Supply (m.g.d.) 1990	2000	2010	2020
City of Nacogdoches				
Projected Maximum Day Water Supply Requirement	13.78	17.56	21.21	24.37
Projected Available Water Supply from Existing Wells	4.41	2.49	2.49	0.00
Projected Available Water Supply from Existing W.T.P.	11.00	11.00	11.00	11.00
Projected Additional Water Supply Needs	-1.63	4.07	7.72	13.37
Remainder of Nacogdoches County				
Projected Maximum Day Water Supply Requirement	9.87	11.33	12.82	14.52
Projected Available Water Supply from Existing Wells	7.86	7.57	7.42	5.43
Projected Additional Water Supply Needs	2.01	3.76	5.40	9.09
Water Supply Needs for All of Nacogdoches County	**0.38**	**7.82**	**13.12**	**22.46**

Notes:

1. The projected water supply requirement for the City of Nacogdoches does not include wholesale customers which are currently being served by the City.
2. All calculations are based upon maximum day demands.

Table 10

Summary of Existing and Required Water Supply

(all quantities in m.g.d.)

Entity	1990 Existing Water Supply	1990 Projected Water Supply Required	1990 Additional Needed Water Supply	2000 Existing Water Supply	2000 Projected Water Supply Required	2000 Additional Needed Water Supply	2010 Existing Water Supply	2010 Projected Water Supply Required	2010 Additional Needed Water Supply	2020 Existing Water Supply	2020 Projected Water Supply Required	2020 Additional Needed Water Supply	2040 Existing Water Supply	2040 Projected Water Supply Required	2040 Additional Needed Water Supply
Appleby W.S.C.	1.66	1.08	0.00	1.66	1.52	0.00	1.66	1.76	0.10	1.37	2.07	0.70	0.00	2.73	2.73
Caro W.S.C.	0.47	0.56	0.09	0.47	0.65	0.18	0.47	0.76	0.29	0.33	0.87	0.54	0.00	1.14	1.14
Central Heights W.S.C.	0.00	0.30	0.00	0.00	0.36	0.36	0.00	0.39	0.39	0.00	0.43	0.43	0.00	0.54	0.54
Cushing, City of	0.43	0.39	0.00	0.14	0.40	0.26	0.14	0.43	0.29	0.14	0.46	0.32	0.00	0.55	0.55
D&M W.S.C.	0.34	0.71	0.00	0.34	0.95	0.61	0.34	1.19	0.85	0.34	1.43	1.09	0.34	1.99	1.65
Etoile W.S.C.	0.65	0.39	0.00	0.65	0.50	0.00	0.65	0.62	0.00	0.58	0.73	0.15	0.00	1.01	1.01
Garrison, City of	0.69	0.53	0.00	0.69	0.68	0.00	0.53	0.73	0.20	0.25	0.79	0.54	0.00	0.90	0.90
Libby W.S.C.	0.13	0.13	0.00	0.13	0.17	0.04	0.13	0.20	0.07	0.13	0.23	0.10	0.00	0.29	0.29
Lilbert-Looneyville W.S.C.	0.17	0.11	0.00	0.17	0.12	0.00	0.17	0.14	0.00	0.17	0.15	0.00	0.00	0.19	0.19
Lilly Grove W.S.C.	0.38	0.60	0.00	0.38	0.79	0.41	0.38	0.92	0.54	0.00	1.07	1.07	0.00	1.41	1.41
Melrose W.S.C.	0.96	0.78	0.00	0.96	0.94	0.00	0.96	1.11	0.15	0.71	1.29	0.58	0.07	1.71	1.64
Nacogdoches, City of	15.41	13.78	0.00	13.49	19.43	5.94	13.49	21.82	8.33	11.00	24.11	13.11	11.00	31.66	20.66
Nacogdoches County M.U.D. #1	0.00	0.05	0.00	0.00	0.08	0.00	0.00	0.09	0.00	0.00	0.10	0.00	0.00	0.13	0.00
Sacul W.S.C.	0.07	0.12	0.05	0.07	0.13	0.06	0.07	0.14	0.07	0.07	0.15	0.08	0.00	0.16	0.16
Swift W.S.C.	1.02	0.59	0.00	1.02	0.77	0.00	1.02	0.86	0.00	0.68	0.99	0.31	0.00	1.27	1.27
Woden W.S.C.	0.90	0.50	0.00	0.90	0.64	0.00	0.90	0.76	0.00	0.68	0.91	0.23	0.00	1.25	1.25
Totals	23.27	20.62	0.14	21.06	28.13	7.86	20.91	31.92	11.28	16.43	35.78	19.26	11.41	46.93	35.39

Notes:

1. The projected water supply requirements are based upon actual projections or regulatory requirements, whichever are greater.
2. Central Heights, D&M, Lilly Grove, Nacogdoches County M.U.D. #1 also receive water from the City of Nacogdoches. This water supply is not shown.
3. Projected water demands for the City of Nacogdoches does not include it's current wholesale customers.

FIGURE 1
SUMMARY OF NACOGDOCHES COUNTY
PROJECTED AVAILABLE AND REQUIRED WATER PRODUCTION AND TREATMENT FACILITIES
(BASED ON TOTALS - TABLE 10)

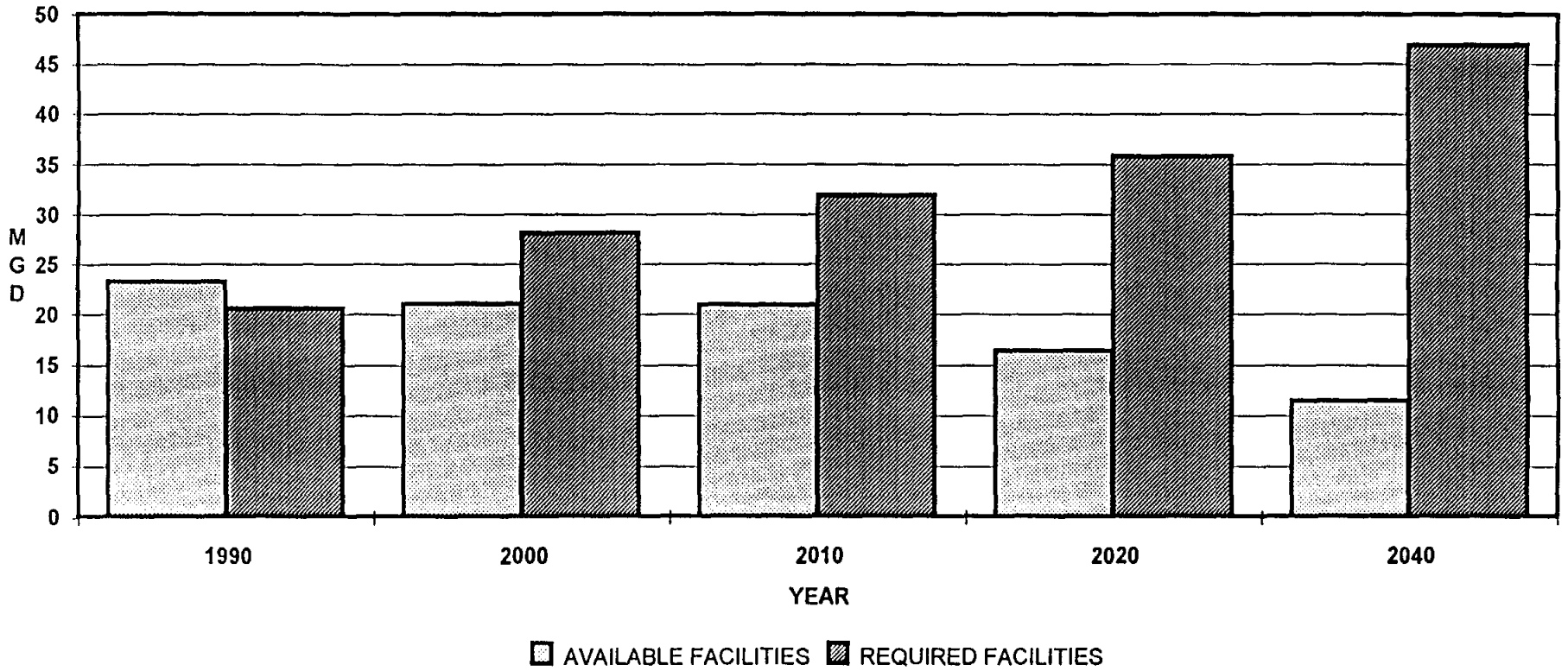

Table 11-A

Summary of Existing and Required Water Supply

Maintaining Existing Supplies Throughout the Period Studied

(all quantities in m.g.d.)

Entity	1990 Existing Water Supply	1990 Projected Water Supply Required	1990 Additional Needed Water Supply	2000 Existing Water Supply	2000 Projected Water Supply Required	2000 Additional Needed Water Supply	2010 Existing Water Supply	2010 Projected Water Supply Required	2010 Additional Needed Water Supply	2020 Existing Water Supply	2020 Projected Water Supply Required	2020 Additional Needed Water Supply	2040 Existing Water Supply	2040 Projected Water Supply Required	2040 Additional Needed Water Supply
Appleby W.S.C.	1.66	1.08	0.00	1.66	1.52	0.00	1.66	1.76	0.10	1.66	2.07	0.41	1.66	2.73	1.07
Caro W.S.C.	0.47	0.56	0.09	0.47	0.65	0.18	0.47	0.76	0.29	0.47	0.87	0.40	0.47	1.14	0.67
Central Heights W.S.C.	0.00	0.30	0.00	0.00	0.36	0.36	0.00	0.39	0.39	0.00	0.43	0.43	0.00	0.54	0.54
Cushing, City of	0.43	0.39	0.00	0.43	0.40	0.00	0.43	0.43	0.00	0.43	0.46	0.03	0.43	0.55	0.12
D&M W.S.C.	0.34	0.71	0.00	0.34	0.95	0.61	0.34	1.19	0.85	0.34	1.43	1.09	0.34	1.99	1.65
Etoile W.S.C.	0.65	0.39	0.00	0.65	0.50	0.00	0.65	0.62	0.00	0.65	0.73	0.08	0.65	1.01	0.36
Garrison, City of	0.69	0.53	0.00	0.69	0.68	0.00	0.69	0.73	0.04	0.69	0.79	0.10	0.69	0.90	0.21
Libby W.S.C.	0.13	0.13	0.00	0.13	0.17	0.04	0.13	0.20	0.07	0.13	0.23	0.10	0.13	0.29	0.16
Lilbert-Looneyville W.S.C.	0.17	0.11	0.00	0.17	0.12	0.00	0.17	0.14	0.00	0.17	0.15	0.00	0.17	0.19	0.02
Lilly Grove W.S.C.	0.38	0.60	0.00	0.38	0.79	0.41	0.38	0.92	0.54	0.38	1.07	0.69	0.38	1.41	1.03
Melrose W.S.C.	0.96	0.78	0.00	0.96	0.94	0.00	0.96	1.11	0.15	0.96	1.29	0.33	0.96	1.71	0.75
Nacogdoches County M.U.D. #1	0.00	0.05	0.00	0.00	0.08	0.00	0.00	0.09	0.00	0.00	0.10	0.00	0.00	0.13	0.00
Sacul W.S.C.	0.07	0.12	0.05	0.07	0.13	0.06	0.07	0.14	0.07	0.07	0.15	0.08	0.07	0.16	0.09
Swift W.S.C.	1.02	0.59	0.00	1.02	0.77	0.00	1.02	0.86	0.00	1.02	0.99	0.00	1.02	1.27	0.25
Woden W.S.C.	0.90	0.50	0.00	0.90	0.64	0.00	0.90	0.76	0.00	0.90	0.91	0.01	0.90	1.25	0.35
Totals	7.86	6.84	0.14	7.86	8.70	1.66	7.86	10.10	2.51	7.86	11.67	3.76	7.86	15.27	7.28

Notes:

1. The projected water supply requirements are based upon actual projections or regulatory requirements, whichever are greater.
2. Central Heights, D&M, Lilly Grove, Nacogdoches County M.U.D. #1 also receive water from the City of Nacogdoches. This water supply is not shown.
3. Projected water demands for the City of Nacogdoches does not include it's current wholesale customers.

Table 11-B

Summary of Existing and Required Water Supply

With Conservation

Maintaining Existing Water Supplies Throughout the Period Studied

(all quantities in m.g.d.)

Entity	1990			2000			2010			2020			2040		
	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply
Appleby W.S.C.	1.66	1.08	0.00	1.66	1.41	0.00	1.66	1.54	0.00	1.66	1.76	0.10	1.66	2.22	2.46
Caro W.S.C.	0.47	0.56	0.09	0.47	0.65	0.18	0.47	0.76	0.29	0.47	0.87	0.40	0.47	1.14	0.67
Central Heights W.S.C.	0.00	0.30	0.00	0.00	0.33	0.33	0.00	0.34	0.34	0.00	0.38	0.38	0.00	0.48	0.48
Cushing, City of	0.43	0.39	0.00	0.43	0.40	0.00	0.43	0.43	0.00	0.43	0.46	0.03	0.43	0.55	0.12
D&M W.S.C.	0.34	0.71	0.00	0.34	0.95	0.61	0.34	1.19	0.85	0.34	1.43	1.09	0.34	1.99	1.65
Etoile W.S.C.	0.65	0.39	0.00	0.65	0.50	0.00	0.65	0.62	0.00	0.65	0.73	0.08	0.65	1.01	0.36
Garrison, City of	0.69	0.53	0.00	0.69	0.63	0.00	0.69	0.64	0.00	0.69	0.67	0.00	0.69	0.74	0.05
Libby W.S.C.	0.13	0.13	0.00	0.13	0.16	0.03	0.13	0.17	0.04	0.13	0.19	0.06	0.13	0.25	0.12
Lilbert-Looneyville W.S.C.	0.17	0.11	0.00	0.17	0.12	0.00	0.17	0.14	0.00	0.17	0.15	0.00	0.17	0.19	0.02
Lilly Grove W.S.C.	0.38	0.60	0.00	0.38	0.74	0.36	0.38	0.89	0.51	0.38	1.05	0.67	0.38	1.41	1.03
Melrose W.S.C.	0.96	0.78	0.00	0.96	0.94	0.00	0.96	1.11	0.15	0.96	1.29	0.33	0.96	1.71	0.75
Nacogdoches County M.U.D. #1	0.00	0.05	0.00	0.00	0.07	0.00	0.00	0.08	0.00	0.00	0.09	0.00	0.00	0.11	0.00
Sacul W.S.C.	0.07	0.12	0.05	0.07	0.13	0.06	0.07	0.14	0.07	0.07	0.15	0.08	0.07	0.16	0.09
Swift W.S.C.	1.02	0.59	0.00	1.02	0.71	0.00	1.02	0.82	0.00	1.02	0.94	0.00	1.02	1.24	0.22
Woden W.S.C.	0.90	0.50	0.00	0.90	0.61	0.00	0.90	0.72	0.00	0.90	0.83	0.00	0.90	1.10	0.20
Totals	7.86	6.84	0.14	7.86	8.35	1.57	7.86	9.59	2.25	7.86	10.99	3.23	7.86	14.30	8.22

Notes:

1. The projected water supply requirements are based upon actual projections or regulatory requirements, whichever are greater.
2. Central Heights, D&M, Lilly Grove, Nacogdoches County M.U.D. #1 also receive water from the City of Nacogdoches. This water supply is not shown.
3. Projected water demands for the City of Nacogdoches does not include it's current wholesale customers.

SECTION VI

SCREENING OF ALTERNATIVE WATER SUPPLY SOURCES

SECTION VI

SCREENING OF ALTERNATIVE WATER SUPPLIES

A. GENERAL

In Section II C water use projections for the county have projected an increase of approximately 8.7 MGD in average daily demand and increase in 14.6 MGD in peak day demands for the year 2020. Furthermore, assuming a 50 year life for wells, many of the wells in the County will fail for various reasons during the 30 year planning period. This deletion of wells will further increase the need for additional water production facilities. Estimated additional water production needed including the removal of these wells is 19.3 MGD by the year 2020. This increased demand must be met from existing or new sources of water and water supply facilities.

Nacogdoches County is fortunate to have several alternative water supplies available to it. This section will identify and screen these alternatives and make recommendations on which should be further evaluated in more detail.

B. GROUNDWATER ALTERNATIVE

1. Carrizo Aquifer

The Carrizo Aquifer has been the major source of water supply for the County. Water use in the Carrizo in Angelina County has a direct impact on available water in Nacogdoches County; therefore, the Carrizo Aquifer must be evaluated by considering water usage in both Counties. In the Texas Water Development Board, Report 110, entitled "Groundwater Conditions in Angelina and Nacogdoches Counties, Texas", the yield of the Carrizo Sand is 32 MGD. The most current year with the most complete data of pumping

from the Aquifer is 1985. In 1985, it is estimated that 29.6 MGD was pumped from the Carrizo Aquifer. It is reported that in 1988 the Champion paper mill reduced its pumpage from approximately 17 MGD to approximately 12 MGD. However, water levels in the City of Nacogdoches most southerly wells do not reflect a rise in water levels which is expected. The Carrizo Aquifer is a system which warrants further study although its use to supply increased needs may probably be limited to isolated cases as a part of a conjunctive use of general water and surface water.

2. **Wilcox Formation**

The Wilcox formation currently provides water to several entities in Nacogdoches County, it was described in Section III A.1. This formation, according to the TWDB Report 110, can produce about 8 MGD of water with less than 1000 ppm T.D.S. Most of this water should be available to Nacogdoches County. In Angelina County, the water in the aquifer exceeds 1000 parts per million of total dissolved solids which is the Texas Department of Health regulations limit. Current pumpage from the formation is approximately 1.1 MGD. Water quality in general is good. The water bearing sands are generally channel sands with a limited width. Therefore, location of wells is critical. This formation could possibly serve some of the northern part of the County. Therefore, it warrants further investigation.

3. **Sparta Sand**

The Sparta Sand is also a relatively untapped groundwater resource in the southern part of the County. It was described in Section III A3. as an existing, water supply since there is limited pumpage from the Aquifer. The TWDB, Report 110, estimates approximately 8 MGD of yield is available

from the Sparta Sand in both Angelina and Nacogdoches County. It is estimated that about 3.0 MGD is available to Nacogdoches County. Pumping from the Sparta Sand in 1985 was approximately 0.1 MGD. Water quality is variable and often has high iron and hardness. Despite these possible water quality problems, it still could be feasible to develop and treat as a source of water in the southern part of the County along Hwy. 103.

4. Yegua Formation

The Yegua formation is a water resource which is widely used in Angelina County but has very limited use in Nacogdoches County because its availability is only in the extreme southern end of the County south of Hwy 103. It is estimated that about 1.0 MGD is available to this area of the County. In Nacogdoches County, although there are a few small users of water from the Yegua, total pumpage is minimal. Water quality can vary from good to bad. Several existing wells in Angelina County are known to have iron, odor, and color problems. The water is generally very soft. It may be the only source of groundwater available to the southern tip of the County.

Since this area is remote and lightly developed it may be the only feasible source for this area. It should be considered in any groundwater alternative considered.

5. Other Groundwater Sources.

There are other minor sources of groundwater. These include the Queen City Sand and isolated sands in the Weches, Reklaw, Cook Mountain, and Jackson Groups. Production wells from these formations will be too small to develop for a public water system. They may serve as a water supply for individual homes or other small, individual users. However, their use as

part of a regional system is not considered feasible.

C. SURFACE WATER ALTERNATIVES

1. Lake Nacogdoches

Lake Nacogdoches was built in 1976 and serves as a water supply for the City of Nacogdoches. It has an annual yield of 22,000 acre feet or 19.6 MGD. The City is permitted a maximum diversion rate of 56 CFS or 36 MGD. Peak use of the Lake occurred in 1988 when the City used 4,000 acre feet and had a maximum daily use of 14.2 MGD. Projected use by the City in 2020, the end of the planning period, is 12,140 acre-feet. Therefore additional yield remains in the year 2020.

The City of Nacogdoches currently provides water to Central Heights, D&M, and Lilly-Grove Water Supply Corporations and to the Nacogdoches County Municipal Utility District #1 which serves the Woodland Hills Development. Furthermore, Woden and Appleby Water Supply Corporations are connected to the City's water system for emergency use only. Therefore, the City is currently serving other water supply entities. A report done for the City of Nacogdoches by KSA Engineers in 1988 determined that within 50 years by 2040, the city will need all of its water supply from Lake Nacogdoches for its own use. Whether the City wants to maintain, expand, reduce, or eliminate serving other entities will have to be determined.

Whether Lake Nacogdoches serves just the City of Nacogdoches or other entities, it will play a major role in providing water in Nacogdoches County. Therefore, it must be included in any regional plan that is developed.

2. Sam Rayburn Reservoir

Sam Rayburn Reservoir is a major surface water reservoir bordering the southern tip of Nacogdoches County. Although nearly all of the water rights allocated for municipal use is currently committed, according to a Corps of Engineers' study conducted at the request of the Lower Neches Valley Authority who own all the water rights in Sam Rayburn, an additional 4,523 acre-feet of yield may be available.

Water quality upstream of and for some distance down stream of the Hwy 103 bridge over the Angelina River is a problem due to color as well as other potential water quality problems. Any intake structure would probably have to be at the southern tip of the County or on the Attoyac arm of the reservoir.

The City of Lufkin currently pays less than $.01/1000 gallons for its water rights in Sam Rayburn. If raw water is available at or near this cost then Sam Rayburn may be a possible water supply. If raw water cost at the intake structure is close to raw water cost of other alternatives, the cost of transmission of the water from the south end of Nacogdoches County to the northern half of the County where the largest demands are will make this alternative cost prohibitive.

In conclusion this alternative warrants further consideration.

3. Lake Eastex

Lake Eastex is a proposed reservoir on Mud Creek in eastern Cherokee County. It currently is in the permitting phase. If developed, it will be a 10,000 surface acre reservoir with a storage volume of 187,839 acre-feet and a dependable yield of 85,507 acre-feet.

The City of Nacogdoches is the only water supply entity in Nacogdoches County with a legal commitment to water from the reservoir. They have a commitment of 6,800 acre-feet. Although all water in the lake is currently committed, it is very probable that some of the existing sponsors will drop out and some water rights will become available. Therefore this alternative should be considered.

4. Lake Naconiche

Lake Naconiche is a proposed reservoir in northeast Nacogdoches County currently in the planning phase. The reservoir was initially conceived as a flood control, recreation, and potential water supply reservoir by the County and the U.S. Soil Conservation Service. However, the County is now considering making the Lake a water supply lake. Currently the Lake is designed to have 692 surface acres and 9072 acre-feet of storage at normal maximum operation level.

Lake Naconiche is fairly well located in relationship to the water supply needs of Nacogdoches County. If a major portion of the cost of the lake can be paid for with other funds to accomplish its flood control and recreational purposes, then Lake Naconiche may be an attractive alternative.

D. RECOMMENDED ALTERNATIVES FOR FURTHER EVALUATION

Based on the possible groundwater and surface water sources identified in the previous sections, the following alternatives are recommended for further evaluation.

1. A conjunctive use of surface water from Lake Nacogdoches and groundwater from existing wells and additional wells in the Wilcox, Carrizo, Sparta and Yegua formations. This option is an extension of current water supplies, as presently operated. Additional wells and well fields will be

developed to provide the most cost effective arrangement of wells and surface water sources to meet the needs of the County. Any use of water out of Lake Nacogdoches for other than the City of Nacogdoches needs would have to be approved by the City of Nacogdoches. In this alternative, the use of ground water would play an increasing role in the planning period.

2. Conjunctive use of groundwater with surface water from Lake Nacogdoches and from Sam Rayburn. In this alternate, groundwater use would play a decreasing role in the County's water supply. Few new wells would be developed except in isolated areas where it may be unfeasible to extend a supply main from the regional system.

3. Conjunctive use of groundwater and surface water from Lake Nacogdoches and from Lake Eastex. This is essentially the same alternative as alternate (2) except that Lake Eastex would be used to supply additional needs.

4. Conjunctive water use of groundwater and surface water from Lake Nacogdoches and from Lake Naconiche. This also is the same alternative as alternate (2) except that Lake Naconiche would supply future needs of the County.

The evaluation of each alternative will include, not only further evaluation of the yield and water quality of each groundwater and surface water source, but will also include the determination of needed water supply facilities. The sizing and location of these will include water production and treatment facilities, pump stations, supply mains, and ground storage facilities. Service pumps and distribution system improvements are not in the scope of the study.

In remote areas such as in the northwest corner of the county, including Cushing and Sacul, and in the south end of the County, including Etoile, the continued use of locally available ground water will be evaluated in comparison with providing water through a regional supply system from other areas of the County. These local supply facilities could be owned and managed by the local water supply entities or by one entity managing and operating the regional system.

Integral to each alternative will be the implementation of a water conservation plan. The proposed Water Conservation and Drought Contingency plan for Nacogdoches County has proposed a 18.5% decrease in per capita water consumption for the next 50 years.

Major issues to be resolved in each alternative will be:

(a) The balance of groundwater from existing wells, water from Lake Nacogdoches, and water from other surface water sources or new groundwater sources.

(b) The best organizational structure to implement alternative.

(c) Any environmental issues encountered.

(d) Any legal constraints determined.

SECTION VII

EVALUATION OF ALTERNATIVES

SECTION VII

EVALUATION OF ALTERNATIVES

A. OVERVIEW

Evaluation of the alternatives recommended for further study involved a comparison of the alternatives based on locations and quantities of needs and yield, water quality, proposed facilities, and cost. It was found that the largest demands were located in the northeastern quadrant of Nacogdoches County, with the exception of D&M Water Supply Corporation in the southwestern portion of the county. These demands are shown in Tables 12 A & B as those demands which need to be supplied by a regional system. For comparison, the demands of other entities are listed in Tables 13 A & B.

In evaluation of the various supply sources and supply facilities, this study applied two different measures of demand. For new water supplies, evaluations were based upon average daily demand. Water supplies are normally lakes or aquifers which have very large storage capacity and are able to equalize peak demands. This number provides the most accurate estimate of the necessary yield required from a source. Evaluation of the water production and treatment facilities are based on peak day demands. Use of peak day demands for sizing of system facilities assures that the design of those structures is adequate for all supply needs.

Water quality was evaluated through study of current supplies and published information about Nacogdoches County's resources. This information was measured

Table 12-A

Summary of Existing and Required Water Supply

for Areas of Proposed Service by Lake Naconiche

Maintaining Existing Supplies Throughout the Period Studied

(all quantities in m.g.d.)

Entity	1990			2000			2010			2020			2040		
	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply
Appleby W.S.C.	1.66	1.08	0.00	1.66	1.52	0.00	1.66	1.76	0.10	1.66	2.07	0.41	1.66	2.73	1.07
Caro W.S.C.	0.47	0.56	0.09	0.47	0.65	0.18	0.47	0.76	0.29	0.47	0.87	0.40	0.47	1.14	0.67
Central Heights W.S.C.	0.00	0.30	0.00	0.00	0.36	0.36	0.00	0.39	0.39	0.00	0.43	0.43	0.00	0.54	0.54
D&M W.S.C. (Post Oak Tank)	0.34	0.71	0.00	0.34	0.95	0.61	0.34	1.19	0.85	0.34	1.43	1.09	0.34	1.99	1.65
Libby W.S.C.	0.13	0.13	0.00	0.13	0.17	0.04	0.13	0.20	0.07	0.13	0.23	0.10	0.13	0.29	0.16
Lilly Grove W.S.C.	0.38	0.60	0.00	0.38	0.79	0.41	0.38	0.92	0.54	0.38	1.07	0.69	0.38	1.41	1.03
Melrose W.S.C.	0.96	0.78	0.00	0.96	0.94	0.00	0.96	1.11	0.15	0.96	1.29	0.33	0.96	1.71	0.75
Nacogdoches Co. M.U.D. #1	0.00	0.05	0.05	0.00	0.08	0.08	0.00	0.09	0.09	0.00	0.10	0.10	0.00	0.13	0.13
Totals	3.93	4.21	0.14	3.93	5.46	1.68	3.93	6.42	2.49	3.93	7.49	3.56	3.93	9.94	6.01

Notes:

1. The projected water supply requirements are based upon actual projections or regulatory requirements, whichever are greater.
2. Central Heights, D&M, Lilly Grove, Nacogdoches County M.U.D. #1 also receive water from the City of Nacogdoches. This water supply is not shown.
3. Projected water demands for the City of Nacogdoches does not include it's current wholesale customers.

FIGURE 2
SUMMARY OF REGIONAL EXISTING AND REQUIRED
WATER TREATMENT AND SUPPLY FACILITIES MAINTAINING EXISTING SUPPLIES
(BASED ON TOTALS - TABLE 12-A)

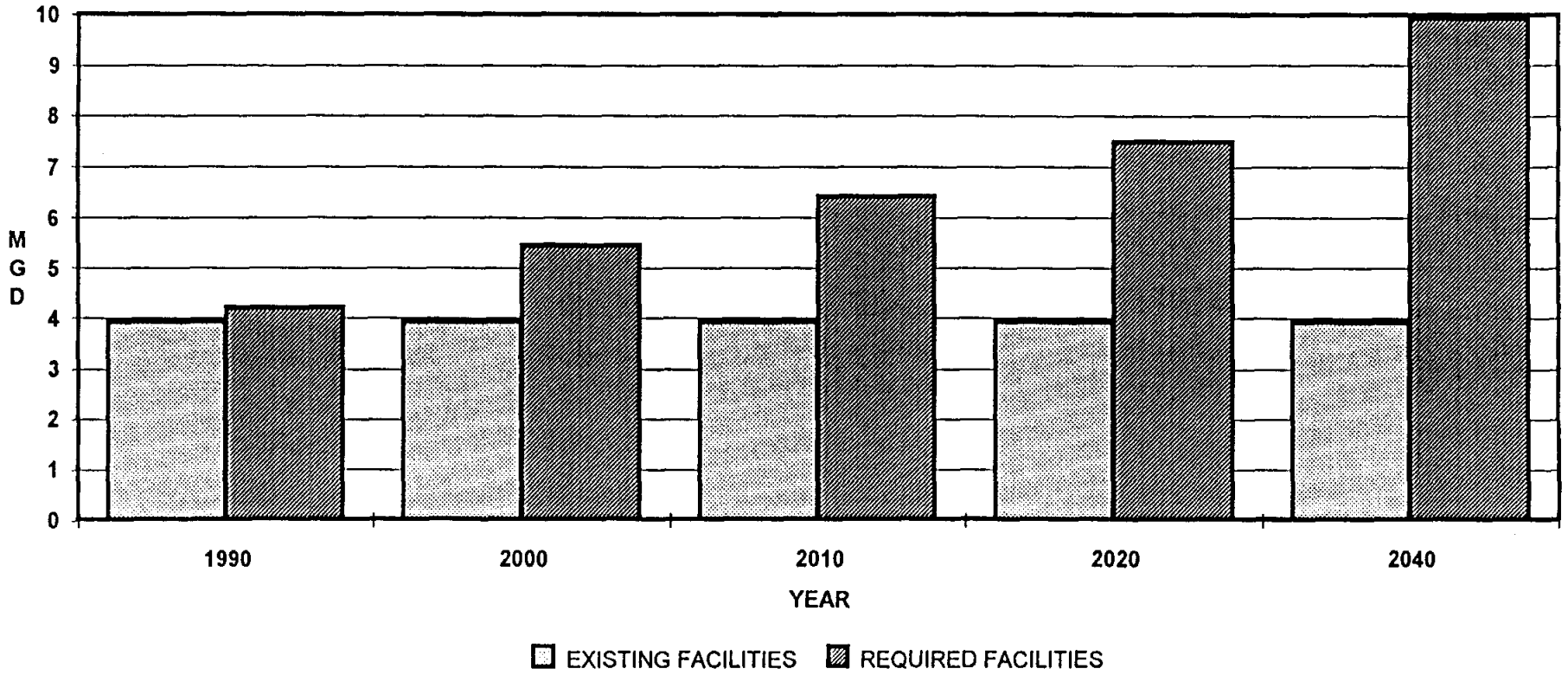

Table 12-B
Summary of Existing and Required Water Supply
With Conservation
for Areas Proposed for Supply by Lake Naconiche
Maintaining Existing Water Supplies Throughout the Period Studied
(all quantities in m.g.d.)

Entity	1990			2000			2010			2020			2040		
	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply
Appleby W.S.C.	1.66	1.08	0.00	1.66	1.41	0.00	1.66	1.54	0.00	1.66	1.76	0.10	1.66	2.22	0.56
Caro W.S.C.	0.47	0.56	0.09	0.47	0.65	0.18	0.47	0.76	0.29	0.47	0.87	0.40	0.47	1.14	0.67
Central Heights W.S.C.	0.00	0.30	0.00	0.00	0.33	0.33	0.00	0.34	0.34	0.00	0.38	0.38	0.00	0.48	0.48
D&M W.S.C. (Post Oak Tank)	0.34	0.71	0.00	0.34	0.95	0.61	0.34	1.19	0.85	0.34	1.43	1.09	0.34	1.99	1.65
Libby W.S.C.	0.13	0.13	0.00	0.13	0.16	0.03	0.13	0.17	0.04	0.13	0.19	0.06	0.13	0.25	0.12
Lilly Grove W.S.C.	0.38	0.60	0.00	0.38	0.74	0.36	0.38	0.89	0.51	0.38	1.05	0.67	0.38	1.41	1.03
Melrose W.S.C.	0.96	0.78	0.00	0.96	0.94	0.00	0.96	1.11	0.15	0.96	1.29	0.33	0.96	1.71	0.75
Nacogdoches County M.U.D. #1	0.00	0.05	0.05	0.00	0.07	0.07	0.00	0.08	0.08	0.00	0.09	0.09	0.00	0.11	0.11
Totals	3.93	4.21	0.14	3.93	5.25	1.58	3.93	6.08	2.27	3.93	7.06	3.13	3.93	9.31	5.38

Notes:

1. The projected water supply requirements are based upon actual projections or regulatory requirements, whichever are greater.
2. Central Heights, D&M, Lilly Grove, Nacogdoches County M.U.D. #1 also receive water from the City of Nacogdoches. This water supply is not shown.
3. Projected water demands for the City of Nacogdoches does not include it's current wholesale customers.

Table 13-A
Summary of Existing and Required Water Supply
for Areas not Serviced by Lake Naconiche
Maintaining Existing Supplies Throughout the Period Studied
(all quantities in m.g.d.)

Entity	1990			2000			2010			2020			2040		
	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply
Cushing, City of	0.43	0.39	0.00	0.43	0.40	0.00	0.43	0.43	0.00	0.43	0.46	0.03	0.43	0.55	0.12
Etoile W.S.C.	0.65	0.39	0.00	0.65	0.50	0.00	0.65	0.62	0.00	0.65	0.73	0.08	0.65	1.01	0.36
Garrison, City of	0.69	0.53	0.00	0.69	0.68	0.00	0.69	0.73	0.04	0.69	0.79	0.10	0.69	0.90	0.21
Lilbert-Looneyville W.S.C.	0.17	0.11	0.00	0.17	0.12	0.00	0.17	0.14	0.00	0.17	0.15	0.00	0.17	0.19	0.02
Sacul W.S.C.	0.07	0.12	0.05	0.07	0.13	0.06	0.07	0.14	0.07	0.07	0.15	0.08	0.07	0.16	0.09
Swift W.S.C.	1.02	0.59	0.00	1.02	0.77	0.00	1.02	0.86	0.00	1.02	0.99	0.00	1.02	1.27	0.25
Woden W.S.C.	0.90	0.50	0.00	0.90	0.64	0.00	0.90	0.76	0.00	0.90	0.91	0.01	0.90	1.25	0.35
Others	2.40	3.03	0.63	2.40	3.03	0.63	2.40	3.03	0.63	2.40	3.03	0.63	2.40	3.03	0.63
Totals	6.33	5.66	0.68	6.33	6.27	0.69	6.33	6.71	0.74	6.33	7.21	0.93	6.33	8.36	2.03

Notes:

1. The projected water supply requirements are based upon actual projections or regulatory requirements, whichever are greater.
2. Central Heights, D&M, Lilly Grove, Nacogdoches County M.U.D. #1 also receive water from the City of Nacogdoches. This water supply is not shown.
3. Projected water demands for the City of Nacogdoches does not include it's current wholesale customers.

Table 13-B

Summary of Existing and Required Water Supply

With Conservation

For Areas Not Serviced by the Regional System

Maintaining Existing Water Supplies Throughout the Period Studied

(all quantities in m.g.d.)

Entity	1990			2000			2010			2020			2040		
	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply	Existing Water Supply	Projected Water Supply Required	Additional Needed Water Supply
Cushing, City of	0.43	0.39	0.00	0.43	0.40	0.00	0.43	0.43	0.00	0.43	0.46	0.03	0.43	0.55	0.12
Etoile W.S.C.	0.65	0.39	0.00	0.65	0.50	0.00	0.65	0.62	0.00	0.65	0.73	0.08	0.65	1.01	0.36
Garrison, City of	0.69	0.53	0.00	0.69	0.56	0.00	0.69	0.59	0.00	0.69	0.68	0.00	0.69	0.81	0.12
Lilbert-Looneyville W.S.C.	0.17	0.11	0.00	0.17	0.12	0.00	0.17	0.14	0.00	0.17	0.15	0.00	0.17	0.19	0.02
Sacul W.S.C.	0.07	0.12	0.05	0.07	0.13	0.06	0.07	0.14	0.07	0.07	0.15	0.08	0.07	0.16	0.09
Swift W.S.C.	1.02	0.59	0.00	1.02	0.71	0.00	1.02	0.82	0.00	1.02	0.94	0.00	1.02	1.24	0.22
Woden W.S.C.	0.90	0.50	0.00	0.90	0.61	0.00	0.90	0.72	0.00	0.90	0.83	0.00	0.90	1.10	0.20
Others	2.40	3.03	0.63	2.40	3.03	0.63	2.40	3.03	0.63	2.40	3.03	0.63	2.40	3.03	0.63
Totals	6.33	5.66	0.68	6.33	6.06	0.69	6.33	6.49	0.70	6.33	6.97	0.82	6.33	8.09	1.76

Notes:

1. The projected water supply requirements are based upon actual projections or regulatory requirements, whichever are greater.
2. Central Heights, D&M, Lilly Grove, Nacogdoches County M.U.D. #1 also receive water from the City of Nacogdoches. This water supply is not shown.
3. Projected water demands for the City of Nacogdoches does not include it's current wholesale customers.

against the Texas Department of Health and United States Environmental Protection Agency's (EPA) primary and secondary standards for treated water supplies. Research by the Texas Agricultural Extension Service has shown that water with high dissolved solids content can be detrimental to poultry production. Further research has shown water with high TDS may increase risk to human health as well. Although the EPA currently allows the use of water with total dissolved solids of 1000 parts per million or less, they have proposed a secondary standard of 500 ppm. Also, past experience has shown a trend towards tighter regulation of water quality by the EPA, so their secondary standard of 500 ppm TDS was used as a where feasible goal for water supply in this study.

Locations and sizes of the current and future supplies varied with the source, which could be categorized as either primarily groundwater or primarily surface water, and were positioned in all portions of the county. Quality of the sources varied likewise.

Cost comparisons show present value and annualized costs. Present value figures summarize all costs for the life of the project as if they all occurred at the start of the project. This allows for comparison of project costs from a common vantage. Annualized costs show a yearly payment on the project cost if money was borrowed at the outset to pay for all expenses for the life of the project.

B. ASSUMPTIONS

The following assumptions were made for evaluating the alternatives:

1. The City of Nacogdoches was not included in the regional system demands. By 2040 the City of Nacogdoches is projected to have a need for 18.1 mgd of water. The yield of Lake Nacogdoches is 19.6 mgd. It is project that the City's wells will be systematically phased out of use over that period of time, and the city will require all of Lake Nacogdoches for its own use.
2. Those entities currently purchasing water from the City of Nacogdoches need to be supplied from some other source, although the City will continue to supply these entities unil a new source is developed.
3. Treated water supplies for Nacogdoches County will comply to the Texas Department of Health and United States Environmental Protection Agency primary and secondary standards. These standards are included in Appendix C.
4. Each entity will maintain its existing level of supply through repair or replacement of facilities as required.

C. GROUNDWATER

Of the four alternatives considered, only one proposed a total dependence on groundwater to supply areas outside of the City of Nacogdoches. Four geologic formations were evaluated for use as groundwater sources in both the groundwater solution and in those solutions calling for additional wells for entities outside of a

regional system. These formations, the Wilcox Group, Carrizo, Yegua, and Sparta Sands, were judged by their yield, composition, location, water quality, current use, projected demands, and cost.

1. WILCOX

As mentioned in previous sections, the Wilcox Group consists of interbedded gravel, sand, clay, and shale. In Nacogdoches County this formation varies in thickness from 800 feet to 2000 feet, with about 40 to 60 percent of the total thickness being sand. Much of the Wilcox Group exists in channel formations. Those channels in the northern half of Nacogdoches County, run roughly north to south. Wells must be located in these channels to produce large quantities of water.

Water quality in the Wilcox is relatively good. Application of the Texas Department of Health secondary standards for total dissolved solids to the water quality information available excludes only three Wilcox wells currently being used. Information provided for this report indicates that one of Appleby W.S.C.'s wells has a total dissolved solids level of 759 ppm, the City of Cushing has an older well with total dissolved solids of 521 ppm, and the City of Garrison has a TDS level of 799 in its newest well. Each of these entities reportedly have minor pH problems in these or other wells. In Nacogdoches County, the southern limit of the area that can be pumped from the Wilcox to provide water with TDS of 500 ppm or less cuts across the

county from just south of Swift, through the northern limits of the City of Nacogdoches, and on up to Cushing, as illustrated in Figure 3.

Of the entities involved in this study, seven are located in areas favorable for development of wells in the Wilcox. Currently Appleby, Caro, Garrrison, Libby, Lilly Grove, and Swift have wells in the Wilcox. Central Heights, which purchases water from the City of Nacogdoches at this time, is also located within the bounds of this area favorable for the development of the Wilcox.

Two additional entities, D&M and Nacogdoches County Municipal Utilities District Number 1, currently purchase water from the City of Nacogdoches, too. D&M purchases water from the city for transfer to D&M's facilities nearby Lake Nacogdoches. Nacogdoches County M.U.D. No. 1 is metered directly off of the city's system with no storage facilities. D&M, with its large projected demand and Nacogdoches County M.U.D. No. 1, with its lack of storage and alternate means of supply, will both have important needs when the City of Nacogdoches ceases to supply them with water. Both entities are geographically well removed from the main regional demands, but they can be included in the system through exchanging water with the City of Nacogdoches. If the regional system supplies the City through its Post Oak Tank, the city can supply D&M and Nacogdoches County M.U.D. No. 1 while saving on pumping costs to move water from Lake Nacogdoches to the northeastern portion of the city. Therefore, their needs can be included with

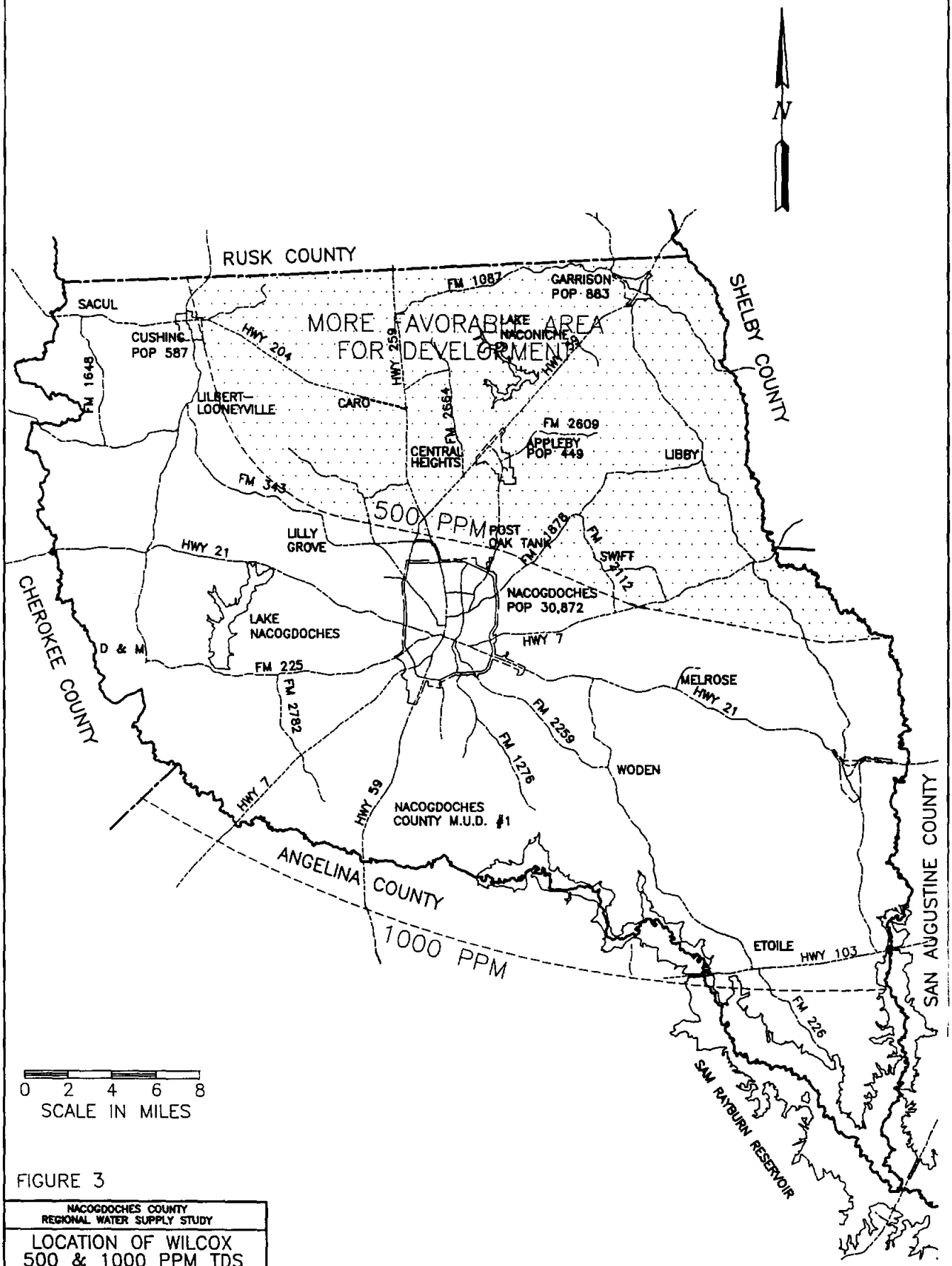

FIGURE 3

NACOGDOCHES COUNTY REGIONAL WATER SUPPLY STUDY
LOCATION OF WILCOX 500 & 1000 PPM TDS

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the other Wilcox demands.

If the above mentioned entities all rely on water from the Wilcox to meet their future demands, it is projected that the total demand on the Wilcox by the year 2020 will be 4.19 mgd and 5.90 mgd by the year 2040. These numbers are high use projections based on the demands of those entities located in the area favorable for development of the Wilcox and including D&M and Nacogdoches County M.U.D. No. 1. D&M's demands exclude the water they are currently able to pump from their new well.

In the Texas Water Development Board Report 110, "Groundwater Conditions in Angelina and Nacogdoches Counties, Texas," the estimated yield of the Wilcox Group is 8.0 mgd for water containing less than 1000 ppm total dissolved solids. Analysis of the quality of the water available out of the Wilcox has shown that, in general, the deeper a well is drilled, the higher the total dissolved solids level which exists in the water produced from that well. From well logs and water quality data, the average thickness of a Wilcox well providing water with TDS of 1000 ppm or less and the average thickness for a Wilcox well yielding 500 ppm TDS or less were determined. The thickness of the formation in the Appleby area yielding 500 ppm TDS is approximately one-third the thickness of the formation yielding 1000 ppm TDS. Futhermore, the approximate width of the formation in the County yielding water with less than 500 ppm of TDS is about 80% of the width of the formation containing 1000 ppm as determined from information available in Report 110. The cross

sectional area of the aquifer yielding 500 ppm total dissolved solids or less is approximately 26 percent of the cross sectional area of the aquifer providing water with 1000 ppm TDS or less. Therefore, the total water available from the Wilcox with less than 500 ppm is about 2.0 mgd. A schematic illustration of this reduction in allowable well depth and total available aquifer width is presented in Figure 4.

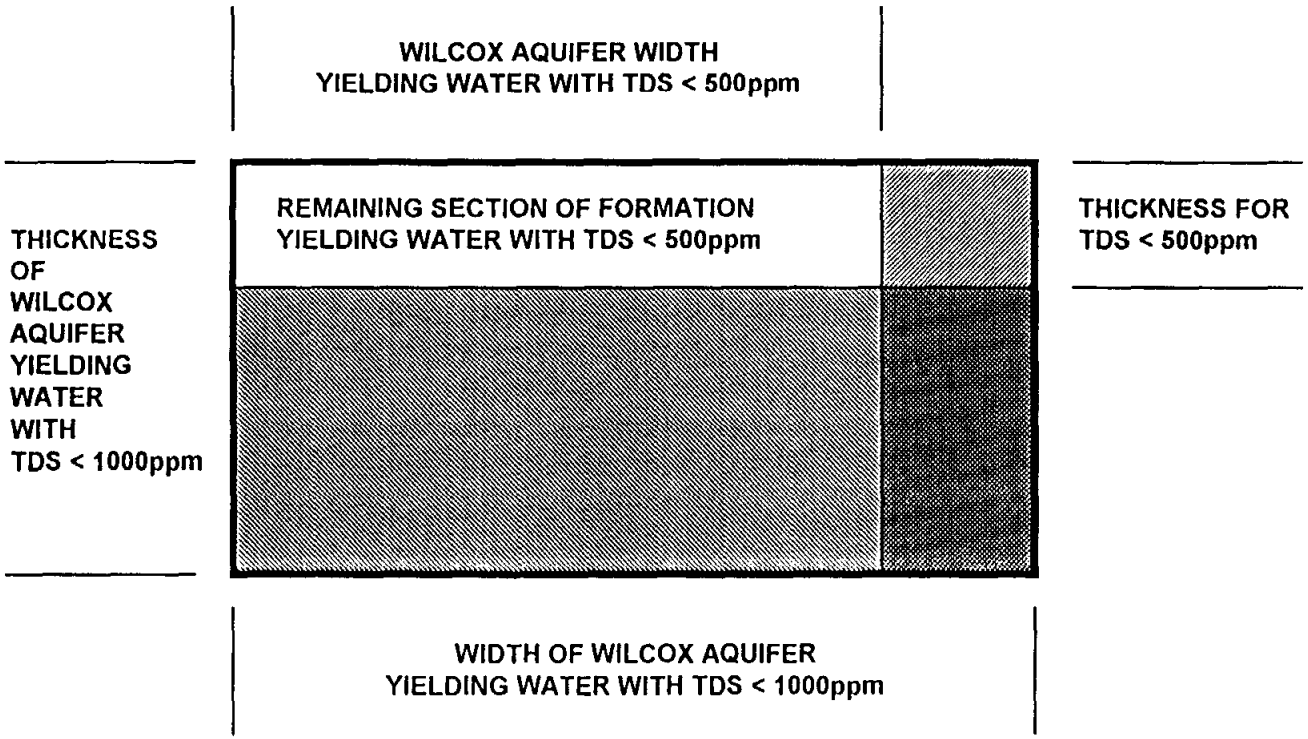
Without the limit of 500 ppm total dissolved solids, there should currently be about 5.3 mgd available for further development in the Wilcox. Current pumpage is approximately 2.7 MGD and is in excess of the limits of the Wilcox yield 2.0 MGD for water with less than 500 ppm total dissolved solids.

2. CARRIZO

The Carrizo Sand is a blanket formation overlying the Wilcox Group. It outcrops in northern Nacodgoches County and is available for production in most of Nacogdoches County south of Appleby. It varies in thickness from 20 to 170 feet, dipping to the southwest.

The Carrizo Sand is one of the major water sources currently serving Nacogdoches County. It currently supplies over 5.0 million gallons per day to the County. An evaluation of the yield and production of water from the Carrizo has to include both Angelina and Nacogdoches water. Both Counties extensively use the Carrizo, and the available yield of the aquifer in each county is dependent on the production from the aquifer in the other County.

FIGURE 4
REDUCTION IN WILCOX YIELD
LIMITING TDS TO 500ppm OR LESS



According to the Texas Water Development Board report 110, "Groundwater Conditions In Angelina and Nacogdoches Counties, Texas," there is an estimated yield of 32 MGD available from the Carrizo Sands and the upper sands of the Wilcox which are hydraulicly connected to the Carrizo. Table 14 entitled "Historic Carrizo Production" gives historic production from the Carrizo from 1956 to 1985. After reaching a peak production in 1974 of 32.2 MGD, production has fallen off to a low of 28.0 MGD in 1983 and was at 29.6 MGD in 1985. This reduction in production is due primarily to a partial conversion to surface water by Champion International and the City of Nacogdoches. Champion has reduced its usage by 4.5 MGD and Nacogdoches has had slight reduction in its usage. Despite these decreases of around 5.0 MGD, the total production from the aquifer has dropped only 2.6 MGD. This difference in decreased production is due to increased water use by the City of Lufkin and other municipal users.

Many cities and water supply corporations in Angelina County are turning to the Carrizo as an additional water supply. Angelina County has just completed a regional study which determined that the Carrizo will be their source for future water for the next 15 to 20 years. Since recent Carrizo production is near its yield, Champion International has reportedly reduced their pumpage from 17 MGD to 12 MGD to provide additional yield to supply the needs of Angelina County. This additional 5 MGD is projected to be used in Angelina County within the next 15 to 20 years. Since Angelina

TABLE 14
HISTORIC CARRIZO PRODUCTION

YEAR	NACOGDOCHES AVG DAY GPD	LUFKIN AVG DAY GPD	CHAMPION AVG DAY GPD	MUNICIPAL AVG DAY GPD	OTHERS* AVG DAY GPD	TOTAL AVG DAY GPD
1956	1,627,956	2,372,537	10,989,041	50,000	255,672	15,297,162
1957	1,390,186	1,859,943	8,454,795	50,000	199,834	11,956,720
1958	1,284,932	1,859,962	8,873,973	40,110	205,003	12,265,937
1959	1,524,564	2,124,975	8,586,301	47,260	208,813	12,493,873
1960	1,634,674	2,217,553	8,586,301	28,207	211,935	12,680,630
1961	1,694,600	2,175,449	9,295,890	28,198	224,300	13,420,398
1962	1,907,586	2,562,384	12,167,123	31,945	283,374	16,954,374
1963	2,218,321	3,002,318	18,923,288	36,083	411,060	24,593,032
1964	2,494,895	2,997,556	16,378,082	58,367	372,791	22,303,565
1965	2,290,682	3,490,123	17,750,685	171,230	402,946	24,107,631
1966	2,888,718	3,846,836	18,531,507	253,083	433,842	25,955,952
1967	3,255,203	4,183,932	18,643,836	415,812	450,479	26,951,229
1968	3,243,312	3,847,329	18,126,027	470,883	436,688	26,126,207
1969	3,978,540	4,183,342	19,142,466	553,722	473,587	28,333,626
1970	4,448,342	4,110,274	19,156,164	746,845	483,848	28,947,443
1971	4,246,564	4,104,616	20,413,699	824,709	503,023	30,094,583
1972	3,718,601	4,355,156	20,704,110	885,570	504,278	30,169,687
1973	3,966,004	4,380,323	20,767,123	965,985	511,350	30,592,758
1974	4,493,193	4,639,586	21,545,205	1,002,932	538,576	32,221,467
1975	4,174,664	5,222,433	20,071,233	940,010	516,942	30,927,257
1976	4,533,279	4,911,616	20,328,767	1,201,443	526,577	31,503,659
1977	5,794,877	5,324,518	19,665,753	1,221,411	544,112	32,552,648
1978	4,264,759	5,938,836	19,668,493	1,268,933	529,397	31,672,396
1979	4,079,564	5,699,425	18,638,356	1,319,087	505,519	30,243,930
1980	4,064,953	5,831,479	18,391,781	1,648,767	508,929	30,447,890
1981	3,544,893	5,237,932	17,041,096	1,734,278	468,489	28,028,668
1982	3,629,948	5,487,808	17,145,205	1,799,012	477,054	28,541,009
1983	3,732,512	5,200,260	16,830,137	1,740,907	467,565	27,973,364
1984	4,128,981	5,821,808	17,216,438	1,919,594	494,476	29,583,281
1985	4,180,534	6,021,000	17,068,493	1,847,619	495,000	29,614,631

*ESTIMATED AT 1.67% OF TOTAL OF OTHER USE

County has a greater range of draw-down than Nacogdoches County, this 5 MGD is not available to Nacogdoches County as the Carrizo cannot be pumped as low in Nacogdoches County as in Angelina County. Another consideration in limiting dependency on the Carrizo Sands is the recent Edwards Aquifer Ruling. In 1992 the Texas Water Commission declared the Edwards Aquifer to be an underground lake, placing it under all the regulations in effect for a surface water source. If this precedent holds, groundwater rights could be effected statewide, in turn effecting the use of the Carrizo, possibly to this benefit of Angelina County rather than Nacogdoches County.

The production of the Carrizo Sands near the limit of its yield is reflected in the low water levels in the water wells in the Carrizo Sand in Nacogdoches County. This is especially true with the City of Nacogdoches wells where static water levels have dropped anywhere from 80 to 270 feet. Well No. One, the first major well produced in the Carrizo, was drilled in 1929. In this sixty year period since it was drilled, static levels have fallen 270 feet. Since 1964 when wells 6, 7, 8 and 9 were drilled, static levels have fallen about 90 feet. Due to reduced pumpage within the last ten years water levels have stabilized to a near level condition.

These low levels have necessitated that the City of Nacogdoches reduce its production and the pumping rate of most of its wells. Of the nine wells still producing, pumping levels are near or below the top of the sand in six of

the wells. Two wells have had pumping levels below the top of the sand. Five wells are currently being choked to reduce the pumping rate and keep the water level above the top of the sands. Pumping rates have had to be reduced by about 40%. Figures 5 and 6 are graphs of historic water levels in Wells 5 and 8. These are typical of what has occurred in all of the City Wells.

In conclusion, the production from the Carrizo Sands has been at is maximum limits. Only scattered, isolated wells can be produced at the western or eastern sides of the County without having a negative impact on the critical water levels in the City of Nacogdoches wells. The Carizzo will be able to continue to meet the demands of those currently producing water from the sand, however, it is recommended that no new major well fields be created to meet the projected needs of the large additional future demand in the northeast portion of the County.

Quality of water in the Carrizo Sands is generally good. Iron, odor, and low pH tend to be problems in wells north, east, and west of the City of Nacogdoches. In the southern part of the county, though, the iron and pH problem is not as prominent. Other than in the southern tip of the county including Etoile, there is no problem with meeting the total dissolved solids limit of 500 ppm.

Eight of the sponsoring entities are located in areas accessible for development of the Carrizo. These entities are Cushing, D&M, Lilbert-Looneyville, Melrose, the City of Nacogdoches, Sacul, Swift, and Woden.

FIGURE 5

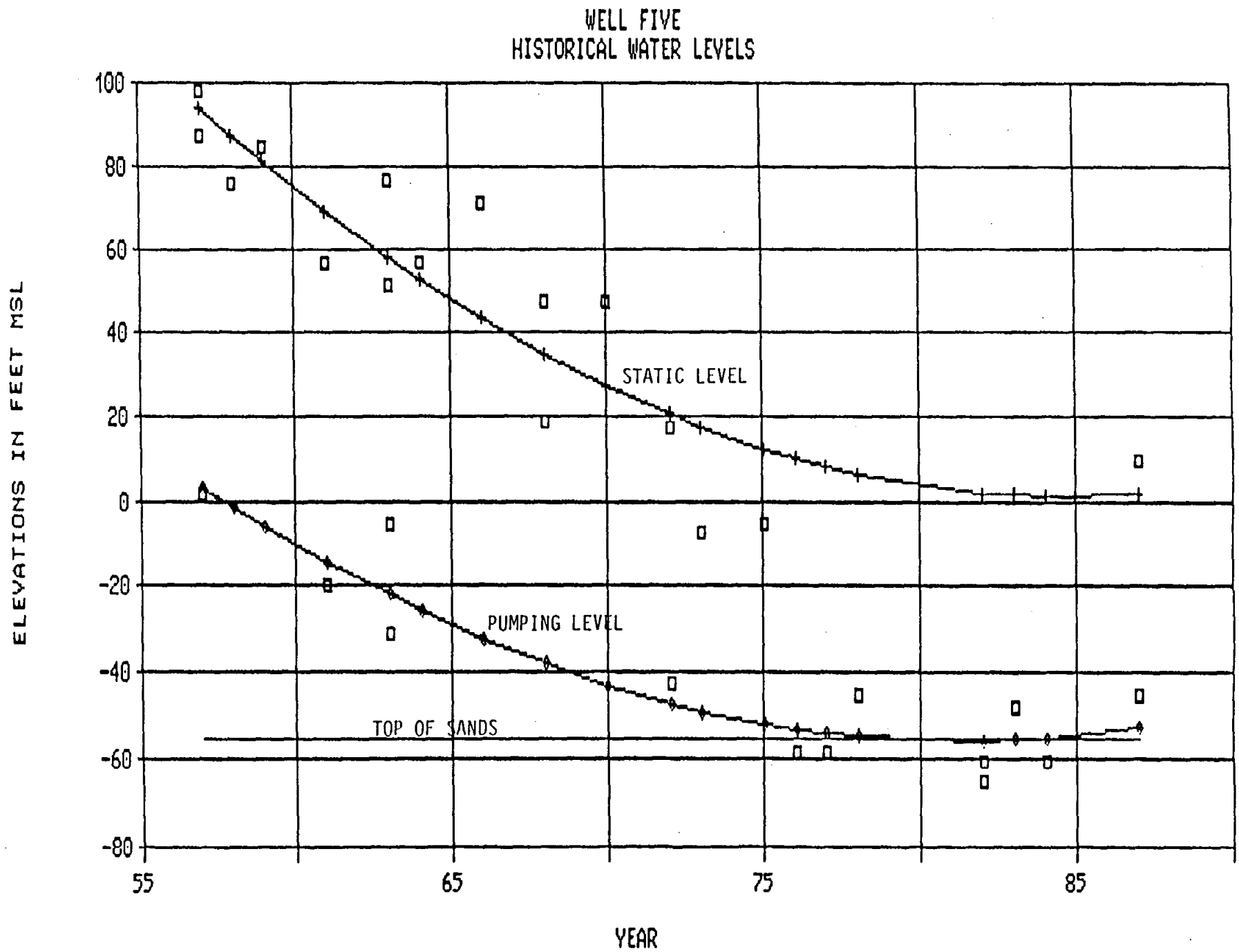
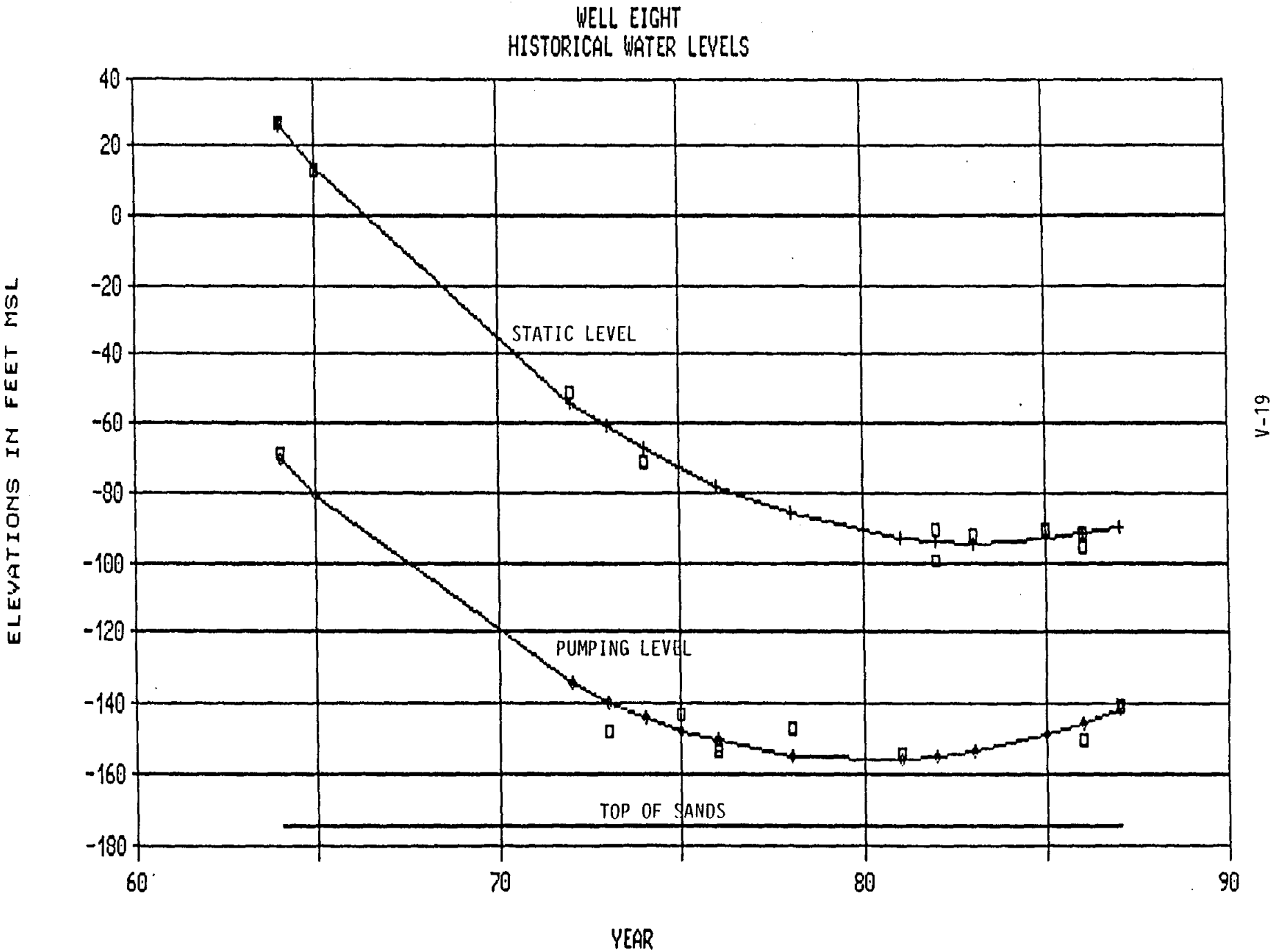

WELL FIVE
HISTORICAL WATER LEVELS
ELEVATIONS IN FEET MSL
100
80
60
40
20
0
-20
-40
-60
-80
55
65
75
85
YEAR
STATIC LEVEL
PUMPING LEVEL
TOP OF SANDS

FIGURE 6


WELL EIGHT
HISTORICAL WATER LEVELS
ELEVATIONS IN FEET MSL
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
STATIC LEVEL
PUMPING LEVEL
TOP OF SANDS
60
70
80
90
YEAR

Currently these entities are pumping a total of 5.1 mgd out of the Carrizo. Total pumpage by these entities is expected to decrease to 2.6 mgd in the year 2040, as the City of Nacogdoches reduces its use of its wells and eventually takes all of its water from Lake Nacogdoches.

3. SPARTA

Shown in Figure 7, the area available for development of the Sparta Sand in Nacogdoches County is located in a pocket including Etoile and State Highway 103, roughly paralleling the highway. Quality of water in this formation varies, including high iron contents and hardness problems when problems exist.

Of the sponsoring entities, only Etoile W.S.C. is located suitably for effective utilization of this resource. At this time, none of the sponsoring entities are pumping water from the Sparta Sand. Others pumping from the sand are estimated to be using 0.1 mgd. With an estimated yield of 3.0 mgd, of water containing 1000 ppm or less of total dissolved solids which is reduced to 1.0 mgd when held to the limit of 500 ppm total dissolved solids or less, the Sparta could easily and economically supply all of the projected needs for Etoile.

4. YEGUA

Water from the Yegua formation is available for use by Nacogdoches

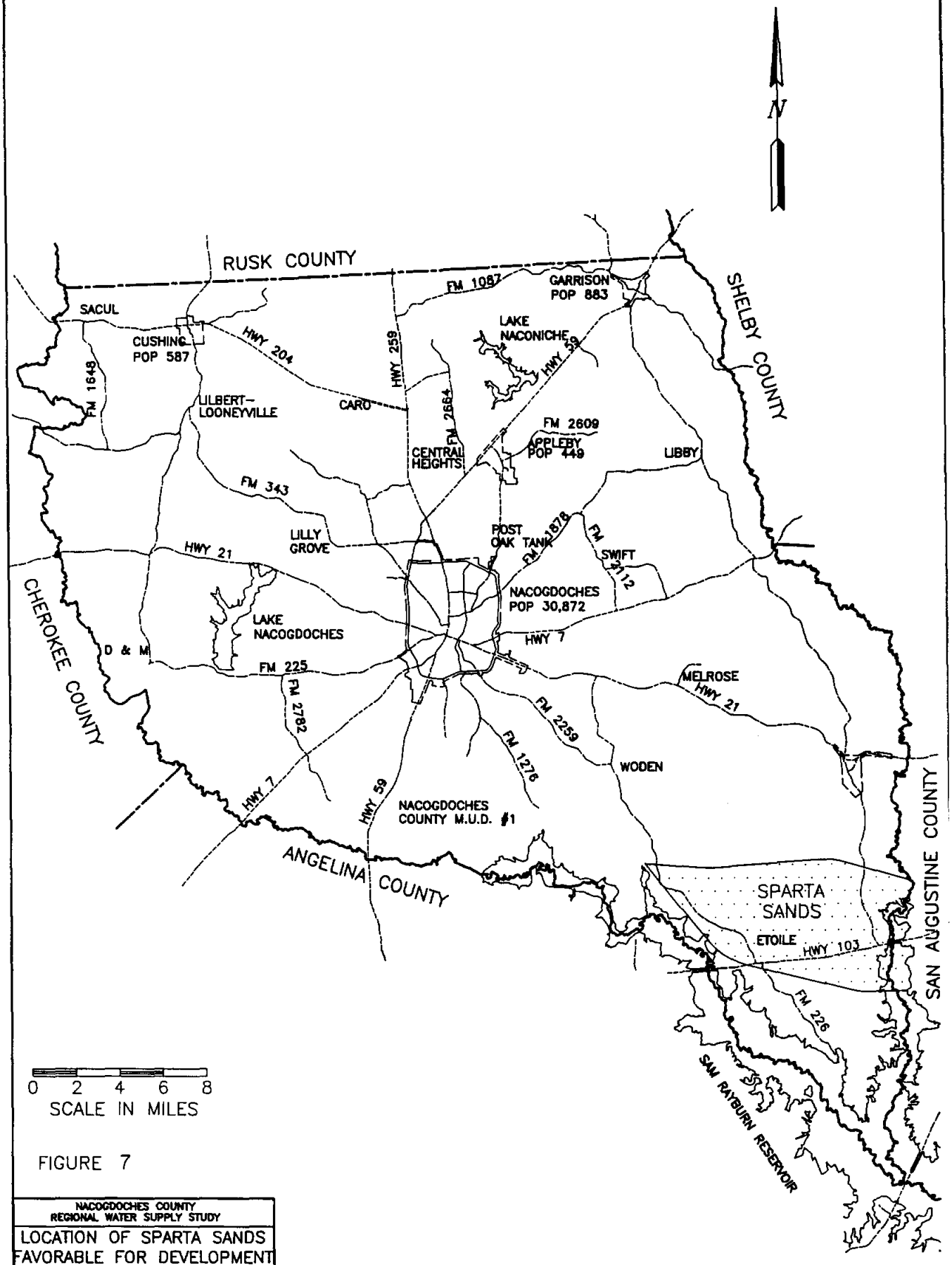


FIGURE 7

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY

LOCATION OF SPARTA SANDS FAVORABLE FOR DEVELOPMENT

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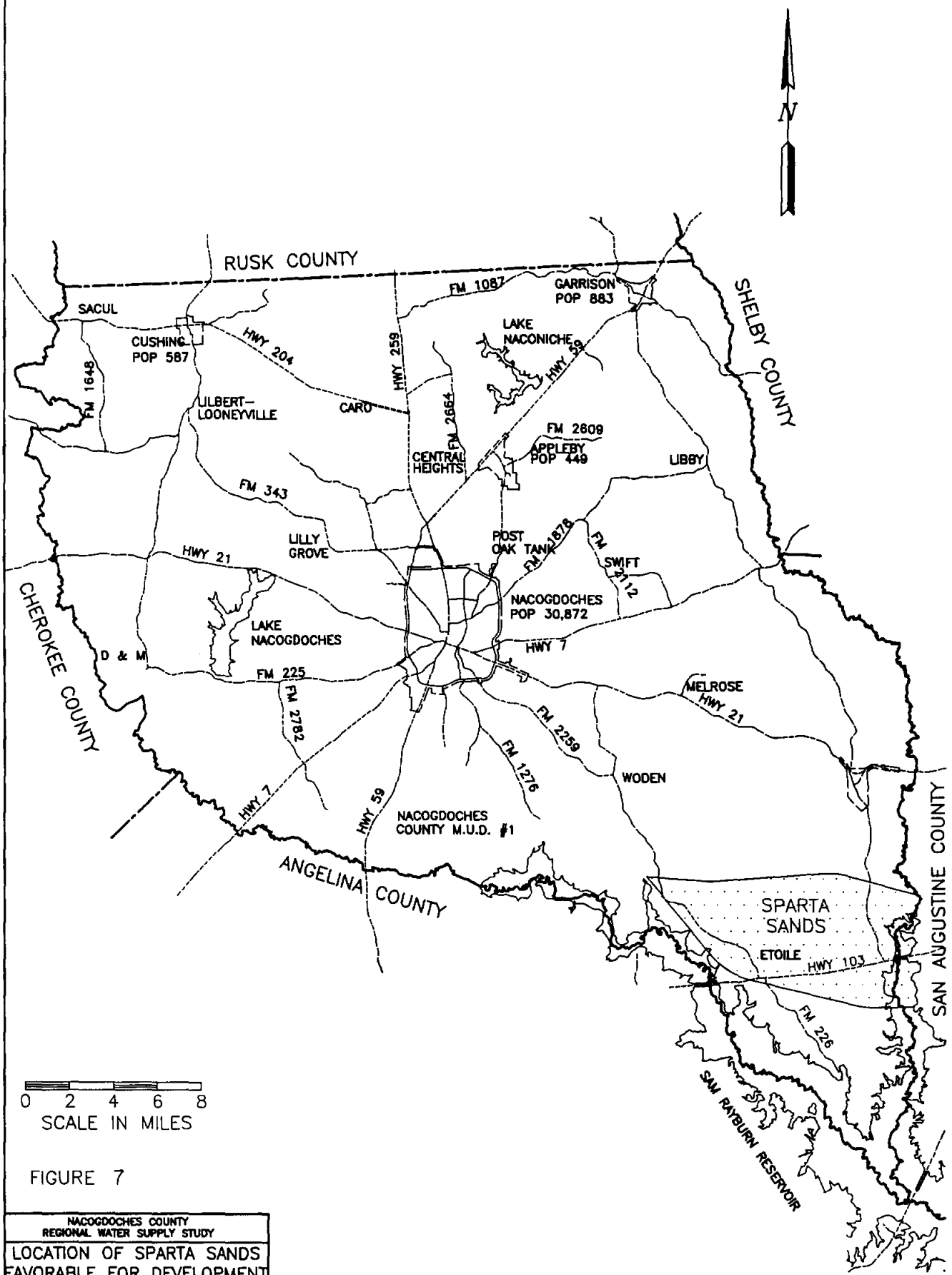


FIGURE 7

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY

LOCATION OF SPARTA SANDS
FAVORABLE FOR DEVELOPMENT

KSA ENGINEERS, INC.

County in only the extreme southern end of the county. Other than Etoile, no other participating entities are near enough to this source to make it beneficial as a system supply. Analysis of the quality of the water produced from this source indicates that the water is generally poor, having iron, TDS, odor, and color problems. Estimated yield from the Yegua is 1.0 mgd. The Yegua could possibly be used by small, remote users, with no other means of water supply, but due to its remote location, it is not feasible as a county wide resource.

5. REGIONAL WELL FIELD SOLUTION

Development of a regional well field for the purpose of supplying the needs of Nacogdoches County aside from the needs of the City of Nacogdoches has to account for relative location of the needs and the resources. Review of the projected needs indicates that the greatest demands on the county's water resources will be in the northeastern quadrant of the county. If the resources are required to meet the limitation of 500 ppm total dissolved solids, there is not enough groundwater to meet the county's needs over the course of the period studied.

To make the study more thorough, a well field solution was modeled using water with a total dissolved solids of up to 1000 ppm. Following this assumption, the Wilcox Group appears to be the ideal location for a regional

well field, being the groundwater resource with available yield and the best location to meet the county's demands.

Analysis of the existing and required water supplies in Nacogdoches County shows the demands projected to occur the earliest and grow the largest to be those of Appleby, Caro, Central Heights, D&M W.S.C., Libby, Lilly Grove, and Melrose. Nacogdoches County M.U.D. No. 1 will also experience a need as the City of Nacogdoches requires use of all water from Lake Nacogdoches and ceases to sell water to the M.U.D.. Five of these eight entities are located in the northeastern portion of the county in good proximity to be served by a regional system drawing on the Wilcox. Melrose is farther to the south, but still accessible to a regional system joining the other five entities. D&M W.S.C. and Nacogdoches M.U.D. No. 1 are too far away to be directly tied to a regional system located in the Wilcox, but as both have access to the City of Nacogdoches' system, they could possibly be supplied by the city, while the city is provided water in exchange from the Wilcox system. The other entities show comparatively smaller demands, greater isolation, or both, so that their demands would need to be met by locally available groundwater.

Two major constraints typically apply to the development of a well field. Most basic to the selection of a well field is the estimated yield and the demand to be placed on that yield. The Wilcox, with an estimated total yield of 8.0 mgd of water with TDS of 1000 ppm or less could supply all of

Nacogdoches County's needs through the year 2020. Another constraint of importance to the development of a well field is the combined draw-down or interference between wells. To avoid this problem, wells must be placed far enough apart to keep them from limiting each other's productivity. This poses a problem for the development of the Wilcox.

The Wilcox consists of a number of channel sands originally laid in old river channels. Therefore, placement of wells not only involves proper spacing, but also proper location of the Wilcox channels. Each channel effectively acts as a separate well field with increased importance placed on the spacing between wells. The spacing between wells in a channel must be increased because of the lack of breadth of the sand from which to draw water. For this study, the suggested spacing of one-half mile apart for wells in a continuous formation has been increased to about two miles to account for the lack of cross sectional width to draw from. In the Texas Water Development Board Report 110, "Groundwater Conditions in Angelina and Nacogdoches Counties, Texas," it is suggested that well fields in the Wilcox formation be separated by a distance of about seven miles. Using this guideline, three well fields were chosen to represent possible locations of channel sands for a groundwater supply system. As the system is developed wells would then have to be located within these channel sands at sites with public access and available power supplies.

The three well field locations chosen to represent a possible

groundwater supply are spread out across approximately two-thirds of the northern half of the county as seen in Figure 8. Each well field consists of four wells assumed to be drawing on one particular channel. All of the wells are assumed to produce 250 gpm. On the western side of the system, the four wells pump into a 700,000 gallon ground storage tank just north of Lilly Grove on FM 698. One of the four wells is at the same location as the ground storage tank for this well field. Running roughly parallel to a line from Appleby to Swift, the central well field pumps into a 700,000 gallon ground storage tank near the intersection of US 59 and FM 2609 in Appleby. The eastern well field follows along side FM 95 and fills a 700,000 gallon tank located on US 59 just southwest of the City of Garrison.

As an interconnected system, these twelve 250 gpm wells and three 0.7 million gallon storage tanks meet the projected peak day demands of Appleby, Caro, Central Heights, D&M W.S.C., Libby, Lilly Grove, Melrose, and Nacogdoches County M.U.D. No. 1. Appleby, Caro, Central Heights, Libby, Lilly Grove, and Melrose are supplied directly from lines connecting their current storage facilities. If the City of Nacogdoches is willing to provide water to D&M W.S.C. and Nacogdoches County M.U.D. No. 1, it could be traded for water pumped out of the regional groundwater system into the city's Post Oak Tank located on the northeast side of the city. This would enable the system to meet D&M's and Nacogdoches County M.U.D. No. 1's, projected needs. The City of Nacogdoches could save on the cost of pumping

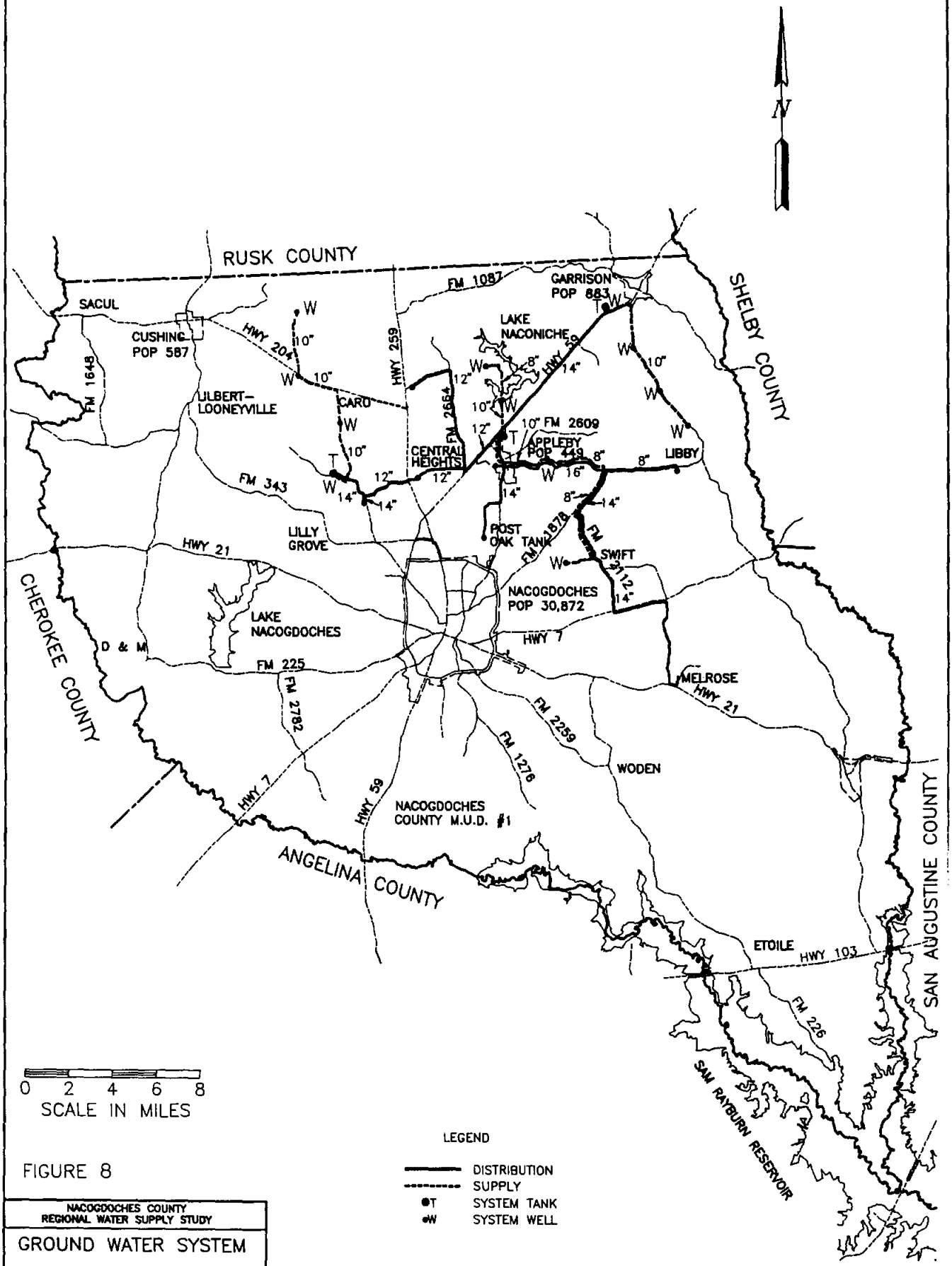


FIGURE 8

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY

GROUND WATER SYSTEM

KSA ENGINEERS, INC.

water from Lake Nacogdoches to the northeast side of town. Piping required for this system would involve over 350,000 linear feet of PVC ranging in size from 6" to 14" in diameter.

In addition to supplying the needs of those entities which would be placed on the regional groundwater system, there is also a need to supply the other entities. These entities will be supplied by the addition of individual wells or upgrading of current pumping capacities to meet their needs. This requires increasing the pumping capacity for Etoile, the City of Garrison, the City of Cushing, and Woden. Sacul is the only entity projected to need a new well to meet its needs with this alternative.

The assumption that all current supplies will be maintained affects all of the entities. To accomplish this, the entities will be required to replace pumps and wells as they fail. Wells and tanks are assumed to have an average life of 50 years. Replacement wells will necessarilly be drilled into the same formations as the wells they are replacing as some entities have different wells in different formations. Replacement of a Wilcox well with a Carrizo well, for example, might adversely affect the production from the Carrizo formation. Cost of pump replacement is included only if needed to increase the capacity of the well. Replacement of pumps for maintenance reasons are considered to be apart of the O & M cost.

The present value of total cost required to construct, operate and maintain this groundwater alternative is estimated at about $14.7 million. A

break down of general areas of cost is shown in Table 15. A more detailed listing of the cost for this system is located in Appendix D. Cost for the system wells includes the cost of a test hole. Pump station costs include material, labor, and energy costs. Entity costs are primarilly those costs incurred for the replacement of obsolete wells, pumps, and tanks.

D. SURFACE WATER

Three of the alternatives presented for further analysis call for the conjunctive use of an additional surface water source other than Lake Nacogdoches with continued production from current groundwater sources for the overall supply of water in Nacogdoches County. The surface water sources offered for analysis are Sam Rayburn Reservoir, Lake Eastex, and Lake Naconiche.

1. BASIC SYSTEM

As mentioned in the discussion of the groundwater solution, the prominent needs occuring over the course of this study are located in the northeastern portion of Nacogdoches County with the exception of D&M W.S.C.. All of these needs, including D&M and Nacogdoches M.U.D. No. 1, can be connected through a pipe system which includes individual entity storage and the City of Nacogdoches' Post Oak Tank. For each of the surface water solutions, a basic pipe network connecting Appleby, Caro, Central Heights, Libby, Lilly Grove,

TABLE 15
NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
COST ANALYSIS
GROUNDWATER ALTERNATIVE

EVALUATIONS BASED ON

YEARS 30

INTEREST RATE 0.07

ITEM	AVERAGE LIFE YEARS	SALVAGE VALUE AT END	O&M COST ANNUAL	RAW WATER COST ANNUAL	PRESENT VALUE CAPITAL COST	PRESENT VALUE SALVAGE VALUE	PRESENT VALUE O&M COST	PRESENT VALUE RAW WATER COST	PRESENT VALUE TOTAL COST
SUPPLY MAINS	50	2,140,726	53,518		5,351,814	-281,221	664,109		5,734,702
SYSTEM STORAGE	50	460,469	23,023		1,151,174	-60,491	285,699		1,376,382
AERATION EQUIP.	50	59,516	11,903		148,791	-7,819	147,708		288,681
PUMP STATIONS	30		53,232		548,178		660,561		1,208,739
SYSTEM WELLS	40	469,867	214,413		1,879,467	-61,725	2,660,664		4,478,406
LAKE COSTS	100								
ENTITY WELLS	50	56,048	16,548		140,120	-7,363	205,340		338,097
ENTITY PUMPS	20	-105,071	11,281		210,142	13,803	139,986		363,931
ENTITY STORAGE	50	375,943	18,797		939,858	-49,387	233,255		1,123,726
TOTAL PRESENT VALUE		3,457,499	402,716		10,369,544	-454,202	4,997,323		14,912,666

Melrose, and the Post Oak Tank was used with minor variations given the source of water. Swift could be connected to any of the systems as it is located within the framework of the basic system. In this analysis Swift is not included in the regional supply system as it is not projected to have any additional need through the year 2020. Supply mains from the water source and other additional piping are attached to the basic system for each alternative and sized to provide the appropriate volumes of water to each entity. Each completed system also includes the construction of a 3.6 mgd water treatment facility for flocculation, clarification, filtration, disinfection of the raw water, storage, and high service pumping.

Water supply beyond that provided by this basic system would come from upgrading of current supplies or addition of wells. This coincides with the assumption that current supplies will be maintained through repair or replacement of failing pumps and wells. New wells will be located in the formation best suited for each individual entity while replacement wells will tap into the same formation as the well that they are replacing.

2. SAM RAYBURN RESERVOIR

Sam Rayburn Reservoir is located on the southern border of Nacogdoches County. Based on previous studies, it may be possible to obtain an additional 4,523 acre-feet from this reservoir beyond that

which is already committed.

Connecting this source to the basic system requires a 145,300 LF 20" diameter supply line from the reservoir to the nearest system line as seen in Figure 9. This supply line allows for Etoile and Woden to receive water from a regional system if necessary without any change in sizing for the system piping. Entities remaining on groundwater sources include the City of Cushing, the City of Garrison, Lilbert-Looneyville, Sacul and Swift. Of these, Sacul requires an additional well and Cushing and Garrison need to upgrade their pumping capacities.

The quality of water available from Sam Rayburn Reservoir is poor on the upper end of the Angelina River branch of the reservoir. Water in this portion of the reservoir north of the Hwy 103 bridge and some ways downstream has color and other quality problems. For this reason, the proposed intake structure has been located on the Attoyac Bayou side of the reservoir, south of Etoile.

Moving water from this source to the system in the northeastern portion of the county incurs some extra costs. Since the source is so far removed from the demands and lower in elevation, this system requires the construction of a 2.0 mgd ground storage tank and a 1,600 gpm pump station. The system also needs a greater amount of large diameter pipe and about 45,000 LF of higher pressure rated pipe.

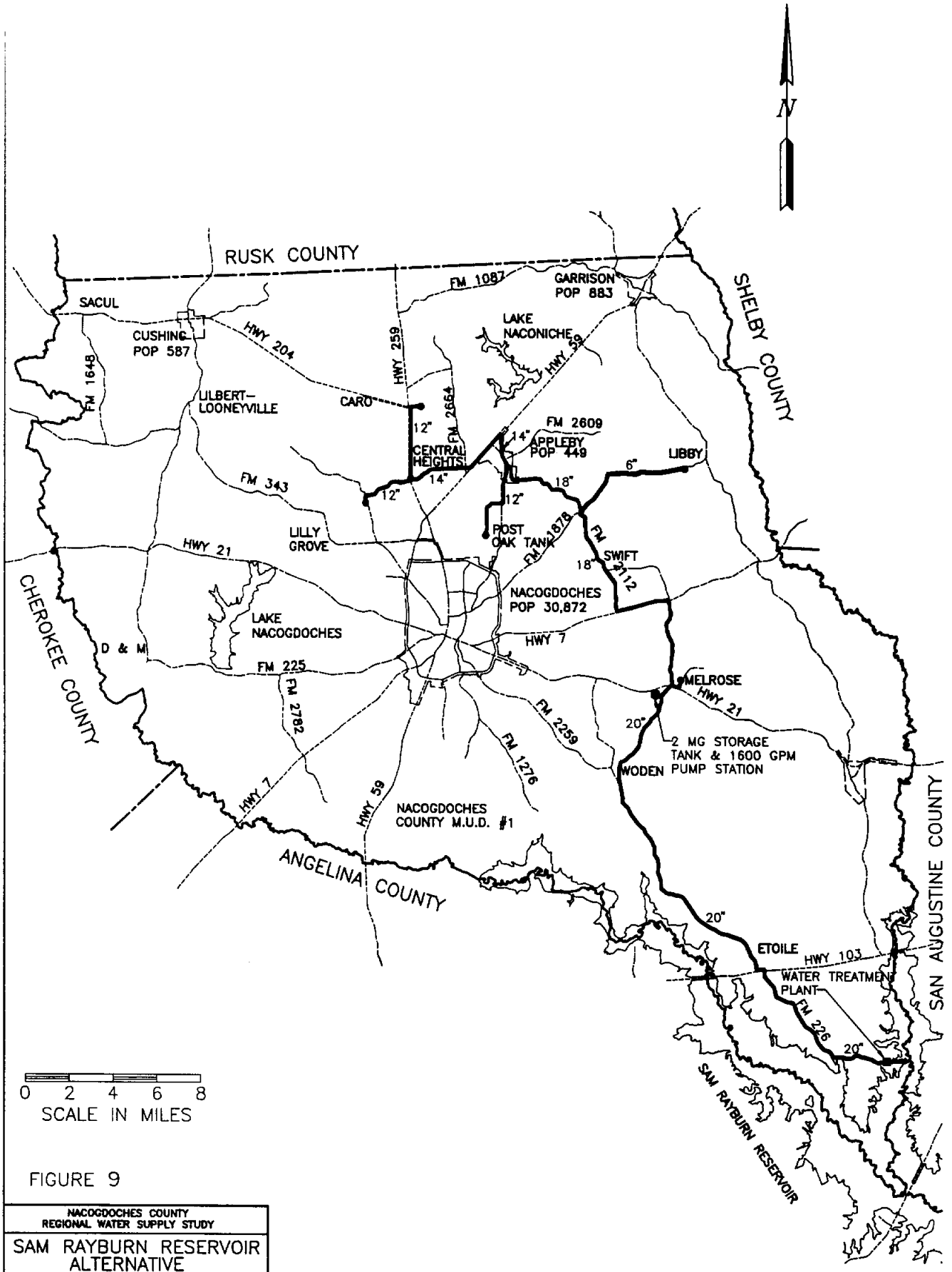


FIGURE 9

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY

SAM RAYBURN RESERVOIR
ALTERNATIVE

KSA ENGINEERS, INC.

The present value of the cost to construct, operate, and maintain the Sam Rayburn Reservoir system is $22.2 million. Break down of this cost into general categories can be seen in Table 16. A more detailed listing of the costs for this alternative is located in Appendix D . The pump station and water plant costs include materials, maintenance, and labor costs. Lake costs basically cover the cost of purchasing water from the Lower Neches Valley and storage capacity from the Corps of Engineers. This cost is estimated at $0.01 per 1000 gallons. Entity costs are those costs incurred to upgrade or replace entity wells, pumps, or storage facilities to maintain and meet their needs aside from the regional system.

3. LAKE EASTEX

Lake Eastex, currently in the permitting stage, is a proposed reservoir on Mud Creek in Cherokee County as shown in Figure 10. The City of Nacogdoches is the only entity in Nacogdoches County currently holding a commitment to water from this reservoir, this commitment being 6,800 acre-feet. It is thought that one or more of the sponsors may give up their commitments opening Lake Eastex as an alternate water source for the county.

To obtain water from Lake Eastex, it is assumed that an intake structure could be located on the Angelina River, south of Sacul.

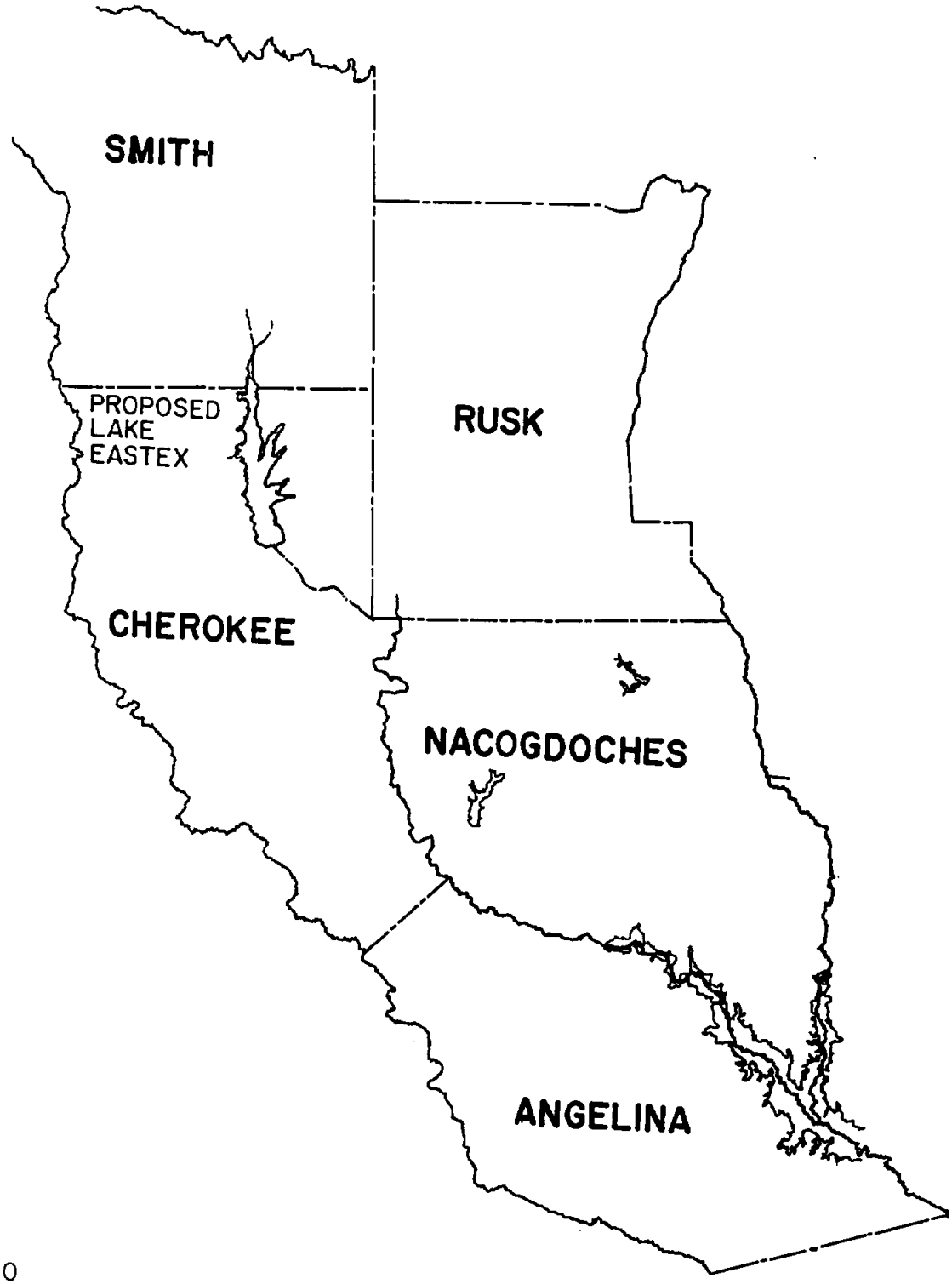


FIGURE 10

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY

GENERAL LOCATION
LAKE EASTEX

KSA ENGINEERS, INC.

TABLE 16
NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
COST ANALYSIS
SAM RAYBURN ALTERNATIVE

EVALUATIONS BASED ON

YEARS 30

INTEREST RATE 0.07

ITEM	AVERAGE LIFE YEARS	SALVAGE VALUE AT END	O&M COST ANNUAL	RAW WATER COST ANNUAL	PRESENT VALUE CAPITAL COST	PRESENT VALUE SALVAGE VALUE	PRESENT VALUE O&M COST	PRESENT VALUE RAW WATER COST	PRESENT VALUE TOTAL COST
SUPPLY MAINS	50	3,584,661	89,617		8,961,652	-470,907	1,112,055		9,602,801
SYSTEM STORAGE	50	287,983	14,399		719,957	-37,831	178,680		860,805
PUMP STATIONS	30		48,536		359,978		602,284		962,263
RAW WATER PUMP STA	40	271,500	65,160		1,086,000	-35,666	808,573		1,858,907
WATER PLANT	40	1,004,250	261,021		4,017,000	-131,925	3,239,025		7,124,100
LAKE COSTS	100	70,000	5,000	11,332	100,000	-9,196	62,045	140,618	293,468
ENTITY WELLS	50	56,048	16,548		140,120	-7,363	205,340		338,097
ENTITY PUMPS	20	-52,540	5,630		105,080	6,902	69,863		181,845
ENTITY STORAGE	50	375,943	18,797		939,858	-49,387	233,255		1,123,726
TOTAL PRESENT VALUE		5,597,845	524,708		16,429,646	-735,373	6,511,120	140,618	22,346,011

Water would be released from the lake into Mud Creek, thence to the Angelina river from which it could be pumped into the regional system. This requires the addition of about 90,100 LF of 18" and 20" supply line to the basic system as seen in Figure 11. Sacul and Cushing, located along this supply main, could easily be added to the regional system. With the addition of about 58,600 LF of 12" line, Lilbert-Looneyville and D&M W.S.C. could be directly tied to the regional system. For this alternative, it was decided not to include the line from Cushing to Lilbert-Looneyville and D&M W.S.C.. Those entities not connected to the regional system through any means then would be Etoile, the City of Garrison, Lilbert-Looneyville, Swift, and Woden.

Total present cost to construct the Lake Eastex system is $20.6 million. Break down of this cost can be seen in Table 17. A more detailed listing of the cost for this alternative is located in Appendix D. Unlike the Sam Rayburn system, the Lake Eastex system does not require system storage beyond that located at the treatment facilities, nor does it require an additional pump station. Again, the water plant costs include material, maintenance, and labor for the facility. Entity costs for this alternative are slightly lower as Sacul does not require an additional well since it is on the regional system.

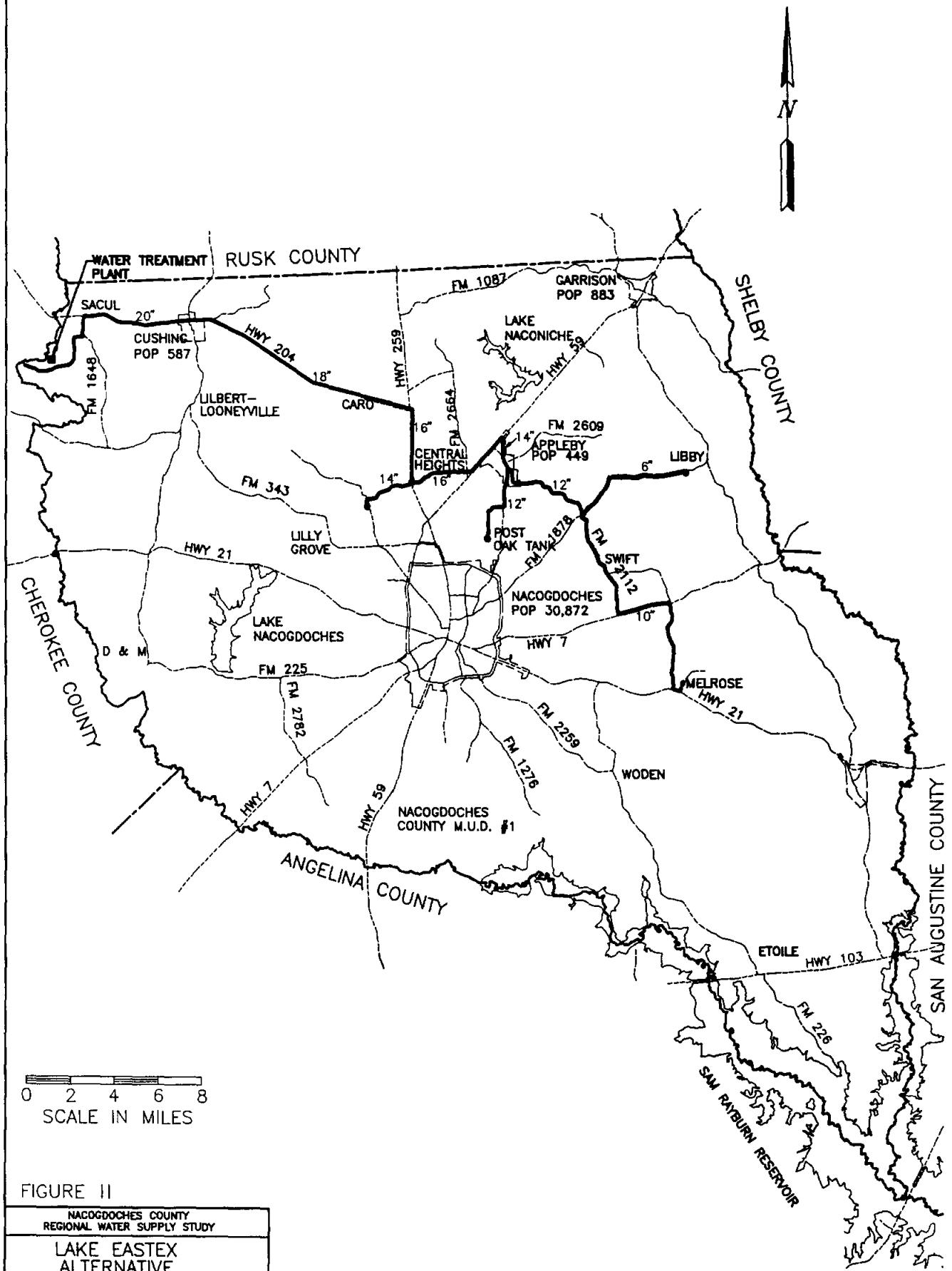


FIGURE II

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY

LAKE EASTEX
ALTERNATIVE

KSA ENGINEERS, INC.

TABLE 17
NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
COST ANALYSIS
LAKE EASTEX ALTERNATIVE

EVALUATIONS BASED ON
YEARS 30
INTEREST RATE 0.07

ITEM	AVERAGE LIFE YEARS	SALVAGE VALUE AT END	O&M COST ANNUAL	RAW WATER COST ANNUAL	PRESENT VALUE CAPITAL COST	PRESENT VALUE SALVAGE VALUE	PRESENT VALUE O&M COST	PRESENT VALUE RAW WATER COST	PRESENT VALUE TOTAL COST
SUPPLY MAINS	50	2,449,184	61,230		6,122,960	-321,742	759,801		6,561,018
SYSTEM STORAGE	50								
PUMP STATIONS	30								
RAW WATER PUMP STA	40	271,500	65,160		1,086,000	-35,666	808,573		1,858,907
WATER PLANT	40	1,004,250	261,021		4,017,000	-131,925	3,239,025		7,124,100
LAKE COSTS	100			312,294				3,875,269	3,875,269
ENTITY WELLS	50								
ENTITY PUMPS	20	-52,531	10,246		105,062	6,901	127,143		239,106
ENTITY STORAGE	50	375,943	18,797		939,858	-49,387	233,255		1,123,726
TOTAL PRESENT VALUE		4,048,346	416,454	312,294	12,270,880	-531,820	5,167,797	3,875,269	20,782,126

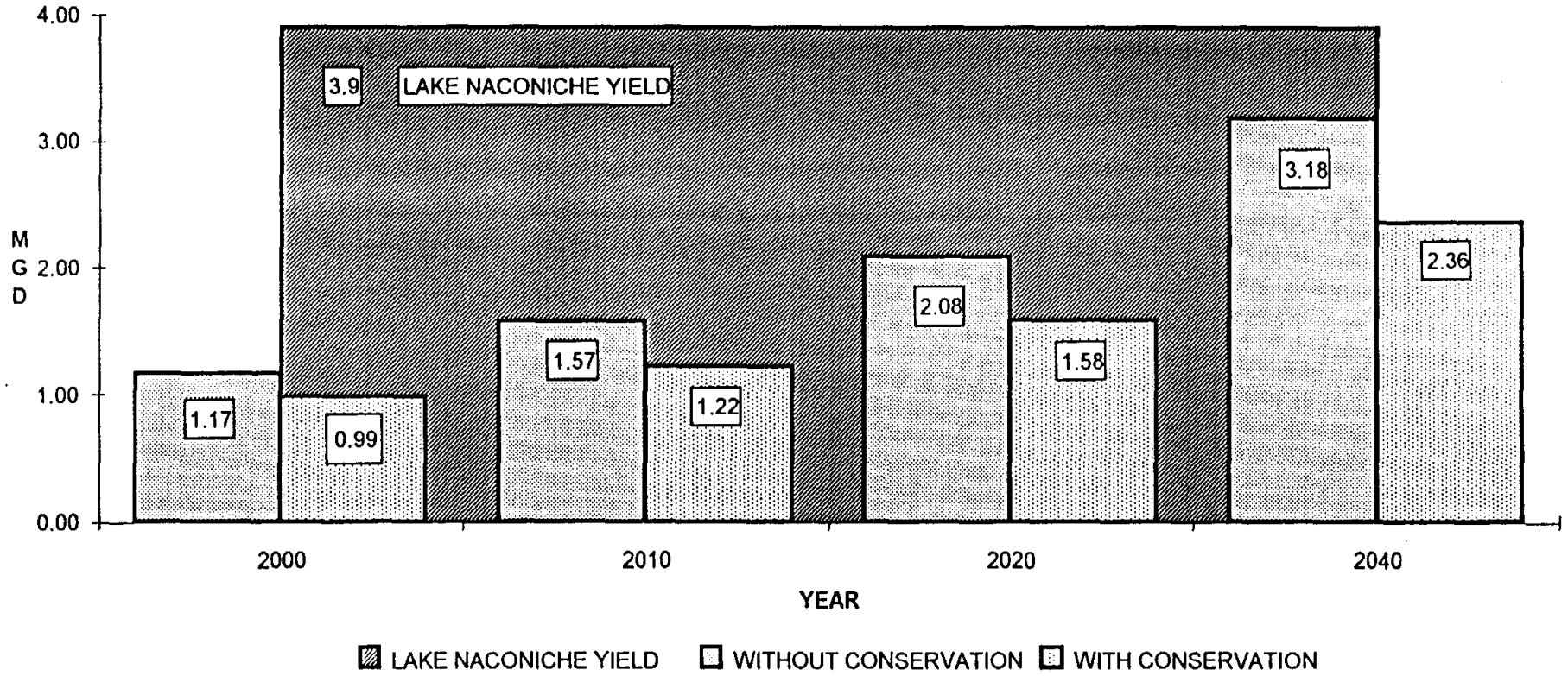
4. LAKE NACONICHE

Lake Naconiche is a proposed reservoir in northeast Nacogdoches County. In the planning phase, this reservoir was initially conceived as a flood control structure by Nacogdoches County and the U.S. Soil Conservation Service. For its design surface of 692 acres and storage of 9072 acre-feet, the yield is calculated at about 4400 acre-feet or 3.9 mgd. Appendix F summarizes this yield calculation.

Located in the heart of Nacogdoches County's largest water needs, Lake Naconiche would not require a long supply line to connect it to the basic regional distribution system. For this analysis, the intake structure and water treatment plant are located just north of Appleby along the edge of the proposed lake location as shown in Figure 12.

Several items must be addressed before Lake Naconiche can be used as a water supply for Nacogdoches County. Permitting for the construction of a new surface water source involves a number of issues. It must be shown that the surface supply will not significantly affect the environment, or if it does, that sufficient mitigation measures are offered to minimize the environmental impact. Environmental issues are more fully discussed in a later section of this report. Benefits of the lake aside from the water supply must also be measured. Lake Naconiche would serve as a flood control structure as well as a recreational facility. Use of the water from the reservoir would not

FIGURE 13
NACOGDOCHES COUNTY REGIONAL WATER SUPPLY STUDY
WATER SUPPLY DEMANDS ON LAKE NACONICHE
HIGH PROJECTIONS FOR AVERAGE DAILY DEMANDS



adversely affect its function as a flood control structure, but heavy use could reduce the recreational benefits of the lake. Table 18 summarizes the results of the calculation of probable cost of lost recreational benefits. Appendix G provides the complete set of calculations of lost recreational benefits.

As mentioned above, it has been estimated that an annual yield of 3.9 mgd would be available from Lake Naconiche. Since no flow data is available on Naconiche Creek, this number was determined by estimating the stream flow in Naconiche Creek with flow data on LaNana Creek. It is thought that the reservoir might also benefit from perennial flow from springs in the outcrop area of the Carrizo, but the amount of additional water supplied by these sources is uncertain and may be needed downstream during dry conditions by wildlife, plant life and other uses.

The present value of the cost to construct, operate and maintain the Lake Naconiche system is $14.1 million. A break down of this cost is given in Table 19. A more detailed listing of the cost for this alternative is located in Appendix D. Water plant costs include raw water pumping, water treatment, and raw water cost. Entity costs are those costs incurred for the repair, upgrading, or replacement of entity wells, pumps, and storage for those entities not included in the regional system.

TABLE 18
SUMMARY OF
LOSS OF RECREATIONAL BENEFITS

PROBABILITY	RECREATIONAL BENEFITS	RECREATIONAL LOSSES	PROBABLE COSTS
1	$244,000	$295,876	$2,959
2	$244,000	$155,972	$1,560
3	$244,000	$106,800	$1,068
4	$244,000	$106,800	$1,068
5	$244,000	$106,800	$1,068
6	$244,000	$106,800	$1,068
7	$244,000	$104,749	$1,047
8	$244,000	$93,956	$940
9	$244,000	$73,565	$736
10	$244,000	$56,074	$561
11	$244,000	$41,693	$417
12	$244,000	$27,754	$278
13	$244,000	$12,844	$128
14	$244,000	$0	$0

TOTAL ANNUAL COST	**$12,897**
PRESENT VALUE OF ANNUAL COST	**$393,678**

PRESENT VALUE CALCULATIONS BASED ON 100 YEARS AT 3.125%
AS SPECIFIED IN THE SCS CALCULATIONS OF BENEFITS.

TABLE 19
NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
COST ANALYSIS
LAKE NACONICHE ALTERNATIVE

EVALUATIONS BASED ON

YEARS 30

INTEREST RATE 0.07

ITEM	AVERAGE LIFE YEARS	SALVAGE VALUE AT END	O&M COST ANNUAL	RAW WATER COST ANNUAL	PRESENT VALUE CAPITAL COST	PRESENT VALUE SALVAGE VALUE	PRESENT VALUE O&M COST	PRESENT VALUE RAW WATER COST	PRESENT VALUE TOTAL COST
SUPPLY MAINS	50	1,119,176	27,979		2,797,940	-147,023	347,198		2,998,115
SYSTEM STORAGE	50								
PUMP STATIONS	30								
RAW WATER PUMP STA	40	271,500	65,160		1,086,000	-35,666	808,573		1,858,907
WATER PLANT	40	1,004,250	261,021		4,017,000	-131,925	3,239,025		7,124,100
LAKE COSTS	100		3,937				48,852	393,678	442,530
ENTITY WELLS	50	56,048	16,548		140,120	-7,363	205,340		338,097
ENTITY PUMPS	20	-105,071	11,281		210,142	13,803	139,986		363,931
ENTITY STORAGE	50	375,943	18,797		939,858	-49,387	233,255		1,123,726
TOTAL PRESENT VALUE		2,721,846	404,723		9,191,060	-357,561	5,022,228	393,678	14,249,405

Cost for construction of Lake Naconiche itself is not included in these figures since this cost will be borne by the U.S. Soil Conservation Service. Cost to the SCS includes permitting, design, and construction of the lake. Most of the necessary land has already been purchased by the county. The SCS anticipates average annual benefits from the lake in 1990 dollars to include $234,000 for recreation, $28,800 for damage reduction from reduced flooding, and $18,900 for increased use of the floodplain.

Further study is needed to better quantify reservoir yield and capability, environmental impact and corresponding litigation, total project costs, and the impact of the water supply feature on proposed flood control and recreational benefits. These areas will be addressed during the state and federal permit phases.

E. SUMMARY OF ANALYSIS

Groundwater, given that it is not limited to the Texas Department of Health secondary standard of 500 ppm total dissolved solids, is available for use in meeting the county's needs. Given access to Sam Rayburn or Lake Eastex, those bodies of water could sufficiently supply the county's water needs. Also, construction of Lake Naconiche and use of its storage could effectively meet the water needs of Nacogdoches County over the course of the period studied.

All of the alternatives have challenges to their use, though. For the

Sam Rayburn Reservoir system, rights to the reported additional water would need to be secured. Also, the quality of the water may not be as good as the other sources. For Lake Eastex, questions arise as to whether or not there will be any water commitments available. Since the lake is still in the permitting stage, it is also important to remember that it does not exist as a true resource yet. In order for the groundwater solution to be selected at all, the limit of 500 ppm TDS must be overlooked. If this limit is observed there is not enough groundwater to effectively meet the projected demands. Removal of TDS from water is expensive, so if this limit is ignored and future regulations become stricter than those currently in effect, this could prove an expensive decision for the county. Another problem with the development of the groundwater system is the difficulty in mapping the Wilcox channels to assure the proper location of well fields. This mapping may prove to be expensive as well as increasing the expense of the regional pipe network if the spacing is greater than assumed. Lake Naconiche is faced with a number of issues Among these issues is the fact that it, like Lake Eastex, has not been constructed yet. It also must address a series of environmental concerns which are enumerated in a later section of this report.

A cost comparison of alternatives was also made. Capital and operation and maintenance costs were calculated and then combined for the purpose of comparing the alternatives. Capital costs and construction expenses are based on 1991 costs from other current projects. O&M costs

include $0.07 per kilowatt-hour for electricity and 1.03 mgd average daily usage from the years 2000 to 2020. For each alternative, O&M cost was based on 1991 dollars.

Table 20 summarizes the cost of each alternative in the same table. As it shows, Lake Naconiche is the least expensive of the alternatives followed by groundwater, Lake Eastex, and Sam Rayburn Reservoir. This analysis and comparison finds that the Lake Naconiche alternative is the most technically sound and economically feasible solution for water supply available to Nacogdoches County.

TABLE 20
NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
COST ANALYSIS
SUMMARY OF ALTERNATIVES

ALTERNATIVE	PRESENT VALUE				
	CAPITAL COST	SALVAGE VALUE	O&M COST	RAW WATER COST	TOTAL COST
LAKE NACONICHE	9,191,060	-357,561	5,022,228	393,678	**14,249,405**
SAM RAYBURN RES	16,429,646	-735,373	6,511,120	140,618	**22,346,011**
LAKE EASTEX	12,270,880	-531,820	5,167,797	3,875,269	**20,782,126**
GROUNDWATER	10,369,544	-454,202	4,997,323		**14,912,666**

ALTERNATIVE	ANNUALIZED COSTS				
	CAPITAL COST	SALVAGE VALUE	O&M COST	RAW WATER COST	TOTAL COST
LAKE NACONICHE	740,674	-28,815	404,723	31,725	**1,148,308**
SAM RAYBURN RES	1,324,006	-59,261	524,708	11,332	**1,800,785**
LAKE EASTEX	988,866	-42,857	416,454	312,294	**1,674,757**
GROUNDWATER	835,644	-36,602	402,716		**1,201,758**

SECTION VIII

IMPACT OF WATER CONSERVATION

SECTION VIII

IMPACT OF WATER CONSERVATION

Another means of managing any supply and demand problem is conservation. In this study, water demands in Nacogdoches County were projected assuming water conservation and no water conservation. This allowed for a more thorough analysis of the alternatives.

For the groundwater solution, it was suggested that water be supplied from the Wilcox Group. Two scenarios were discussed, one limiting the supply of water to less than 500 ppm TDS and the other limiting the supply of water to less than 1000 ppm TDS. If the source is not limited to the 500 ppm TDS yield, then the total yield of the aquifer is approximately 8 mgd. The cost of treating the water for TDS makes this alternative unreasonable. On the other hand, as has already been discussed, the limiting of the aquifer to the stricter quality reduces the total yield to about 2.1 mgd.

Comparing the projected daily demands, with and without conservation, to the proposed groundwater source reveals the inadequacy of this alternative. Total projected demand on the Wilcox Group without conservation is 4.9 mgd in the year 2000, 4.5 mgd in 2010, 4.9 mgd in 2020, and 5.9 mgd in 2040. With conservation, these numbers become 3.9 mgd in the year 2000, 3.9 mgd in 2010, 4.2 mgd in 2020, and 4.8 mgd in 2040. If additional wells in the Wilcox are to be held to the 500 ppm TDS level, demands on the water, even with conservation, exceed the 2.1 mgd total yield available from the aquifer.

Of the three surface water solutions, Lake Naconiche is the proposed alternative. It will have a total available yield of 3.9 mgd, as discussed in previous sections. This solution assumes the continued use of current resources at their current levels, including a current demand of 2.7 mgd on the Wilcox Group.

When the projected daily demands, with and without conservation, are compared to

the yield available from Lake Naconiche, it is found that the lake is sufficient to meet the projected demands. Total projected demand on Lake Naconiche without conservation is 1.17 mgd in the year 2000, 1.57 mgd in 2010, 2.08 mgd in 2020, and 3.18 mgd in 2040. The calculated 3.9 mgd yield of the lake is easily capable of supplying these demands even without conservation. If conservation is practiced, though, the projected demands on the lake are .99 mgd for the year 2000, 1.22 mgd for 2010, 1.58 mgd for 2020, and 2.36 mgd for the year 2040. Conservation will either extend the period for which the Lake is adequate for the proposed users or allow additional use for water supply.

Analysis of the treatment and distribution facilities is also affected by the implementation of water conservation. Without conservation, the treatment facilities will be required to meet peak day demands of 1.7 mgd in the year 2000, 2.5 mgd in 2010, 3.6 mgd in 2020, and 6.0 mgd in the year 2040. These are the numbers upon which the proposed treatment facilities are based. If water conservation for Nacogdoches County is implemented these numbers become 1.6 mgd for the year 2000, 2.3 mgd for 2010, 3.1 mgd for 2020, and 5.4 mgd for 2040. Conservation increases the number of years the 3.6 mgd facilities could be used before additional facilities are required or could reduce the size and cost of the facilities.

Legislation or the increased cost of water can encourage water conservation. It is possible that future legislation could require the implementation of a water conservation plan. Increasing water cost will also encourage water conservation. Water Conservation is a good water management tool. A Water Conservation and Drought Contingency Plan accompanies this report. It sets goals for water conservation and specifies ways to implement and encourage water conservation.

SECTION IX

ENVIRONMENTAL ANALYSIS OF PROPOSED FACILITIES

SECTION IX

ENVIRONMENTAL ANALYSIS OF PROPOSED FACILITIES

A. GENERAL:

The proposed facilities include Lake Naconiche, a 3.6 MGD water treatment plant, and about 43 miles of 6, 8, 10, 12, and 16 inch water supply mains. A more detailed description of the project can be found in Section VII of this report.

Lake Naconiche is a 692 acre, 9072 acre-feet impoundment in the northeast Nacogdoches County. The proposed dam is on Naconiche Creek just north of U.S. Highway 59. It is a project currently being developed by the Soil Conservation Service for flood control and recreational purposes.

The following is a brief identification and discussion of potential environmental issues. In 1980, the Soil Conservation Service prepared the "Final Impact Statement Attoyac Bayou Watershed" which contains a more detailed discussion of the impacts of Lake Naconiche. It is the intent of this study to summarize some of the more important impacts identified in this study.

B. SOCIAL AND ECONOMIC ASSESSMENT

The economic impact of this project will be the enabling of future economic growth in Nacogdoches County especially outside the City of Nacogdoches. The current growth industry in the county is poultry. To sustain this industry and allow for growth, a reliable adequate water supply is essential. Chickens will die quickly without water, especially during the heat of the summer. A lack of water can be a

disaster to a small independent grower. To obtain loans for the poultry business, a grower must have a backup source of water. Due to large water demands of poultry houses, many public water supplies cannot provide the houses with this water.

Information provided from the Texas Agricultural Extension Service indicates that water with high levels of total dissolved solids can be detrimental to poultry production. It has also been found that high levels of TDS can present health risks for humans. Construction of a lake could provide higher quality water for consumption than is available from groundwater sources, again benefiting the poultry industry as well as the general population.

The lake is also being designed for flood control to reduce flood damage to agricultural lands in the flood plain down stream of the site. This protection will stimulate the agricultural economy downstream of the site by reducing flood damages by approximately 30%.

The main social impact is allowance for continued growth in the rural areas. Many water supply corporations, are having difficulty, (especially in the northeastern part of the County) providing for the water needs of their customers. Continued growth in the area will place more demands not only on water systems, but also on adequate disposal of waste water and solid waste and upon rural roads. The lake is also being designed by the SCS for recreation. Therefore, additional water related recreational opportunities will be available to the area. This will include fishing, swimming, boating, skiing, scuba diving, and other water related activities.

C. HISTORIC AND ARCHAEOLOGIC ASSESSMENT

A description of the proposed project has been submitted to Texas Historical Commission for their preliminary evaluation of any impact on historical or archaeological sites. Their comments discuss landmarks uneffected by the scope of this project, therefore, are not included, other than as Appendix H.

Dr. James Corbin of the Stephen F. Austin University, has been consulted for any known sites in the immediate lake area. He knew of no confirmed site locations, but indicated that there is a possibility of important Pre-Caddo Indian sites located in the general vicinity of the lake which may contain some important archaeological artifacts.

D. ECOLOGICAL ASSESSMENT

The following ecological impacts were identified in the "Final Environmental Impact Statement" prepared by the Soil Conservation Service in 1980.

1. Adversely affect about 700 acres of existing terrestrial wildlife habitat.
2. Convert approximately 300 acres of wetlands to surface water.
3. Commit the potential lignite deposits under 1100 acres of land to the multipurpose facility.
4 Cover 10 miles of stream.
5. Convert 692 acres of pasture land and woodlands to a lake.
6. Affect other wetlands downstream.

Other potential concerns which have been identified are:

1. Possible existence of the Texas Trillium, a plant on the TOES watch list, in the project area.
2. Possible existence of the Whorled Pogonia Orchid, the Cut-leaved Toothwort, the Green Rein Orchid, the Southern Wayblade Orchids, Bloodroot, the Green Dragon, the Spider Lily and the Blue Iris in the area.

The Soil Conservation Service is currently revising their 1980 Environmental Impact Statement (EIS) with respect to these issues. Changes to the 1980 EIS will address current recreational benefits based upon current demographics and trends as well as an updating of the benefit cost package to present values. Historic issues portion of the study has not been completed at this time. Environmental issues are being researched through a Habitat Evaluation Procedure (HEP) in the areas which would be effected directly by Lake Naconiche as well as downstream of the structure. The HEP makes use of accepted models of ecological systems and direct field research of the impacted areas to identify and address mitigation needs. At this time, the updating of the 1980 EIS is estimated to be about 65% complete. Upon completion, plans for mitigation of any problems will be prepared and presented for review and approval.

SECTION X

IMPLEMENTATION PLAN

SECTION X

IMPLEMENTATION PLAN

A. DESCRIPTION OF THE PROPOSED PLAN

1. GENERAL

The proposed plan is a conjunctive use of groundwater primarily from the Wilcox and Carizzo formation, and surface water from Lake Nacogdoches and Lake Naconiche for the planning period through the year 2020.

It is proposed that the following entities continue to obtain their water from the stated ground water sources.

ENTITY	GROUNDWATER SOURCES
City of Cushing	Carizzo
Etoile WSC	Carizzo/Sparta
City of Garrison	Carizzo/Wilcox
Lilbert-Looneyville WSC	Carizzo
Sacul WSC	Carizzo
Swift WSC	Carizzo/Wilcox
Woden WSC	Carizzo

Along with the above proposal, it is recommended that the following entities continue to obtain water from their existing wells, replacing these wells as necessary to maintain their current production, while forming a regional system to meet needs exceeding current production.

Appleby WSC	Caro WSC
D & M WSC	Libby WSC
Lilly Grove WSC	Melrose WSC
Nacogdoches Municipal Utility District	

Additional water demands and water to replace water currently supplied by

the City of Nacogdoches are proposed to be obtained from Lake Naconiche as soon as the Lake and necessary water production facilities are built. The development of Lake Naconiche and the water treatment plant and supply mains are proposed to be developed as a Regional System. The water supply mains will be built to meet the year 2020 water demands. However, the water treatment plant will be built in two phases to eventually meet the year 2020 water demands. In the interim, those currently receiving water from the City of Nacogdoches will continue to do so.

The prefered solution recommends that water be provided to D & M WSC and the Nacogdoches County MUD #1 indirectly by exchanging water with the City of Nacogdoches. The City of Nacogdoches would provide water to both and the Regional System would provide an equal amount of water to the City of Nacogdoches at its Post Oak tank on the northeast side of the City. This adjustment would save the City the cost of pumping water about 18 miles from Lake Nacogdoches to the Post Oak tank. It would also save the Regional System the cost of a pipeline from the Lilly Grove area to D & M and Nacogdoches MUD #1 and the cost of pumping water about 30 miles from Lake Naconiche.

It is proposed that the City of Nacogdoches will continue to provide its water from the Carizzo Sands and from Lake Nacogdoches. If groundwater levels remain low or resume falling, the City will gradually reduce its groundwater usage and increase its surface water. It is estimated that in about thirty (30) years the City may no longer use groundwater.

2. PHASING OF WATER TREATMENT PLANT

Phase I includes the construction of the Lake, a 2.4 MGD water treatment plant to meet the year 2020 demands and all the supply mains. The water treatment plant will be built with two 1.2 MGD treatment trains so that operation and maintenance cost can be reduced by running only half the plant when possible and to allow for maintenance of a part of the plant while still maintaining some production from the plant. The supply mains consist of about 43 miles of 8, 10, 12, and 16 inch water lines. The system is shown in Figure 12.

Tables 21 and 22 are detailed cost estimates of the water treatment plant, raw water intake, raw water pump station, raw water line, and the supply mains.

The cost of the water treatment plant is for a conventional plant with chemical addition, flocculation, clarification, filtration, disinfection, storage, and high service pumping.

Since Lake Naconiche is being constructed by the Soil Conservation Service, the proposed Regional System will only have to pay for any lost flood control or recreational benefits caused by diverting water from the Lake for water supply needs. The cost of these lost benefits are included as an annual cost in the operation and maintenance cost discussed later in this section.

The total estimate capital cost, in 1991 cost, of Phase I is $7,651,000, as summarized in Tables 21 and 22.

The only improvement remaining in Phase II is the expansion of the water treatment plant from a capacity of 2.4 MGD to 3.6 MGD. Table 23 is a detailed

TABLE 21
NACOGDOCHES COUNTY REGIONAL WATER SUPPLY STUDY
PHASE I COST ESTIMATE
2.4 MGD WATER TREATMENT PLANT

NO.	DESCRIPTION	COST
1	SITE WORK	$140,000.00
2	CLARIFIERS	$260,000.00
3	FILTERS & CONTROL BLDG	$440,000.00
4	CLEAR WELL (0.30 MG)	$210,000.00
5	HIGH SERVICE PUMP STATION & BACKWASH PUMP	$220,000.00
6	MUD WELL & RETURN PUMP STATION	$140,000.00
7	LAB, ADMIN, CHEM BUILDING	$330,000.00
8	DISINFECTION AND CHEMICAL FEED FACILITIES	$220,000.00
10	YARD PIPING	$260,000.00
11	ELECTRICAL & INSTRUMENTATION	$290,000.00
12	TELEMETRY	$100,000.00
13	SLUDGE LAGOONS	$30,000.00
	SUBTOTAL	$2,640,000.00
	INTAKE STRUCTURE (4.0 MGD)	$400,000.00
	RAW WATER PUMP STATION (2.4 MGD)	$170,000.00
	RAW WATER LINE (16" - 4000 LF)	$90,000.00
	ACCESS ROAD (4000 LF)	$80,000.00
	SUBTOTAL	$740,000.00
	TOTAL CONSTRUCTION COST	$3,380,000.00
	CONTINGENCIES	$338,000.00
	ENGINEERING	$237,000.00
	SURVEYING	$20,000.00
	GEOTECHNICAL	$70,000.00
	INSPECTION	$100,000.00
	LAND & ACQUITION (20 ACRE)	$60,000.00
	FISCAL & LEGAL	$132,000.00
	INTEREST DURING CONSRUCTION	$326,000.00
	SUBTOTAL	$1,283,000.00
	TOTAL PROJECT COST	$4,663,000.00

TABLE 22
NACOGDOCHES COUNTY REGIONAL WATER SUPPLY STUDY
WATER SUPPLY MAIN COST ESTIMATE

LAKE NACONICHE ALTERNATIVE
PHASE I

ITEM	QUANTITY	UNIT	UNIT COST	COST
1. 6" PVC PIPE	31600	LF	$3.90	$123,240.00
2. 8" PVC PIPE	65700	LF	$5.80	$381,060.00
3. 10" PVC PIPE	25600	LF	$8.10	$207,360.00
4. 12" PVC PIPE	61700	LF	$10.80	$666,360.00
5. 16" PVC PIPE	43800	LF	$18.50	$810,300.00
6. 20" PVC PIPE	100	LF	$26.60	$2,660.00
7. 14" BORE W/CASING	160	LF	$42.00	$6,720.00
8. 16" BORE W/CASING	60	LF	$64.00	$3,840.00
9. 20" BORE W/CASING	640	LF	$80.00	$51,200.00
10. 30" BORE W/CASING	60	LF	$120.00	$7,200.00
SUBTOTAL CONSTRUCTION COST				**$2,259,940.00**
CONTINGENCY				$226,060.00
ENGINEERING				$154,000.00
SURVEYING				$16,000.00
GEOTECHNICAL				$16,000.00
INSPECTION				$40,000.00
EASEMENTS ACQUSITION				$0.00
LEGAL & FISCAL				$68,000.00
INTEREST DURING CONSTRUCTION				$208,000.00
SUBTOTAL OTHER COST				**$728,060.00**
TOTAL COST THIS PROJECT				**$2,988,000.00**

TABLE 23
NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
COST ESTIMATE
1.2 MGD WATER TREATMENT PLANT
PHASE II

NO.	DESCRIPTION	COST
1	SITE WORK	$60,000.00
2	CLARIFIERS	$170,000.00
3	FILTERS & CONTROL BLDG	$250,000.00
4	CLEAR WELL (0.30 MG)	$120,000.00
5	HIGH SERVICE PUMP STATION & BACKWASH PUMP	$50,000.00
6	MUD WELL & RETURN PUMP STATION	$60,000.00
7	LAB, ADMIN, CHEM BUILDING	$0.00
8	DISINFECTION AND CHEMICAL FEED FACILITIES	$70,000.00
10	YARD PIPING	$50,000.00
11	ELECTRICAL & INSTRUMENTATION	$80,000.00
12	TELEMETRY	$20,000.00
13	SLUDGE LAGOONS	$0.00
	SUBTOTAL	$930,000.00
	INTAKE STRUCTURE (4.0 MGD)	$0.00
	RAW WATER PUMP STATION (2.4 MGD)	$80,000.00
	RAW WATER LINE (16" - 4000 LF)	$0.00
	ACCESS ROAD (4000 LF)	$0.00
	SUBTOTAL	$80,000.00
	TOTAL CONSTRUCTION COST	$1,010,000.00
	CONTINGENCIES	$101,000.00
	ENGINEERING	$76,000.00
	SURVEYING	$5,000.00
	GEOTECHNICAL	$30,000.00
	INSPECTION	$70,000.00
	LAND & ACQUITION (20 ACRE)	$0.00
	FISCAL & LEGAL	$40,000.00
	SUBTOTAL	$322,000.00
	TOTAL PROJECT COST	$1,332,000.00

cost estimate of capital cost of Phase II. Total capital cost is estimated to be $1,332,000.

The expansion of the plant to 3.6 MGD in Phase II would provide the needs of the regional system through the year 2020, the end of this study period. Actual annual demand from the Lake of 1.7 MGD is less than half of the Lake's yield. A preliminary calculation of the Lake yield, based primarily on runoff from rainfall and not including water from springs in the Carizzo, is 3.9 MGD. Therefore, another 2.2 MGD may be available from the Lake. This will be more than adequate to meet the needs of the regional entities through the year 2040.

3. CITY OF NACOGDOCHES

The City of Nacogdoches has adequate water resources to meet its needs for the next 50 years. However, additional water treatment plant capacity is currently needed to provide not only its needs but also the need of the Water Supply Corporations currently receiving water from the City of Nacogdoches until they can develop their own sources of groundwater.

The additional water needs of Nacogdoches were evaluated in a two phase study for the City done by KSA Engineers in 1988 and 1989. This report recommended the phasing out of the City's water wells as they fail, unless production in the Carizzo drops and levels in the wells allow for sufficient pumping capacity. It also recommended that the water treatment plant at Lake Nacogdoches be increased now from 11 MGD to 16.5 MGD and to 22 MGD in the year 2000. Phase I cost to increase the capacity from 11 to 16.5 MGD is $4,754,000. Phase II in the

year 2000 will include the expansion to 22 MGD and also a new 36" transmission main parallelling the existing 30" transmission main from the water treatment plant to the City's southwest pump station. Phase II cost are estimated in 1991 dollars at $9,810,000.

B. FINANCIAL CONSIDERATIONS

Final cost of the project will be dependent on the schedule of the project. Construction costs will be most of the expense. Costs shown in this report are based on 1991 costs. These costs will have to be updated to the year of construction when that year can be better estimated. Design and construction cannot start until state and federal permits are obtained for the project and all legal agreements between involved parties are executed. The time frame for obtaining permits is very difficult to estimate, making starting dates for design and construction difficult to set.

Since there is no ongoing revenue stream, interest during construction will have to be capitalized as a part of one of the bond issues. At least two bond issues are expected. One issue is needed to finance the cost of planning and design and one to finance the cost of construction.

Since the design phase is expected to take about one year, staggering the bond issue for construction can save one year of interest on construction cost. For purpose of this report an average of one year of interest at 7% was capitalized into the project cost. Annual debt service of the bond issue was based upon 7% for 25 years and includes 7% additional annual cost for funding a reserve fund to equal one year of debt service.

C. COST OF WATER

1. GENERAL

This section discusses two categories of cost. The first category of costs includes only the costs of the Regional System. The second category of cost is the cost for all entities to maintain their annual groundwater production facilities, and in the case for those not in the regional system, the cost of adding larger pumps or additional wells to meet future water demands.

2. REGIONAL FACILITY

Those entities to be served by the regional facility are Appleby WSC, Caro WSC, Central Heights WSC, D&M WSC, Libby WSC, Lilly Grove WSC, Melrose WSC, and the Nacogdoches County Municipal Utility District #1. Cost of water to serve these entities is based on the cost of the initial phase of construction, as detailed earlier in Section VIII of this report, and the annual operation and maintenance cost for the water production facilities. As O&M costs will vary with the amount water treated, Table 24 shows costs for a range of production flows varying from 0.6 mgd to 1.8 mgd.

It is estimated that the plant would be operated at 1.0 mgd to 1.4 mgd at a cost ranging from $2.56 to $1.96 per 1000 gallons. In order to assure payment of annual debt service, volumes of water to be purchased by each entity on the regional system would need to be set and charged on a take or pay rate. Actual water use from the regional system would be provided at rates based on the O&M cost. The rates as shown in Table 24, are comparable to those charged by other water

TABLE 24
UNIT COST OF WATER
LAKE NACONICHE ALTERNATIVE

DAILY WATER PRODUCTION	ANNUAL DEBT SERVICE	ANNUAL O&M COST	TOTAL ANNUAL COST	COST PER 1000 GALLONS
600,000	656,536	211,548	868,084	3.96
800,000	656,536	243,104	899,640	3.08
1,000,000	656,536	277,900	934,436	2.56
1,200,000	656,536	309,456	965,992	2.21
1,400,000	656,536	346,412	1,002,948	1.96
1,600,000	656,536	377,968	1,034,504	1.77
1,800,000	656,536	412,764	1,069,300	1.63

purveying entities in this area which have made a conversion to surface water supply sources. The City of Huntsville charges the Texas Department of Corrections and Sam Houston State University $2.70 per 1000 gallons for water from their system. Livingston charges $2.00 per 1000 gallons. Carthage charges $2.30 per 1000 gallons for volumes up to 6,000,000 gallons per month which is close to the projected needs of the individual entity needs to be serviced by the Regional System.

Table 25 is an example of how operation and maintenance costs are derived. For supply mains, it is estimated that one percent of the construction cost for the line work will cover O&M expenses for the piping.

O&M costs for water treatment facilities are also included in Table 25. These costs include labor, power, chemicals, raw water costs, parts, and testing. Power costs are calculated based on $0.07 per KWH and assuming a pump efficency of 80% and a motor efficiency of 90%. In Table 25 the estimate is for a 1.2 MGD treatment plant for Phase II of the proposed Lake Naconiche alternative. Raw water cost for this alternative is based upon the annual lost benefits calculated in Table 18. Chemical cost is estimated from current costs for similar projects. A reserve fund cost is included as cost to insure moneys available for payment on the construction debt.

3. COST OF GROUNDWATER

The proposed alternative is a conjunctive use of ground water and surface water. Cost of surface water from Lake Naconiche was determined in the previous

TABLE 25
NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
OPERATION & MAINTENANCE COSTS
LAKE NACONICHE ALTERNATIVE
0.9 MGD AVERAGE DAILY FLOW

LINE WORK	1% OF CONSTRUCTION COSTS					$22,600
TANKS	2% OF CONSTRUCTION COSTS					$0
PUMP STATIONS	5% OF CONSTRUCTION COSTS PLUS POWER COST					$0
POWER COSTS=(.189*COST/KWH*1000'S GALLONS*HEAD)/(PUMP EFF*MOTOR EFF*60)						
WATER TREATMENT PLANT			NO.	RATE	OVERHEAD	TOTAL
LABOR	SUPERINTENDANT		0.5	24000	0.8	$21,600
	OPERATORS		2.6	18000	0.8	$84,240
	LABORERS		0.9	12000	0.8	$19,440
	TOTAL					$125,280
POWER	(2*RW) + HS PUMP STATION					$35,046
CHEMICALS	LIME	TOTAL CHEMICAL COST = $0.04/1000 GALLONS				
	CHLORINE					
	CL02	TOTAL CHEMICAL COST =				$13,140
	AMMONIA					
RAW WATER COST						$12,897
PARTS	CONSTRUCTION COST					$52,686
TESTING						$7,250
RESERVE FUND						$46,000
					TOTAL WTP COST	$292,299
					TOTAL SYSTEM COST	$314,899

section. The proposed alternative assumes that each existing city and water supply corporation would maintain their existing groundwater production and assumes that those not being served by surface water from Lake Naconiche would have to meet their future needs, which are beyond their current capacities, by increasing pumping capacity in their existing wells or by drilling an additional well where needed. These costs also include the cost for replacement or addition of ground storage facilities. Cost of additional pump station capacity or needed line work within each system is not included.

Wells and ground storage tanks were assumed to have a life of 50 years and the cost to replace wells and ground storage tanks were included if their expected life ended prior to the year 2020. The following is a Table of Capital Cost for needed groundwater facilities for each entity. Appendix E contains a breakdown of these costs for each entity.

TABLE 26

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
SUMMARY OF CAPITAL COST ESTIMATE
GROUND WATER COSTS FOR PROPOSED ALTERNATIVE

ENTITY	TOTAL COST
APPLEBY WSC	$ 0
CARO WSC	$ 280,000
CENTRAL HEIGHTS WSC	$ 0
CITY OF CUSHING	$ 318,000
D & M WSC	$ 188,000
ETOILE WSC	$ 234,000
CITY OF GARRISON	$ 374,000
LIBBY WSC	$ 63,000
LILBERT-LOONEYVILLE WSC	$ 63,000
LILLY GROVE WSC	$ 94,000
MELROSE WSC	$ 189,000
SACUL WSC	$ 175,000
SWIFT WSC	$ 469,000
WODEN WSC	$ 297,000
TOTAL	$ 2,744,000

D. SCHEDULING OF PROJECT

The project from start of design to the completion of construction will take approximately 36 months. The following Table summarizes the estimated schedule.

EVENT	MONTHS FROM START
Regional Organization	0
SCS Contracts	12
State Permit	24
Federal Permit	24
Financing and Design	48
Bidding and Construction	72

Actual date of the authorization to proceed with the design of the project cannot be reasonably, estimated at this time. One complication is that the Lake is a federally funded project and is being planned and constructed by the Soil Conservation Service. A related complication is the process of getting a 404 permit from the Corps of Engineers and permits from the Texas Water Commission for the Lake and for the diversion of water from the Lake for water supply needs. The SCS has already done much work towards obtaining these permits. However, what additional studies, data, and information are needed to meet the requirements of the permitting agencies is not clear at this time and often increases or changes throughout the permitting process. Furthermore, the length of the public hearing process can be relatively short or relatively long depending on the extent of any public opposition and the validity of their concerns.

E. ORGANIZATIONAL OPTIONS

1. General

Several organizational options are available for implementation of this plan. The ones best suited for this plan are a regional water supply district, a regional water supply corporation, the Angelina Neches River Authority, a combination of a regional water supply corporation or district and the Angelina Neches River Authority (ANRA).

2. Regional Water Supply District

A regional water supply district can be formed to construct, own, and

operate the regional facilities. This district would be a political subdivision of the state and created by the State. It can be created by the Texas Water Commission as a Municipal Utility District with the defined powers authorized by law by this process. It can also be created through legislation and be made with the powers that the sponsors select.

Some of the advantages of implementation with this method are:

1. Can be very flexible in its creation if created through legislation
2. Can have the power of eminent domain in order to acquire necessary land.

Some of the disadvantages are:

1. May be viewed negatively as another layer of government especially if given taxing authority.
2. Can be time consuming to create especially if by legislation and the legislators are not due to be in session for several months.

3. **Regional Water Supply Corporation**

The main differences between this corporation and the district previously discussed is that this corporation is not a governmental body. It is a private non-profit corporation. Its advantages are:

1. Its powers are very flexible and can be created with the powers the sponsors want.
2. It can be formed relatively quickly in comparison with the District.
3. Will not be viewed as another layer of government.

Some of the disadvantages are:

1. Has no right of eminent domain to condemn property if essential to the project.

2. Cannot be given taxing authority if desired by the sponsors.

3. Cannot issue tax free bonds.

4. **Angelina Neches River Authority**

The Angelina Neches River Authority is an existing state agency created by the State of Texas to protect and develop water resources in its assigned river basin which includes Nacogdoches County. It is governed by a board of directors appointed by the Governor with membership from the area of its jurisdiction. There are currently three board members from Nacgodoches County, on the Board of Directors. ANRA has the authority to own, construct and operate regional water supply facilities. Revenues are generally raised by sale of water on a take or pay basis. Contractual agreements are needed between

ANRA and the individual entities contractors for the water. These contracts define the rights and powers of each party.

Some of the advantages of this option are:

1. ANRA already exists and was created to provide these types of services if requested by the sponsors. There will be no legal cost or time delays to form a district or corporation.

2. ANRA has expertise in planning, constructing, and managing water

related facilities.

3. ANRA has the authority to finance the project.

The main disadvantage to the use of ANRA is that it may be perceived that the sponsors may have less direct control over the implementation and cost of the project and over the operating of the facilities and the water rates charged. This may be perceived this way since there are no ANRA board members who are elected or appointed by the sponsoring entities. However, other regional projects have created a management committee to represent the participants.

5. **Combined District or Corporation and ANRA**

Another option is to create a District or Corporation to own the facility. The district or corporation could then contract with ANRA for any or all of the following services: finance, construct, manage, and operate the regional facilities. This option may overcome the perceived problem of lack of direct control, but it also creates an additional agency in the process.

6. **Conclusion**

The selection of an organization to implement the project is an important decision which the sponsoring entities will have to make. It is recommended that if they elect to proceed with this project, that they obtain competent, impartial legal counsel to advise them.

APPENDIX A

INDIVIDUAL ENTITY WORKSHEETS

Regional Water Supply Plan
For Nacogdoches County

Appleby Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	2762	1027	178	0.49	1.08	0.89	1.66	0.00	102,677	0
2000	3137	1166	178	0.56	1.23	1.01	1.66	0.00	116,617	0
2010	3622	1346	178	0.64	1.42	1.16	1.66	0.00	134,647	0
2020	4062	1510	178	0.72	1.59	1.30	1.37	0.22	151,004	0
2040	4305	1600	206	0.89	1.95	1.38	1.37	0.58	160,037	0
TWDB High Population Projections										
1990	2762	1027	178	0.49	1.08	0.89	1.66	0.00	102,677	0
2000	3247	1207	213	0.69	1.52	1.04	1.66	0.00	120,706	0
2010	3782	1406	211	0.80	1.76	1.21	1.66	0.10	140,595	0
2020	4336	1612	217	0.94	2.07	1.39	1.37	0.70	161,190	0
2040	5711	2123	217	1.24	2.73	1.83	1.37	1.36	212,305	27,305

Data:

1. 2.69 capita per connection.
2. 2.2 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 100 gallons per connection - TDH ground storage requirement.
5. Projected water supply assumes a useful life of 50 years for existing wells.
6. 185,000 gallons - Existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

Caro Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	1744	648	137	0.24	0.41	0.56	0.47	0.00	129,665	0
2000	1969	732	138	0.27	0.46	0.63	0.47	0.16	146,394	0
2010	2265	842	140	0.32	0.54	0.73	0.47	0.26	168,401	3,401
2020	2534	942	141	0.36	0.61	0.81	0.33	0.49	188,401	23,401
2040	2678	996	172	0.46	0.79	0.86	0.33	0.53	199,108	34,108
TWDB High Population Projections										
1990	1744	648	137	0.24	0.41	0.56	0.47	0.09	129,665	0
2000	2038	758	173	0.35	0.60	0.65	0.47	0.19	151,524	0
2010	2365	879	175	0.41	0.71	0.76	0.47	0.29	175,836	10,836
2020	2705	1006	182	0.49	0.84	0.87	0.33	0.54	201,115	36,115
2040	3552	1320	185	0.66	1.12	1.14	0.33	0.81	264,089	99,089

Data:

1. 2.55 capita per connection.
2. 1.71 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Projected water supply capacity assumes a useful life of 50 years for existing wells.
6. 165,000 gallons - existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

Central Heights Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	884	318	155	0.14	0.30	0.27	0.00	0.30	63,597	0
2000	940	338	152	0.14	0.31	0.29	0.00	0.31	67,626	0
2010	1042	375	148	0.15	0.34	0.32	0.00	0.34	74,964	0
2020	1135	408	145	0.16	0.36	0.35	0.00	0.36	81,655	0
2040	1158	417	155	0.18	0.39	0.36	0.00	0.39	83,309	0
TWDB High Population Projections										
1990	884	318	155	0.14	0.30	0.27	0.00	0.30	63,597	0
2000	973	350	169	0.16	0.36	0.30	0.00	0.36	70,000	0
2010	1088	391	163	0.18	0.39	0.34	0.00	0.39	78,273	0
2020	1212	436	163	0.20	0.43	0.38	0.00	0.43	87,194	0
2040	1536	553	159	0.24	0.54	0.48	0.00	0.54	110,504	0

Data:

1. 2.78 capita per connection.
2. 2.2 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Additional water supply required assumes that the City of Nacogdoches can supply future needs.
6. 120,000 gallons - existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

City of Cushing

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	1257	457	114	0.14	0.19	0.39	0.43	0.00	163,410	0
2000	1245	453	118	0.15	0.20	0.39	0.14	0.25	161,850	0
2010	1313	477	122	0.16	0.21	0.41	0.14	0.27	170,690	0
2020	1377	501	126	0.17	0.23	0.43	0.14	0.29	179,010	0
2040	1330	484	140	0.19	0.25	0.42	0.14	0.27	172,900	0
TWDB High Population Projections										
1990	1257	457	114	0.14	0.19	0.39	0.43	0.00	163,410	0
2000	1289	469	131	0.17	0.23	0.40	0.14	0.26	167,570	0
2010	1371	499	132	0.18	0.24	0.43	0.14	0.29	178,230	0
2020	1470	535	138	0.20	0.27	0.46	0.14	0.32	191,100	0
2040	1765	642	140	0.25	0.33	0.55	0.14	0.41	229,450	0

Data:

1. 2.75 capita per connection.
2. 1.34 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 130 gallons per capita - State Board of Insurance ground storage requirement.
5. Projected water supply capacity assumes a useful life of 50 years for existing wells.
6. 247,000 gallons - existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

D&M Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	2246	817	100	0.22	0.43	0.71	0.34	0.37	163,345	0
2000	2917	1061	99	0.29	0.55	0.92	0.34	0.58	212,145	2,145
2010	3627	1319	99	0.36	0.69	1.14	0.34	0.80	263,782	53,782
2020	4261	1549	98	0.42	0.80	1.34	0.34	1.00	309,891	99,891
2040	4779	1738	114	0.54	1.04	1.50	0.34	1.16	347,564	137,564
TWDB High Population Projections										
1990	2246	817	100	0.22	0.43	0.71	0.34	0.37	163,345	0
2000	3019	1098	119	0.36	0.69	0.95	0.34	0.61	219,564	9,564
2010	3787	1377	118	0.45	0.85	1.19	0.34	0.85	275,418	65,418
2020	4549	1654	121	0.55	1.05	1.43	0.34	1.09	330,836	120,836
2040	6340	2305	121	0.77	1.47	1.99	0.34	1.65	461,091	251,091

Data:

1. 2.75 capita per connection.
2. 1.91 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Additional water supply required assumes that the City of Nacogdoches can supply future needs.
6. 210,000 gallons - existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

Etoile Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	1204	449	60	0.07	0.16	0.39	0.65	0.00	89,851	0
2000	1504	561	55	0.08	0.18	0.48	0.65	0.00	112,239	0
2010	1834	684	51	0.09	0.21	0.59	0.65	0.00	136,866	6,866
2020	2129	794	46	0.10	0.22	0.69	0.58	0.11	158,881	28,881
2040	2355	879	60	0.14	0.31	0.76	0.58	0.18	175,746	45,746
TWDB High Population Projections										
1990	1204	449	60	0.07	0.16	0.39	0.65	0.00	89,851	0
2000	1557	581	76	0.12	0.26	0.50	0.65	0.00	116,194	0
2010	1915	715	73	0.14	0.31	0.62	0.65	0.00	142,910	12,910
2020	2273	848	73	0.17	0.37	0.73	0.58	0.16	169,627	39,627
2040	3124	1166	71	0.22	0.49	1.01	0.58	0.43	233,134	103,134

Data:

1. 2.68 capita per connection.
2. 2.2 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Projected water supply capacity assumes a useful life of 50 years for existing wells.
6. 130,000 gallons - existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

City of Garrison

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	1827	601	181	0.33	0.53	0.52	0.69	0.00	237,510	0
2000	1928	634	182	0.35	0.56	0.55	0.69	0.00	250,640	640
2010	2019	664	184	0.37	0.60	0.57	0.53	0.07	262,470	12,470
2020	2099	690	185	0.39	0.63	0.60	0.25	0.37	272,870	22,870
2040	2313	761	216	0.50	0.80	0.66	0.25	0.55	300,690	50,690
TWDB High Population Projections										
1990	1827	601	181	0.33	0.53	0.52	0.69	0.00	237,510	0
2000	1965	646	216	0.42	0.68	0.56	0.69	0.00	255,450	5,450
2010	2088	687	216	0.45	0.73	0.59	0.53	0.19	271,440	21,440
2020	2197	723	224	0.49	0.79	0.62	0.25	0.54	285,610	35,610
2040	2470	813	227	0.56	0.90	0.70	0.25	0.65	321,100	71,100

Data:

1. 3.04 capita per connection.
2. 1.61 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 130 gallons per capita - State Board of Insurance ground storage requirement.
5. Projected water supply capacity assumes a useful life of 50 years for existing wells.
6. 250,000 gallons - existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

Libby Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	425	153	140	0.06	0.13	0.13	0.13	0.00	30,686	0
2000	462	167	141	0.07	0.14	0.14	0.13	0.01	33,357	0
2010	522	188	143	0.07	0.16	0.16	0.13	0.03	37,690	0
2020	575	208	144	0.08	0.18	0.18	0.13	0.05	41,516	0
2040	598	216	162	0.10	0.21	0.19	0.13	0.08	43,177	0
TWDB High Population Projections										
1990	425	153	140	0.06	0.13	0.13	0.13	0.00	30,686	0
2000	479	173	164	0.08	0.17	0.15	0.13	0.04	34,585	0
2010	545	197	164	0.09	0.20	0.17	0.13	0.07	39,350	0
2020	614	222	168	0.10	0.23	0.19	0.13	0.10	44,332	0
2040	793	286	168	0.13	0.29	0.25	0.13	0.16	57,256	7256.31769

Data:

1. 2.77 capita per connection.
2. 2.2 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Projected water supply assumes a useful life of 50 years for existing wells.
6. 50,000 gallons - existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

Lilbert-Looneyville Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	334	131	70	0.02	0.05	0.11	0.17	0.00	26,299	0
2000	350	138	68	0.02	0.05	0.12	0.17	0.00	27,559	0
2010	386	152	66	0.03	0.06	0.13	0.17	0.00	30,394	0
2020	417	164	64	0.03	0.06	0.14	0.17	0.00	32,835	0
2040	421	166	70	0.03	0.06	0.14	0.17	0.00	33,150	0
TWDB High Population Projections										
1990	334	131	70	0.02	0.05	0.11	0.17	0.00	26,299	0
2000	363	143	78	0.03	0.06	0.12	0.17	0.00	28,583	0
2010	403	159	75	0.03	0.07	0.14	0.17	0.00	31,732	0
2020	445	175	75	0.03	0.07	0.15	0.17	0.00	35,039	0
2040	559	220	73	0.04	0.09	0.19	0.17	0.02	44,016	0

Data:

1. 2.54 capita per connection.
2. 2.2 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Projected water supply capacity assumes a useful life of 50 years for existing wells.
6. 50,000 gallons - existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

Lilly Grove Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	1778	697	142	0.25	0.58	0.60	0.00	0.60	139,451	109,451
2000	2123	833	139	0.30	0.68	0.72	0.00	0.72	166,510	136,510
2010	2529	992	135	0.34	0.79	0.86	0.00	0.86	198,353	168,353
2020	2894	1135	132	0.38	0.88	0.98	0.00	0.98	226,980	196,980
2040	3141	1232	142	0.45	1.03	1.06	0.00	1.06	246,353	216,353
TWDB High Population Projections										
1990	1778	697	142	0.25	0.58	0.60	0.00	0.60	139,451	109,451
2000	2198	862	156	0.34	0.79	0.74	0.00	0.79	172,392	142,392
2010	2641	1036	150	0.40	0.92	0.89	0.00	0.92	207,137	177,137
2020	3090	1212	150	0.46	1.07	1.05	0.00	1.07	242,353	212,353
2040	4167	1634	146	0.61	1.41	1.41	0.00	1.41	326,824	296,824

Data:

1. 2.55 capita per connection.
2. 2.31 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Additional water supply required assumes that the City of Nacogdoches can supply future needs.
6. 30,000 gallons - existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

Melrose Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	2435	905	115	0.28	0.54	0.78	0.96	0.00	181,041	0
2000	2829	1052	114	0.32	0.63	0.91	0.96	0.00	210,335	0
2010	3312	1231	114	0.38	0.73	1.06	0.96	0.11	246,245	0
2020	3747	1393	113	0.42	0.82	1.20	0.71	0.50	278,587	0
2040	4018	1494	129	0.52	1.01	1.29	0.71	0.58	298,736	0
TWDB High Population Projections										
1990	2435	905	115	0.28	0.54	0.78	0.96	0.00	181,041	0
2000	2928	1088	135	0.40	0.77	0.94	0.96	0.00	217,695	0
2010	3458	1286	133	0.46	0.89	1.11	0.96	0.15	257,100	0
2020	4001	1487	136	0.54	1.06	1.29	0.71	0.58	297,472	0
2040	5330	1981	136	0.72	1.41	1.71	0.71	1.01	396,283	26,283

Data:

1. 2.69 capita per connection.
2. 1.94 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Projected water supply assumes a useful life of 50 years for existing wells.
6. 370,000 gallons - existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

City of Nacogdoches

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	30872	9134	235	7.25	13.93	7.89	15.41	0.00	4,013,360	0
2000	36030	10660	234	8.43	15.93	9.21	13.49	2.44	4,683,900	0
2010	40898	12100	234	9.57	17.90	10.45	13.49	4.40	5,316,740	0
2020	46529	13766	233	10.84	19.73	11.89	11.00	8.73	6,048,770	0
2040	48311	14293	271	13.09	23.83	12.35	0.00	23.83	6,280,430	0
TWDB High Population Projections										
1990	30872	9134	235	7.25	13.78	7.89	15.41	0.00	4,013,360	0
2000	37266	11025	279	10.40	19.44	9.53	13.49	5.95	4,844,580	0
2010	42701	12633	278	11.87	21.84	10.92	13.49	8.35	5,551,130	0
2020	48529	14358	284	13.78	24.12	12.41	11.00	13.12	6,308,770	0
2040	63161	18687	286	18.06	31.61	16.15	0.00	31.61	8,210,930	0

Data:

1. 3.38 capita per connection.
2. Maximum day to average day ratio varies from 1.75 to 1.92
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 130 gallons per capita - State Board of Insurance ground storage requirement.
5. Projected water supply capacity assumes 11 m.g.d. for existing water plant plus all wells less than 50 years old.
6. 10,500,000 gallons - existing ground storage capacity.
7. Projected water supply requirement does not include water for wholesale customers.

Regional Water Supply Plan
For Nacogdoches County

Nacogdoches County Municipal Utility District #1

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	187	63	127	0.02	0.05	0.05	0.05	0.00	12,635	n/a
2000	213	72	117	0.02	0.05	0.06	0.06	0.00	14,392	n/a
2010	244	82	107	0.03	0.06	0.07	0.07	0.00	16,486	n/a
2020	274	93	97	0.03	0.06	0.08	0.08	0.00	18,514	n/a
2040	290	98	127	0.04	0.08	0.08	0.08	0.00	19,595	n/a
TWDB High Population Projections										
1990	187	63	127	0.02	0.05	0.05	0.05	0.00	12,635	n/a
2000	220	74	161	0.04	0.08	0.06	0.08	0.00	14,865	n/a
2010	255	86	155	0.04	0.09	0.07	0.09	0.00	17,230	n/a
2020	293	99	155	0.05	0.10	0.09	0.10	0.00	19,797	n/a
2040	385	130	151	0.06	0.13	0.11	0.13	0.00	26,014	n/a

Data:

1. 2.96 capita per connection.
2. 2.2 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Additional water supply required assumes that the City of Nacogdoches can supply future needs.
6. Existing ground storage capacity was not available.

Regional Water Supply Plan
For Nacogdoches County

Sacul Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	353	137	65	0.02	0.05	0.12	0.07	0.05	27,471	n/a
2000	369	144	61	0.02	0.05	0.12	0.07	0.05	28,716	n/a
2010	380	148	56	0.02	0.05	0.13	0.07	0.06	29,572	n/a
2020	388	151	52	0.02	0.04	0.13	0.07	0.06	30,195	n/a
2040	393	153	65	0.03	0.06	0.13	0.07	0.06	30,584	n/a
TWDB High Population Projections										
1990	353	137	65	0.02	0.05	0.12	0.07	0.05	27,471	n/a
2000	393	153	80	0.03	0.07	0.13	0.07	0.06	30,584	n/a
2010	419	163	77	0.03	0.07	0.14	0.07	0.07	32,607	n/a
2020	437	170	77	0.03	0.07	0.15	0.07	0.07	34,008	n/a
2040	474	184	75	0.04	0.08	0.16	0.07	0.09	36,887	n/a

Data:

1. 2.57 capita per connection.
2. 2.21 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Projected water supply capacity assumes a useful life of 50 years for existing wells.
6. Existing ground storage capacity was not available.

Regional Water Supply Plan
For Nacogdoches County

Swift Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	1891	685	134	0.25	0.56	0.59	1.02	0.00	137,029	67,029
2000	2160	783	128	0.28	0.61	0.68	1.02	0.00	156,522	86,522
2010	2505	908	122	0.31	0.67	0.78	1.02	0.00	181,522	111,522
2020	2818	1021	116	0.33	0.72	0.88	0.68	0.21	204,203	134,203
2040	2990	1083	134	0.40	0.88	0.94	0.68	0.26	216,667	146,667
TWDB High Population Projections										
1990	1891	685	134	0.25	0.56	0.59	1.02	0.00	137,029	67,029
2000	2236	810	156	0.35	0.77	0.70	1.02	0.00	162,029	92,029
2010	2615	947	150	0.39	0.86	0.82	1.02	0.00	189,493	119,493
2020	3005	1089	150	0.45	0.99	0.94	0.68	0.31	217,754	147,754
2040	3967	1437	146	0.58	1.27	1.24	0.68	0.60	287,464	217,464

Data:

1. 2.76 capita per connection.
2. 2.2 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Projected water supply capacity assumes a useful life of 50 years for existing wells.
6. 70,000 gallons - existing ground storage capacity.

Regional Water Supply Plan
For Nacogdoches County

Woden Water Supply Corporation

Projected Water Supply and Storage Tank Requirements

Year	Projected Population	Projected Connections	Projected Per Capita Supply Requirement (gpcd)	Projected Avg. Day Water Supply Requirement (m.g.d.)	Projected Max. Day Water Supply Requirement (m.g.d.)	Projected T.D.H. Water Supply Requirement (m.g.d.)	Available Water Supply (m.g.d.)	Additional Water Supply Requirement (m.g.d.)	Projected Ground Storage Requirement (gallons)	Additional Ground Storage Requirement (gallons)
TWDB Low Population Projections										
1990	1616	583	121	0.20	0.43	0.50	0.90	0.00	116,679	0
2000	1878	678	123	0.23	0.51	0.59	0.90	0.00	135,596	0
2010	2197	793	125	0.27	0.60	0.69	0.90	0.00	158,628	0
2020	2485	897	127	0.32	0.69	0.78	0.68	0.10	179,422	0
2040	2666	962	151	0.40	0.89	0.83	0.68	0.21	192,491	12,491
TWDB High Population Projections										
1990	1616	583	121	0.20	0.43	0.50	0.90	0.00	116,679	0
2000	1944	702	150	0.29	0.64	0.61	0.90	0.00	140,361	0
2010	2294	828	150	0.34	0.76	0.72	0.90	0.00	165,632	0
2020	2653	958	156	0.41	0.91	0.83	0.68	0.23	191,552	11,552
2040	3537	1277	160	0.57	1.25	1.10	0.68	0.57	255,379	75,379

Data:

1. 2.77 capita per connection.
2. 2.2 maximum day to average day ratio.
3. 0.6 g.p.m. per connection - TDH water supply requirement.
4. 200 gallons per connection - TDH ground storage requirement.
5. Projected water supply capacity assumes a useful life of 50 years for existing wells.
6. 180,000 gallons - existing ground storage capacity.

APPENDIX B

REQUEST FOR INFORMATION

KSA ENGINEERS, INC.

315 E. FRANK
P.O. BOX 1605
LUFKIN, TEXAS 75901
(409) 637-6061

July 17, 1990

Central Heights Water Supply
Corporation
Rt. 5, Box 1505
Nacogdoches, Texas 75961

Attention: George Grigsby

RE: Nacogdoches County Regional Water Supply Study
Nacogdoches County, Texas

Dear Sir:

KSA Engineers, Inc. has been authorized by the Angelina-Neches River Authority, to research and prepare a Regional Water Supply Study for the County, of which your entity is a part.

In order to prepare a report which would benefit not only your agency, but the County as well, certain information is necessary regarding your present, past, and future water use and your water supply and treatment facilities.

This information is critical for the report to accurately reflect the status of your entity within the scope of the study. Recommendations for future improvements within Nacogdoches County on a regional and local basis cannot be made without your cooperation.

Attached you will find a copy of a form for 1) water use data; 2) water quality data; 3) storage data; and 4) well data. We request that you complete these forms and return them to us in the enclosed envelope.

The water use data should be your well pumpage data as reported on the monthly report sent to the Texas Department of Health. The water sold data should be from your billing records. Well construction data and pumping data at construction should be in a report prepated by the well driller. If any of the information is not available, please leave the space blank.

Also attached Is a form for water quality data. Please provide the most current data you have. Sources of data are as follows:

1) Chemical Analysis by TDH of well water when well was constructed.

2) Recent chemical analysis by TDH. An analysis is normally done once a year.

3) Results of Trihalomethane (THM's) testing done by the TDH

4) Results of volatile organic chemicals (VOC's) testing which may have been done.

If you have any significant water quality problems such as iron or odor, please note at the bottom of the water quality form.

Also please list on a separate sheet of paper any water supply studies for your entity done in the last ten years. Please give the title of the study, the year it was prepared, and who prepared the study. If water use projections were made, please attach a copy of the projects or list the data on the same sheet as the study. If you have extra copies of the study and can release it, please send a copy.

Enclosed you will find a copy of a portion of a USGS Topographic Map of your area. Please mark in red the location of each of your well and storage tanks on these maps, and return to us with the other data requested. Please indicate their respective number.

If you are aware of any major residential, commercial, agricultural, or industrial development which is anticipated in your service area which will have a major impact on your water use, and if you can quantify their water needs in either gallons per day or number of lots, please make a note of this informations on the bottom of the water use form.

Please enclose a copy of the map of your service area which was submitted to the Public Utilities Commission.

Finally, please provide us with a copy of your latest audit or at least the section pertaining to your water system.

Please forward the above requested information before June 29, 1990, to the following address:

KSA ENGINEERS, INC.
P.O. BOX 1605
LUFKIN, TEXAS 75902

Your interest and participation in this project is greatly appreciated. If you have any questions, please do not hesitate to contact me.

Sincerely,

KSA ENGINEERS, INC.

Billy D. Sims

Billy D. Sims, P.E.
Project Manager

Enclosures

WATER USE DATA

_____

(Name of Water Supplier)

MONTH	1988 MONTHLY TOTAL USE	1988 MAXIMUM DAILY USE	1988 NO. OF TAPS	1989 MONTHLY TOTAL USE	1989 MAXIMUM DAILY USE	1989 NO. OF TAPS
JANUARY						
FEBRUARY						
MARCH						
APRIL						
MAY						
JUNE						
JULY						
AUGUST						
SEPTEMBER						
OCTOBER						
NOVEMBER						
DECEMBER						

Major New Developments:

WELL DATA

_____
(Name of Water Supplier)

	WELL NO. 1	WELL NO. 2	WELL NO. 3	WELL NO. 4
CONSTRUCTION				
Year constructed				
Surface Elevation				
Depth to Bottom				
Casing Size				
Screen Size				
Screen Length				
PUMPING DATA				
Pumping Capacity				
Depth to Static Level				
Depth to Pumping Level				
Draw Down				
CURRENT				
Pumping Capacity				
Depth to Static Level				
Depth to Pumping Level				
Draw Down				

STORAGE TANK DATA

	TYPE - (Elevated or Ground)	YEAR INSTALLED	CAPACITY (Gallons)	HEIGHT TO OVERFLOW
Tank No. 1				
Tank No. 2				
Tank No. 3				
Tank No. 4				
Tank No. 5				
Tank No. 6				

WATER QUALITY DATA

_____
(Name of Water Supplier)

PARAMETER	UNITS	DIST. SYSTEM	WELL NO. 1	WELL NO. 2	WELL NO. 3	WELL NO. 4
CALCIUM	mg/l					
CHLORIDE	mg/l					
FLOURIDE	mg/l					
MAGNESIUM	mg/l					
NITRATE (as N)	mg/l					
SODIUM	mg/l					
SULFATE	mg/l					
TOTAL HARDNESS/CaCO3)	mg/l					
PH						
DIL. CONDUCT (umhos/cm)						
TOT. ALKA. as CaCO3	mg/l					
BICARBONATE	mg/l					
CARBONATE	mg/l					
DISSOLVED SOLIDS	mg/l					
P. ALKALINITY / CaCO3	mg/l					
ARSENIC	mg/l					
BARIUM	mg/l					
CADMIUM	mg/l					
CHROMIUM	mg/l					
COPPER	mg/l					
IRON	mg/l					
LEAD	mg/l					
MANGANESE	mg/l					
MERCURY	mg/l					
SELENIUM	mg/l					
SILVER	mg/l					
ZINC	mg/l					

TRIHALOMETHANE

CHLOROFORM	ug/l					
BROMODICHLOROMETHANE	ug/l					
DITROMOCHLOROMETHANE	ug/l					
BROMOFORM	ug/l					
TOTAL	ug/l					

VOLATILE ORGANIC CHEMICALS (VOC'S)

TRICHLOROETHYLENE	ug/l					
CARBON TETRACHLORIDE	ug/l					
VINYL CHLORIDE	ug/l					
1,2-DICHLOROETHANE	ug/l					
BENZENE	ug/l					
para-DICHLOROBENZENE	ug/l					
1,1-DICHLOROETHYLENE	ug/l					
1,1,1-TRICHLOROETHANE	ug/l					

RADIONUCLIDES

GROSS ALPHA	pci/l					
TOTAL RADIUM	pci/l					
GROSS BETA	pci/l					

OTHERS:

_____

_____

_____

_____

WATER QUALITY PROBLEMS:

APPENDIX C

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY AND TEXAS DEPARTMENT OF HEALTH WATER QUALITY STANDARDS

TABLE V-1

PRIMARY DRINKING WATER STANDARDS OF THE TEXAS DEPARTMENT OF HEALTH

CONSTITUENT		LEVEL MILLIGRAMS PER LITER
INORGANICS		
ARSENIC		0.05
BARIUM		1.00
CADMIUM		0.010
CHROMIUM		0.05
LEAD		0.05
MERCURY		0.002
NITRATE (AS N)		10
SELENIUM		0.01
SILVER		0.05
FLUORIDE		4.0
ORGANICS		
CHLORINATED HYDROCARBONS		
ENDRIN		0.0002
LINDANE		0.004
METHOXYCHLOR		0.1
TOXAPHENE		0.005
CHLOROPHENOXYS		
2,4-D		0.1
2,4,5-TP SILVEX		0.01
TURBIDITY		TURBIDITY UNITS
TURBIDITY		1
BIOLOGICAL		# PER 100 ML
COLIFORM BACTERIA		1 AS ARITH. MEAN OF ALL SAMPLES PER MO.
	OR	4 IN MORE THAN ONE SAMPLE WHEN ²20 ARE EXAMINED IN ONE MO.
	OR	4 IN MORE THAN 5% WHEN ³20 ARE EXAMINED IN ONE MONTH
RADIOLOGICAL		
RADIUM-226, RADIUM-228 AND GROSS ALPHA PARTICLE		
COMBINED RADIUM-226 AND RADIUM-228		5 pCI/L
GROSS ALPHA PARTICLE ACTIVITY		15 pCI/L
RADIONUCLIDES		
BETA PARTICLE & PHOTON RADIOACTIVITY		4 MILLIREM/YR. DOSAGE
TRITIUM		20000 pCI/L
STRONTIUM-90		8 pCI/L

TABLE V-2

SECONDARY DRINKING WATER STANDARDS
OF THE
TEXAS DEPARTMENT OF HEALTH

CONSTITUENT	LEVEL
CHLORIDE	300 MG/L
COLOR	15 COLOR UNITS
COPPER	1.0 MG/L
CORROSIVITY	NON-CORROSIVE
FLUORIDE	2.0 MG/L
FOAMING AGENTS	0.5 MG/L
HYDROGEN SULFIDE	0.05 MG/L
IRON	0.3 MG/L
MANGANESE	0.05 MG/L
ODOR	3 THRESHOLD ODOR NO.
pH	$\geq$ 7.0
SULFATE	300 MG/L
TOTAL DISSOLVED SOLIDS	1000 MG/L
ZINC	5.0 MG/L
TOTAL TRIHALOMETHANES	0.1 MG/L

NATIONAL DRINKING WATER STANDARDS
FEBRUARY 1, 1991

PRIMARY STANDARDS

CONTAMINANTS	MCLs mg/l
INORGANICS	
Arsenic	0.05
Asbestos	7 MFL
Barium	1
Cadmium	0.005 — lowered from 01
Chromium	0.1
Fluoride	4.0
Lead	0.05
Mercury	0.002
Nitrate	10
Nitrite	1
Nitrate plus Nitrite	10
Selenium	0.05

MICROBIOLOGICAL

Total Coliform MCL:

Compliance Criteria
a) Where at least 40 samples are collected per month, if no more than 5.0 percent are total coliform-positive.
b) Where less than 40 samples are collected per month, if no more than one sample is total coliform-positive.

Violation Criteria
a) Any fecal coliform-positive or E. coli-positive repeat sample, or any total coliform-positive repeat sample following a fecal coliform-positive or E. coli-positive routine sample, constitutes a violation.

TURBIDITY

Turbidity MCL: 1 Turbidity Unit

Applicable to unfiltered systems until 12/20/91, unless state determines in writing that filtration is required, in which case it is applicable to 6/29/93 or until filtration is installed, whichever is later. Applicable to filtered systems until 6/29/93.

Surface Water Treatment Rule: This rule requires filtration as a treatment technique for systems using a surface water source or a ground water source directly influenced by a surface water source. The rule is effective on the dates listed under Turbidity MCL for unfiltered and filtered systems, respectively, and requires:

99.9 percent (3 log) removal and/or inactivation of Giardia lamblia, and

99.99 percent (4 log) removal and/or inactivation of viruses.

Conventional treatment meeting performance criteria achieves 2.5 log removal of Giardia and 2 log removal of viruses prior to disinfection.

ORGANICS	
Benzene	0.005
Carbon tetrachloride	0.005
Dichlorobenzene ortho-	0.6
Dichlorobenzene para-	0.075
Dichloroethane 1,2-	0.005
Dichloroethylene 1,1-	0.007
Dichloroethylene cis-1,2-	0.07
Dichloroethylene trans-1,2-	0.1

Dichloropropane 1,2-	0.005
Ethylbenzene	0.7
Monochlorobenzene	0.1
Styrene	0.1
Tetrachloroethylene	0.005
Toluene	1
Total Trihalomethane	0.10
Trichloroethane 1,1,1-	0.20
Trichloroethylene	0.005
Vinyl chloride	0.002
Xylenes (Total)	10

PESTICIDES & PCBs

2,4,5-TP	0.05
2,4-D	0.07
Alachlor	0.002
Atrazine	0.003
Carbofuran	0.04
Chlordane	0.002
DBCP	0.0002
EDB	0.00005
Endrin	0.0002
Heptachlor	0.0004
Heptachlor epoxide	0.0002
Lindane	0.0002
Methoxychlor	0.04
PCBs	0.0005
Toxaphene	0.003

RADIOCHEMICAL

Combined Ra-226 and Ra-228	5 picocuries/liter
Gross Alpha Particle Activity (including ra-226, excluding radon & uranium)	15 picocuries/liter
Beta Particle & Photon Radioactivity	Average annual concentration shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem per year.
Tritium	20,000 picocuries/liter
Strontium-90 (bone marrow)	8 picocuries/liter

TREATMENT TECHNIQUE

Acrylamide	TT - 0.05% dosed at 1 mg/l
Epichlorohydrin	TT - 0.01% dosed at 20 mg/l

SECONDARY STANDARDS

Aluminum	0.05 to 0.2
Chloride	250
Color	15 color units
Copper	1.0
Corrosivity	noncorrosive
Fluoride	2.0
Foaming Agents	0.5
Iron	0.3
Manganese	0.05
Odor	3 threshold odor number
pH	6.5 - 8.5
Silver	0.1
Sulfate	250
Total Dissolved Solids (TDS)	500
Zinc	5

APPENDIX D

DETAILED COST INFORMATION

NACOGDOCHES COUNTY REGIONAL WATER SUPPLY STUDY
PRELIMINARY COST ANALYSIS

REGIONAL WELL FIELD ALTERNATIVE

ITEM	QUANTITY	UNIT	UNIT COST	COST
1. 6" PVC PIPE	100	LF	$3.90	$390.00
2. 8" PVC PIPE	18497	LF	$5.80	$107,282.60
3. 10" PVC PIPE	111493	LF	$8.10	$903,093.30
4. 12" PVC PIPE	69613	LF	$10.80	$751,820.40
5. 14" PVC PIPE	150635	LF	$14.80	$2,229,398.00
6. 14" BORE W/CASING	60	LF	$42.00	$2,520.00
7. 16" BORE W/CASING	520	LF	$64.00	$33,280.00
8. 20" BORE W/CASING	260	LF	$80.00	$20,800.00
9. 24" BORE W/CASING	540	LF	$96.00	$51,840.00
12. GROUND STORAGE (0.7 MG)	3		$294,000.00	$882,000.00
13. WELLS	12		$120,000.00	$1,440,000.00
14. TELEMETRY EQUIPMENT				$150,000.00
15. AERATION EQUIPMENT	3		$38,000.00	$114,000.00
16. HIGH SERVICE PUMP STATION	3		$90,000.00	$270,000.00
SUBTOTAL CONSTRUCTION COST				**$6,956,424.30**
CONTINGENCY				$1,043,000.00
ENGINEERING				$417,000.00
SURVEYING				$60,000.00
GEOTECHNICAL				$40,000.00
WILCOX CHANNEL MAPPING				$200,000.00
INSPECTION				$90,000.00
LAND ACQUISITION				$64,000.00
LEGAL & FISCAL				$209,000.00
SUBTOTAL OTHER COST				**$2,123,000.00**
TOTAL COST THIS PROJECT				**$9,079,424.30**

NACOGDOCHES COUNTY REGIONAL WATER SUPPLY STUDY
PRELIMINARY COST ANALYSIS

SAM RAYBURN RESERVIOR ALTERNATIVE

ITEM	QUANTITY	UNIT	UNIT COST	COST
1. 6" PVC PIPE	648	LF	$3.90	$2,527.20
2. 6" SDR-21 PVC PIPE	31152	LF	$4.30	$133,953.60
3. 8" PVC PIPE	3300	LF	$5.80	$19,140.00
4. 10" PVC PIPE	200	LF	$8.10	$1,620.00
5. 12" PVC PIPE	54000	LF	$10.80	$583,200.00
6. 14" PVC PIPE	35400	LF	$14.90	$527,460.00
7. 18" PVC PIPE	25796	LF	$22.30	$575,250.80
8. 18" SDR-21 PVC PIPE	62304	LF	$26.00	$1,619,904.00
9. 20" PVC PIPE	94084	LF	$26.60	$2,502,634.40
10. 20" SDR-21 PVC PIPE	44880	LF	$31.00	$1,391,280.00
11. 20" BORE W/CASING	380	LF	$80.00	$30,400.00
12. 24" BORE W/CASING	320	LF	$96.00	$30,720.00
13. 30" BORE W/CASING	420	LF	$120.00	$50,400.00
14. GROUND STORAGE TANK (2.0 MG) & PUMP STATION (2600GPM)				$900,000.00
SUBTOTAL CONSTRUCTION COST				**$8,368,490.00**
CONTINGENCY				$837,000.00
ENGINEERING				$460,000.00
SURVEYING				$30,000.00
GEOTECHNICAL				$20,000.00
INSPECTION				$70,000.00
LAND ACQUISITION				$5,000.00
LEGAL & FISCAL				$251,000.00
SUBTOTAL OTHER COST				**$1,673,000.00**
TOTAL COST THIS PROJECT				**$10,041,490.00**

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
OPERATION & MAINTENANACE COSTS
SAM RAYBURN RESERVIOR ALTERNATIVE

LINE WORK	1% OF CONSTRUCTION COSTS				
TANKS	2% OF CONSTRUCTION COSTS				$30,537
PUMP STATIONS	5% OF CONSTRUCTION COSTS PLUS POWER COST				
POWER COSTS = (.189*COST/KWH*1000'S GALLONS*HEAD)/(PUMP EFF*MOTOR EFF*60)				0.8	0.9
WATER TREATMENT PLANT		NO.	RATE	OH	TOTAL
LABOR	SUPERINTENDANT	0.5	30000	0.3	19500
	OPERATORS	4	20000	0.3	104000
	LABORS	2	12000	0.3	31200
	TOTAL				$154,700
POWER	(2*RW) + HS PUMP STATION				$60,824
CHEMICALS	LIME	TOTAL CHEMICAL COST = $0.004/1000 GALLONS			
	CHLORINE				
	CL02	TOTAL CHEMICAL COST =			$12,209
	AMMONIA				
PARTS	2% CONSTRUCTION COST				$109,926
TESTING					$10,000
			TOTAL WTP COST		$347,659

NACOGDOCHES COUNTY REGIONAL WATER SUPPLY STUDY
PRELIMINARY COST ANALYSIS

LAKE EASTEX ALTERNATIVE

ITEM	QUANTITY	UNIT	UNIT COST	COST
1. 6" PVC PIPE	31652	LF	$3.90	$123,442.80
2. 8" PVC PIPE	3368	LF	$5.80	$19,534.40
3. 10" PVC PIPE	62304	LF	$8.10	$504,662.40
4. 12" PVC PIPE	84316	LF	$10.80	$910,612.80
5. 14" PVC PIPE	24288	LF	$14.80	$359,462.40
6. 16" PVC PIPE	45936	LF	$18.50	$849,816.00
7. 18" PVC PIPE	57552	LF	$22.30	$1,283,409.60
8. 20" PVC PIPE	32572	LF	$26.60	$866,415.20
9. 16" BORE W/CASING	160	LF	$42.00	$6,720.00
10. 20" BORE W/CASING	120	LF	$64.00	$7,680.00
11. 24" BORE W/CASING	520	LF	$80.00	$41,600.00
12. 30" BORE W/CASING	380	LF	$120.00	$45,600.00
SUBTOTAL CONSTRUCTION COST				**$5,018,955.60**
CONTINGENCY				$502,000.00
ENGINEERING				$291,000.00
SURVEYING				$40,000.00
GEOTECHNICAL				$30,000.00
INSPECTION				$90,000.00
EASEMENTS ACQUSITION				-
LEGAL & FISCAL				$151,000.00
SUBTOTAL OTHER COST				**$1,104,000.00**
TOTAL COST THIS PROJECT				**$6,122,955.60**

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
OPERATION & MAINTENANACE COSTS
LAKE EASTEX ALTERNATIVE

LINE WORK 1% OF CONSTRUCTION COSTS

TANKS 2% OF CONSTRUCTION COSTS

PUMP STATIONS 5% OF CONSTRUCTION COSTS PLUS POWER COST

POWER COSTS = (.189*COST/KWH*1000'S GALLONS*HEAD)/(PUMP EFF*MOTOR EFF*60)

				0.8	0.9	
WATER TREATMENT PLANT			NO.	RATE	OH	TOTAL
LABOR	SUPERINTENDANT		0.5	30000	0.3	19500
	OPERATORS		4	20000	0.3	104000
	LABORS		2	12000	0.3	31200
	TOTAL					$154,700
POWER	(2*RW) + HS PUMP STATION					$79,324
CHEMICALS	LIME	TOTAL CHEMICAL COST = $0.04/1000 GALLONS				
	CHLORINE					
	CL02	TOTAL CHEMICAL COST =				$15,968
	AMMONIA					
PARTS	2% CONSTRUCTION COST					$109,926
TESTING						$10,000
				TOTAL WTP COST		$369,917

NACOGDOCHES COUNTY REGIONAL WATER SUPPLY STUDY
PRELIMINARY COST ANALYSIS

LAKE NACONICHE ALTERNATIVE

ITEM	QUANTITY	UNIT	UNIT COST	COST
1. 6" PVC PIPE	31600	LF	$3.90	$123,240.00
2. 8" PVC PIPE	65700	LF	$5.80	$381,060.00
3. 10" PVC PIPE	25600	LF	$8.10	$207,360.00
4. 12" PVC PIPE	61700	LF	$10.80	$666,360.00
5. 16" PVC PIPE	43800	LF	$18.50	$810,300.00
6. 20" PVC PIPE	100	LF	$26.60	$2,660.00
7. 14" BORE W/CASING	160	LF	$42.00	$6,720.00
8. 16" BORE W/CASING	60	LF	$64.00	$3,840.00
9. 20" BORE W/CASING	640	LF	$80.00	$51,200.00
10. 30" BORE W/CASING	60	LF	$120.00	$7,200.00
SUBTOTAL CONSTRUCTION COST				**$2,259,940.00**
CONTINGENCY				$226,000.00
ENGINEERING				$154,000.00
SURVEYING				$20,000.00
GEOTECHNICAL				$20,000.00
INSPECTION				$50,000.00
EASEMENTS ACQUSITION				-
LEGAL & FISCAL				$68,000.00
SUBTOTAL OTHER COST				**$538,000.00**
TOTAL COST THIS PROJECT				**$2,797,940.00**

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
OPERATION & MAINTENANACE COSTS
LAKE NACONICHE ALTERNATIVE

LINE WORK 1% OF CONSTRUCTION COSTS

TANKS 2% OF CONSTRUCTION COSTS

PUMP STATIONS 5% OF CONSTRUCTION COSTS PLUS POWER COST

POWER COSTS = (.189*COST/KWH*1000'S GALLONS*HEAD)/(PUMP EFF*MOTOR EFF*60)

				0.8	0.9
WATER TREATMENT PLANT		NO.	RATE	OH	TOTAL
LABOR	SUPERINTENDANT	0.5	30000	0.3	$19,500
	OPERATORS	4	20000	0.3	$104,000
	LABORERS	2	12000	0.3	$31,200
	TOTAL				$154,700
POWER	(2*RW) + HS PUMP STATION				$40,839
CHEMICALS	LIME	TOTAL CHEMICAL COST = $0.04/1000 GALLONS			
	CHLORINE				
	CL02	TOTAL CHEMICAL COST =			$15,312
	AMMONIA				
PARTS	2% CONSTRUCTION COST				$40,170
TESTING					$10,000
			TOTAL WTP COST		$261,021

APPENDIX E

ENTITY COSTS TO MAINTAIN CURRENT PRODUCTION LEVELS

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
CAPITAL COST ESTIMATE
GROUND WATER COSTS FOR PROPOSED ALTERNATIVE

NO.	DESCRIPTION	UNIT	QUANT.	UNIT COST	COST
	APPLEBY WSC				
1	WATER WELL 10X6X700 300 GPM	EA	0	$100,000.00	$0.00
2	GROUND STORAGE TANK - 200,000 GAL	EA	0	$148,000.00	$0.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP & MOTOR	EA	0	$15,000.00	$0.00
5					
	SUBTOTAL				$0.00
	CONTINGENCY,ENGINEERING,ETC.				$0.00
	TOTAL PROJECT COST				$0.00
	CARO WSC				
1	WATER WELL 10X6X570 220 GPM	EA	1	$90,000.00	$90,000.00
2	GROUND STORAGE TANK - 150,000 GAL	EA	1	$110,000.00	$110,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					
	SUBTOTAL				$200,000.00
	CONTINGENCY,ENGINEERING,ETC.				$80,000.00
	TOTAL PROJECT COST				$280,000.00
	CENTRAL HEIGHTS WSC				
1	WATER WELL 10X6X700 160 GPM	EA	0	$100,000.00	$0.00
2	GROUND STORAGE TANK - 100,000 GAL	EA	0	$67,000.00	$0.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					
	SUBTOTAL				$0.00
	CONTINGENCY,ENGINEERING,ETC.				$0.00
	TOTAL PROJECT COST				$0.00

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
CAPITAL COST ESTIMATE
GROUND WATER COSTS FOR PROPOSED ALTERNATIVE

NO.	DESCRIPTION	UNIT	QUANT.	UNIT COST	COST
	CITY OF CUSHING				
1	WATER WELL 10X6X500 100 GPM	EA	2	$80,000.00	$160,000.00
2	GROUND STORAGE TANK - 100,000 GAL	EA	1	$67,000.00	$67,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					
	SUBTOTAL				$227,000.00
	CONTINGENCY,ENGINEERING,ETC.				$91,000.00
	TOTAL PROJECT COST				$318,000.00
	D&M WSC				
1	WATER WELL 12X8X1000 400 GPM	EA	0	$140,000.00	$0.00
2	GROUND STORAGE TANK - 100,000 GAL	EA	2	$67,000.00	$134,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					
	SUBTOTAL				$134,000.00
	CONTINGENCY,ENGINEERING,ETC.				$54,000.00
	TOTAL PROJECT COST				$188,000.00
	ETOILE WSC				
1	WATER WELL 10X6X700 200 GPM	EA	1	$100,000.00	$100,000.00
2	GROUND STORAGE TANK - 100,000 GAL	EA	1	$67,000.00	$67,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					
	SUBTOTAL				$167,000.00
	CONTINGENCY,ENGINEERING,ETC.				$67,000.00
	TOTAL PROJECT COST				$234,000.00

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
CAPITAL COST ESTIMATE
GROUND WATER COSTS FOR PROPOSED ALTERNATIVE

NO.	DESCRIPTION	UNIT	QUANT.	UNIT COST	COST
	CITY OF GARRISON				
1	WATER WELL 10X6X360 200 GPM	EA	2	$100,000.00	$200,000.00
2	GROUND STORAGE TANK - 100,000 GAL	EA	1	$67,000.00	$67,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					$0.00
					$0.00
	SUBTOTAL				$267,000.00
	CONTINGENCY,ENGINEERING,ETC.				$107,000.00
	TOTAL PROJECT COST				$374,000.00
	LIBBY WSC				
1	WATER WELL 10X6X360 200 GPM	EA	0	$100,000.00	$0.00
2	GROUND STORAGE TANK - 50,000 GAL	EA	1	$45,000.00	$45,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					$0.00
					$0.00
	SUBTOTAL				$45,000.00
	CONTINGENCY,ENGINEERING,ETC.				$18,000.00
	TOTAL PROJECT COST				$63,000.00
	LILBERT-LOONEYVILLE WSC				
1	WATER WELL 10X6X360 200 GPM	EA	0	$100,000.00	$0.00
2	GROUND STORAGE TANK - 50,000 GAL	EA	1	$45,000.00	$45,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					$0.00
					$0.00
	SUBTOTAL				$45,000.00
	CONTINGENCY,ENGINEERING,ETC.				$18,000.00
	TOTAL PROJECT COST				$63,000.00

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
CAPITAL COST ESTIMATE
GROUND WATER COSTS FOR PROPOSED ALTERNATIVE

NO.	DESCRIPTION	UNIT	QUANT.	UNIT COST	COST
	LILLY GROVE WSC				
1	WATER WELL 10X6X360 200 GPM	EA	0	$100,000.00	$0.00
2	GROUND STORAGE TANK - 100,000 GAL	EA	1	$67,000.00	$67,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					$0.00
					$0.00
	SUBTOTAL				$67,000.00
	CONTINGENCY,ENGINEERING,ETC.				$27,000.00
	TOTAL PROJECT COST				$94,000.00
	MELROSE WSC				
1	WATER WELL 10X6X360 200 GPM	EA	0	$100,000.00	$0.00
2	GROUND STORAGE TANK - 50,000 GAL	EA	3	$45,000.00	$135,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					$0.00
					$0.00
	SUBTOTAL				$135,000.00
	CONTINGENCY,ENGINEERING,ETC.				$54,000.00
	TOTAL PROJECT COST				$189,000.00
	SACUL WSC				
1	WATER WELL 8X4X360 100 GPM	EA	1	$80,000.00	$80,000.00
2	GROUND STORAGE TANK - 50,000 GAL	EA	1	$45,000.00	$45,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					$0.00
					$0.00
	SUBTOTAL				$125,000.00
	CONTINGENCY,ENGINEERING,ETC.				$50,000.00
	TOTAL PROJECT COST				$175,000.00

NACOGDOCHES COUNTY
REGIONAL WATER SUPPLY STUDY
CAPITAL COST ESTIMATE
GROUND WATER COSTS FOR PROPOSED ALTERNATIVE

NO.	DESCRIPTION	UNIT	QUANT.	UNIT COST	COST
	SWIFT WSC				
1	WATER WELL 10X6X360 200 GPM	EA	2	$100,000.00	$200,000.00
2	GROUND STORAGE TANK - 50,000 GAL	EA	3	$45,000.00	$135,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					$0.00
					$0.00
	SUBTOTAL				$335,000.00
	CONTINGENCY,ENGINEERING,ETC.				$134,000.00
	TOTAL PROJECT COST				$469,000.00
	WODEN WSC				
1	WATER WELL 10X6X360 200 GPM	EA	1	$100,000.00	$100,000.00
2	GROUND STORAGE TANK - 100,000 GAL	EA	1	$67,000.00	$67,000.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	3	$15,000.00	$45,000.00
5					$0.00
					$0.00
	SUBTOTAL				$212,000.00
	CONTINGENCY,ENGINEERING,ETC.				$85,000.00
	TOTAL PROJECT COST				$297,000.00
1	WATER WELL 10X6X360 200 GPM	EA	0	$100,000.00	$0.00
2	GROUND STORAGE TANK - 100,000 GAL	EA	0	$40,000.00	$0.00
3	WATER LINE 6"	LF	0	$8.00	$0.00
4	REPLACE PUMP AND MOTOR	EA	0	$15,000.00	$0.00
5					$0.00
					$0.00
	SUBTOTAL				$0.00
	CONTINGENCY,ENGINEERING,ETC.				$0.00
	TOTAL PROJECT COST				$0.00

APPENDIX F

NACONICHE YIELD WORKSHEETS

APPENDIX F

NACONICHE YIELD WORKSHEETS

The yield of Lake Naconiche has been presented in this report as being approximately 3.9 mgd. Yield can be defined as the available water from a lake beyond that of evaporation which would use all the water in the lake assuming 100 year drought conditions. A 100 year drought is an annual drought predicted to have a 1% probability of occurring.

Yield calculations are typically based upon available flow data for the stream on which the reservoir is to be built or data from a stream of similar nature to that on which the reservoir is to be built. In this instance, the data used to determine the yield of Lake Naconiche was taken from Lananna Creek. Lananna Creek and Naconiche Creek have watersheds which are in close proximity and have similar characteristics such as size and ground cover. On the yield calculation sheet included in this appendix the similarity in watershed size can be seen. To correct the minor difference, the flow in Lananna Creek was reduced by ratio of the areas of their water sheds.

Once the flow data was determined, it was subjected to a statistical analysis to find drought conditions which fit the one percent (100 year drought) scenario. On a standard normal curve, one percent is equal to 2.33 standard deviations. Using this information, the 100 year drought flows could be calculated for periods ranging from one year to seven years. The one year and two year periods produced the most severe loss of flow into the reservoir, as can be seen by the table, "Naconiche Creek Flow Data", included in this appendix. These numbers were subsequently entered into the yield calculation worksheet to provide flow data

for the worst case scenario.

In the worst case, the yield of Lake Naconiche is limited to approximately 4400 Acre-feet of water or 3.9 million gallons per day. This leaves a storage of 14 Acre-feet in the reservoir at a surface elevation of 315 feet MSL. The next lowest storage level, though, is 4540 Acre-feet at 341 feet MSL. None of this flow data includes the reported but unmeasured perennial spring flows in Naconiche Creek. Only flow dependent upon rainfall was considered in this calculation.

As the project enters permitting phases, the yield will need to be calculated for a wider number of scenarios, but for planning purposes, this calculation is sufficient.

YIELD CALCULATION

NACONICHE RESERVOIR

DRAINAGE AREA 17500 ACRE - 27.3 SQ. MILES

MAXIMUM STORAGE 9072 ACRE FEET INCLUDING 364 ACRE FEET OF SEDIMENTAL STORAGE

BASED ON ANNUAL RECORDS

TRIAL STUDY FOR BENEFICIAL USE OF 3.9 MGD (4400 ACRE FEET PER YEAR)

PERIOD YEAR	LANANA 31.3 SQ. MI	NACONICHE 17500 ACRE 27.3 SQ.MI	RESERVOIR AREA END OF PERIOD	RESERVOIR AREA AVERAGE AREA	EVAP. DEPTH (NET)	EVAP. AMOUNT	WATER USE 4400	TOTAL DEMAND	STORAGE INCREASE	STORAGE LOSS	IMPOUNDED WATER	SEDIMENT	STORAGE TOTAL	SPILL	SURFACE ELEV
	AC. FT	AC. FT	AC.	AC.	FT.	AC. FT.	AC. FT.	AC. FT.	AC. FT.	AC. FT.	AC. FT.	AC. FT.	AC. FT.	AC. FT.	FT.
1965	14257	12435	692	692	1.68	1162.56	4400	5562.56	6872.44	0	8708	364	9072	6872.44	348
1966	20963	18284	692	692	1.52	1051.84	4400	5451.84	12832.16	0	8708	364	9072	12832.16	348
1967	3613	3151	692	692	0.35	242.2	4400	4642.2	0	-1491.2	7217	364	9072	0	348
1968	39581	34523	692	692	3.06	2117.52	4400	6517.52	28005.48	0	8708	364	9072	28005.48	348
1969	32922	28715	692	692	1.20	830.4	4400	5230.4	23484.6	0	8708	364	9072	23484.6	348
1970	6244	0	511	601.5	0.22	132.33	4400	4532.33	0	-4532.33	4176	364	4540	0	341
1971	2639	0	12	261.5	0.48	125.52	4400	4525.52	0	-4525.52	-350	364	14	0	315
1972	16410	14313	692	352	1.33	468.16	4400	4868.16	9444.84	0	8708	364	9072	9444.84	348
1973	44679	38969	692	692	2.31	1598.52	4400	5998.52	32970.48	0	8708	364	9072	32970.48	348
1974	24858	21681	692	692	1.28	885.76	4400	5285.76	16395.24	0	8708	364	9072	16395.24	348
1975	30953	26997	692	692	1.79	1238.68	4400	5638.68	21358.32	0	8708	364	9072	21358.32	348
1976	12541	10938	692	692	0.18	124.56	4400	4524.56	6413.44	0	8708	364	9072	6413.44	348
1977	11405	9947	692	692	-0.71	-491.32	4400	3908.68	6038.32	0	8708	364	9072	6038.32	348
1978	10965	9564	692	692	-0.36	-249.12	4400	4150.88	5413.12	0	8708	364	9072	5413.12	348
1979	70459	61455	692	692	3.41	2359.72	4400	6759.72	54695.28	0	8708	364	9072	54695.28	348
1980	18804	16401	692	692	-0.69	-477.48	4400	3922.52	12478.48	0	8708	364	9072	12478.48	348
1981	10493	9152	692	692	0.48	332.16	4400	4732.16	4419.84	0	8708	364	9072	4419.84	348
1982	33775	29459	692	692	1.77	1224.84	4400	5624.84	23834.16	0	8708	364	9072	23834.16	348
1983	29087	25370	692	692	0.53	366.76	4400	4766.76	20603.24	0	8708	364	9072	20603.24	348
1984	24272	21170	692	692	-0.07	-48.44	4400	4351.56	16818.44	0	8708	364	9072	16818.44	348
1985	31041	27074	692	692	1.02	705.84	4400	5105.84	21968.16	0	8708	364	9072	21968.16	348
1986	31910	27832	692	692	1.45	1003.4	4400	5403.4	22428.6	0	8708	364	9072	22428.6	348
1987	13829	12062	692	692	-0.31	-214.52	4400	4185.48	7876.52	0	8708	364	9072	7876.52	348
1988	1951	0	567	629.5	-1.43	-900.185	4400	3499.815	0	-3499.815	5208	364	5572	0	343
1989	27921	24353	692	629.5	0.85	535.075	4400	4935.075	19417.925	0	8708	364	9072	19417.925	348
1990	23840	20793	692	692	0.57	394.44	4400	4794.44	15998.56	0	8708	364	9072	15998.56	348

Naconiche Creek
Flow Data

YEAR	ONE YR	TWO YR	THREE YR	FOUR YR	FIVE YR	SIX YR	SEVEN YR
1965	12435						
1966	18284	15360					
1967	3151	10718	11290				
1968	34523	18837	18653	17098			
1969	28715	31619	22130	21168	19422		
1970	5446	17081	22895	17959	18024	17092	
1971	2302	**3874**	12154	17747	**14827**	15404	**14979**
1972	14313	8308	**7354**	**12694**	17060	**14742**	15248
1973	38969	26641	18528	15258	17949	20711	18203
1974	21681	30325	24988	19316	16542	18571	20850
1975	26997	24339	29216	25490	20852	18285	19775
1976	10938	18968	19872	24646	22580	19200	17235
1977	9947	10443	15961	17391	21706	20474	17878
1978	9564	9756	10150	14362	15825	19683	18916
1979	61455	35510	26989	22976	23780	23430	25650
1980	16401	38928	29140	24342	21661	22550	22426
1981	9152	12777	29003	24143	21304	19576	20636
1982	29459	19306	18337	29117	25206	22663	20988
1983	25370	27415	21327	20096	28367	25234	23050
1984	21170	23270	25333	21288	20310	27168	24653
1985	27074	24122	24538	25768	22445	21438	27154
1986	27832	27453	25359	25362	26181	23343	22351
1987	12062	19947	22323	22035	22702	23828	21731
1988	**1702**	6882	13865	17168	17968	19202	20667
1989	24353	13028	12706	16487	18605	19032	19938
1990	20793	22573	15616	14728	17348	18969	19284
AVG	19773	19899	19905	20289	20485	20505	20581
MAX	61455	38928	29216	29117	28367	27168	27154
MIN	1702	3874	7354	12694	14827	14742	14979
STD	13249	9204	6421	4409	3511	3108	3155
NO. OF STD							
2.33	-11097	-1546	4944	10016	12304	13263	13230
2	-6725	1491	7063	11471	13463	14289	14271
1.88	-5135	2595	7834	12000	13884	14662	14650
1.75	-3413	3792	8668	12573	14341	15066	15060
1.64	-1955	4804	9375	13058	14727	15408	15407
1.55	-763	5633	9952	13455	15043	15688	15691
1.48	164	6277	10402	13764	15289	15905	15912
1.41	1092	6921	10851	14072	15534	16123	16132
1.34	2019	7566	11301	14381	15780	16340	16353
1.28	2814	8118	11686	14645	15991	16527	16543
1.23	3477						
1.18	4139						
1.13	4802						
1.08	5464						
1.04	5994						
0.99	6656						
0.95	7186						
0.92	7584						
0.88	8114						
0.84	8644						

NOTE: NEGATIVE VALUES WOULD GIVE A 0 AC-FT FLOW

APPENDIX G

DISCUSSION OF DRAFT AND FINAL WATER USE PROJECTIONS

APPENDIX G

DISCUSSION OF DRAFT AND FINAL WATER USE PROJECTIONS

In the Nacogdoches Regional Water Supply Study (Draft Report), the water use projections presented were those calculated by KSA Engineers, using historic water use data and Texas Water Development Board population projections. In review, the similarities between KSA's numbers and those of the TWDB made it reasonable to present the TWDB's numbers in the final draft of the study. Following is an explanation of how the original numbers were derived and why the TWDB's numbers are suitable for use in this final revision.

The underlying methodology for projecting per capita water use in the Nacogdoches County Regional Water Supply Study was a statistical approach. Historic per capita water use data from each participating entity was submitted to a series of regression analyses. This historic per capita water use data included all uses -- residential, commercial, industrial, and agricultural. From the regression analyses, equations were determined for the projection of the per capita use for each entity.

Regression analysis of the historic water use data for each entity proceeded through a series of linear approximations. Each entity's historic data was approximated by an exponential curve, a straight line, and a natural logarithmic function. In almost every case, the exponential curve and the straight line provided better fits to the historic data than did the logarithmic curve. The projections provided by the exponential curve and the straight line, therefore, gave higher projected per capita water use. If either of these curves had been used, all of the

projections would have been higher. Using the logarithmic function, it was possible to provide a realistic projection of water use and still have a statistically acceptable fit to the historic data.

To arrive at our final projections, the per capita projections for each entity were adjusted to reflect the most current historic data and then used in statistical calculations to provide low and high series. The high and low series were assumed to have a 2% probability of occurring in any given year. Since the water use projections rely both on projected population and projected per capita use, this 2% probability was the product of two variables, each with a 14.14% probability of occurring. For a standard normal curve, this is equivalent to 1.08 standard errors. Application of this standard error to the projected demand for any given year can provide the low and the high projections for that point in time. If applied along the whole curve, one can present a range into which water use can be expected to fall.

For a number of reasons, the high and low series were not presented as a simple outer range paralleling the moderate projections for each entity. Water use data for 1990 was known, making high and low use projections irrelevant for that year. If 1990 was used as a starting point for the high and low series projections, and the year 2000 was then determined through simple application of the standard error, the report would seem to present a dramatic rise in the high and low projections over the first ten years, with an inconsistent rate of change in the following years. Since we were contracted to study the thirty year period from the years 1990 to 2020, it was decided to make the year 2020 a projection point. Once the high and low series

KSA PROJECTIONS
NACOGDOCHES COUNTY
WATER USE PROJECTIONS
HIGH PROJECTIONS W/O CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED GALLONS PER DAY PER CAPITA																			
1990	178	137	155	114	100	60	181	140	70	142	115	235	127	65	134	121	108		
2000	208	169	165	128	116	74	211	160	76	152	132	272	157	78	152	146	125		
2010	214	177	165	134	119	74	219	166	76	152	135	281	157	78	152	152	128		
2020	219	184	165	139	122	74	226	170	76	152	137	287	157	78	152	158	130		
2040	226	193	165	146	126	74	236	175	76	152	141	298	157	78	152	166	133		

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED POPULATION																			
1990	2762	1744	884	1257	2246	1204	1827	425	334	1778	2435	30872	187	353	1891	1616	2938		54753
2000	3247	2038	973	1289	3019	1557	1965	479	363	2198	2928	37266	220	393	2236	1944	2161		64276
2010	3782	2365	1088	1371	3787	1915	2088	545	403	2641	3458	42701	255	419	2615	2294	1853		73580
2020	4336	2705	1212	1470	4549	2273	2197	614	445	3090	4001	48529	293	437	3005	2653	1752		83561
2040	5711	3552	1536	1765	6340	3124	2470	793	559	4167	5330	63161	385	474	3967	3537	1821		108692

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED WATER USE IN GAL/DAY																			
1980	323034	211468	60392	102222	102391	53293	245398	30173	0	94446	175948	7036054	22333	13778	171123	103260	1396251		10141564
1987	451251	199871	119173	128635	190588	66058	306368	52936	20532	206477	233704	6878826	22406	30262	248880	194783	1110100		10460850
1990	491636	238928	137020	143298	224600	72240	330687	59500	23380	252476	280025	7254920	23749	22945	253394	195536	1376027		11380361
2000	675376	344422	160545	164992	350204	115218	414615	76640	27588	334096	386496	10136352	34540	30654	339872	283824	1379015		15254449
2010	809348	418605	179520	183714	450653	141710	457272	90470	30628	401432	466830	11998981	40035	32682	397480	348688	1259908	12000000	29707956
2020	949584	497720	199980	204330	554978	168202	496522	104380	33820	469680	548137	13927823	46001	34086	456760	419174	1162360	12000000	32273537
2040	1290686	685536	253440	257690	798840	231176	582920	138775	42484	633384	751530	18821978	60445	36972	602984	587142	1097544	26800000	53673526

KSA PROJECTIONS
NACOGDOCHES COUNTY
WATER USE PROJECTIONS
HIGH PROJECTIONS W/O CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED PEAK DAY WATER USE IN GAL/DAY																			
PEAK DAY TO AVG DAY RATIO	2.2	1.71	2.2	1.34	1.91	2.2	1.61	2.2	2.2	2.31	1.94	1.9,1.87,1.	2.2	2.21	2.2	2.2	2.2	1.5	
1990	1081599	408567	301444	192019	428986	158928	532406	130900	51436	583220	543249	13784348	52248	50708	557467	430179	3027260		22314964
2000	1485827	588962	353199	221089	668890	253480	667530	168608	60694	771762	749802	18954978	75988	67745	747718	624413	3033832		29494517
2010	1780566	715815	394944	246177	860747	311762	736208	199034	67382	927308	905650	22078125	88077	72227	874456	767114	2771798	18000000	51797388
2020	2089085	851101	439956	273802	1060008	370044	799400	229636	74404	1084961	1063386	24373690	101202	76330	1004872	922183	2557192	18000000	55370253
2040	2839509	1172267	557568	345305	1526784	508587	938501	306305	93465	1463117	1457968	32938462	132979	81708	1326565	1291712	2414597	40200000	89593399

TEXAS WATER DEVELOPMENT BOARD PROJECTIONS

NACOGDOCHES COUNTY

WATER USE PROJECTIONS

HIGH PROJECTIONS W/O CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED GALLONS PER DAY PER CAPITA																			
1990	178	137	155	114	100	60	181	140	70	142	115	235	127	65	134	121	468		
2000	213	173	169	131	119	76	216	164	78	156	135	279	161	80	156	150	654		
2010	211	175	163	132	118	73	216	164	75	150	133	278	155	77	150	150	672		
2020	217	182	163	138	121	73	224	168	75	150	136	284	155	77	150	156	656		
2040	217	185	159	140	121	71	227	168	73	146	136	286	151	75	146	160	579		

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED POPULATION																			
1990	2762	1744	884	1257	2246	1204	1827	425	334	1778	2435	30872	187	353	1891	1616	2938		54753
2000	3247	2038	973	1289	3019	1557	1965	479	363	2198	2928	37266	220	393	2236	1944	2161		64276
2010	3782	2365	1088	1371	3787	1915	2088	545	403	2641	3458	42701	255	419	2615	2294	1853		73580
2020	4336	2705	1212	1470	4549	2273	2197	614	445	3090	4001	48529	293	437	3005	2653	1752		83561
2040	5711	3552	1536	1765	6340	3124	2470	793	559	4167	5330	63161	385	474	3967	3537	1821		108692

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED WATER USE IN GAL/DAY																			
1980	323034	211468	60392	102222	102391	53293	245398	30173	0	94446	176948	7036054	22333	13778	171123	103260	1396251		10141564
1987	451251	199871	119173	128635	190588	66058	306368	52936	20532	206477	233704	6878826	22406	30262	248880	194783	1110100		10460850
1990	491636	238928	137020	143298	224600	72240	330687	59500	23380	252476	280025	7254920	23749	22945	253394	195536	1376027		11380361
2000	692248	353026	164556	169114	358953	118096	424973	78555	28277	342442	396151	10389580	35403	31420	348363	290915	1413465		15635537
2010	799726	413629	177386	181530	445296	140025	451836	89394	30264	396660	461280	11856336	39559	32293	392755	344543	1244930	12000000	29497442
2020	939473	492420	197851	202154	549069	166411	491235	103269	33460	464679	542301	13779525	45511	33723	451897	414711	1149984	12000000	32057673
2040	1240526	658894	243590	247675	767794	222192	560266	133382	40833	608769	722323	18090494	58096	35535	579550	564324	1054890	26800000	52629132

TEXAS WATER DEVELOPMENT BOARD PROJECTIONS

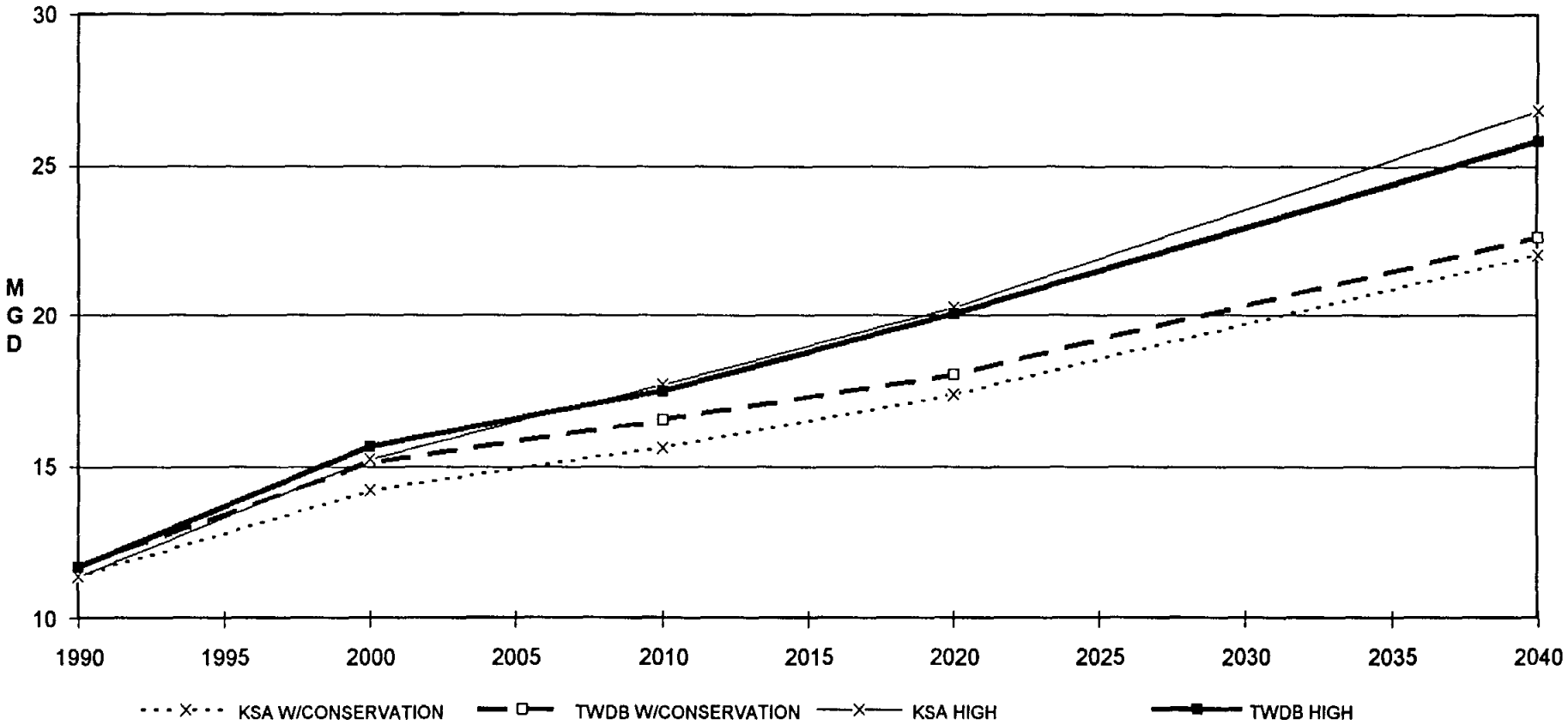
NACOGDOCHES COUNTY

WATER USE PROJECTIONS

HIGH PROJECTIONS W/O CONSERVATION

YEAR	APPLEBY	CARO	CENTRA HEIGHTS	CUSH-ING	D & M	ETOILE	GARRI-SON	LIBBY	LILBER OONE VILLE	LILLY GROVE	MEL-ROSE	NACOG-DOCHES	NAC MUD #1	SACUL	SWIFT	WODEN	OTHERS	STEAM ELECTRIC	TOTAL
PROJECTED PEAK DAY WATER USE IN GAL/DAY																			
PEAK DAY TO AVG DAY RATIO	2.2	1.71	2.2	1.34	1.91	2.2	1.61	2.2	2.2	2.31	1.94	1.9,1.87,1.	2.2	2.21	2.2	2.2	2.2	1.5	
1990	1081599	408567	301444	192019	428986	158928	532406	130900	51436	583220	543249	13784348	52248	50708	557467	430179	3027260	0	22314964
2000	1522946	603675	362023	226613	685600	259812	684206	172820	62210	791042	768534	19428514	77886	69438	766398	640012	3109624	0	30231352
2010	1759398	707305	390249	243250	850515	308056	727456	196668	66581	916284	894884	21815658	87030	71369	864060	757994	2738846	18000000	51395601
2020	2066841	842039	435272	270887	1048721	366104	790889	227191	73612	1073409	1052063	24114170	100125	74528	994173	912364	2529964	18000000	54972350
2040	2729156	1126708	535899	331885	1466487	488822	902028	293440	89832	1406255	1401307	31658364	127811	78533	1275010	1241512	2320758	40200000	87673808

NACOGDOCHES COUNTY WATER SUPPLY STUDY
WATER USE PROJECTIONS - HIGH SERIES



APPENDIX H

COMMENTS FROM THE TEXAS HISTORICAL COMMISSION

THE STATE OF TEXAS
CURTIS TUNNELL
EXECUTIVE DIRECTOR

TEXAS HISTORICAL COMMISSION
P.O. BOX 12276 AUSTIN, TEXAS 78711 (512)463-6100

March 30, 1992

Mr. Lonnie Sikes, Design Engineer
KSA Engineers, Inc.
NCNB Plaza
415 S. First St., Suite 270
P.O. Box 1605
Lufkin, Texas 75901

Re: Lake Naconiche in Nacogdoches County
(SCS, A11)

Dear Mr. Sikes:

We have received your request for information on historic landmarks in the vicinity of proposed Lake Naconiche (Attoyac Bayou Watershed Structure No. 23A). Enclosed are items that should help you with your evaluation of cultural resources in the area. Specifically, we are sending you a list of sites listed on or eligible for listing on the National Register of Historic Places, State Archeological Landmarks, and National Historic Landmarks for Nacogdoches County. Also enclosed are copies of pertinent federal legislation and regulations governing projects with federal involvement.

If you have any questions about our recommendations, please contact Bill Martin of my staff at 512/463-6096.

Sincerely,

Nancy A. Kenmotsu for

James E. Bruseth, Ph.D.
Deputy State Historic Preservation Officer

WAM/JEB

Attachments

(updated 5/90)

NACOGDOCHES

Listed National Register Site(s)
Barret, Tol, House
*Nacogdoches University, Old
*Oil Springs Oil Field Discovery Well
*Sterne, Adolphus, House (41NA144)
Stephen William and Mary Price Blount House

Site(s) Determined Eligible to the National Register
*Bayou Loco Reservoir (41NA18, 20-23)
*Washington Square Mound Site (41NA49)
Old Nacogdoches University
*Oil Springs, Oil Field Discovery Well
*Sterne, Adolphus House
*41NA18, 20-23, 49

State Archeoloical Landmarks

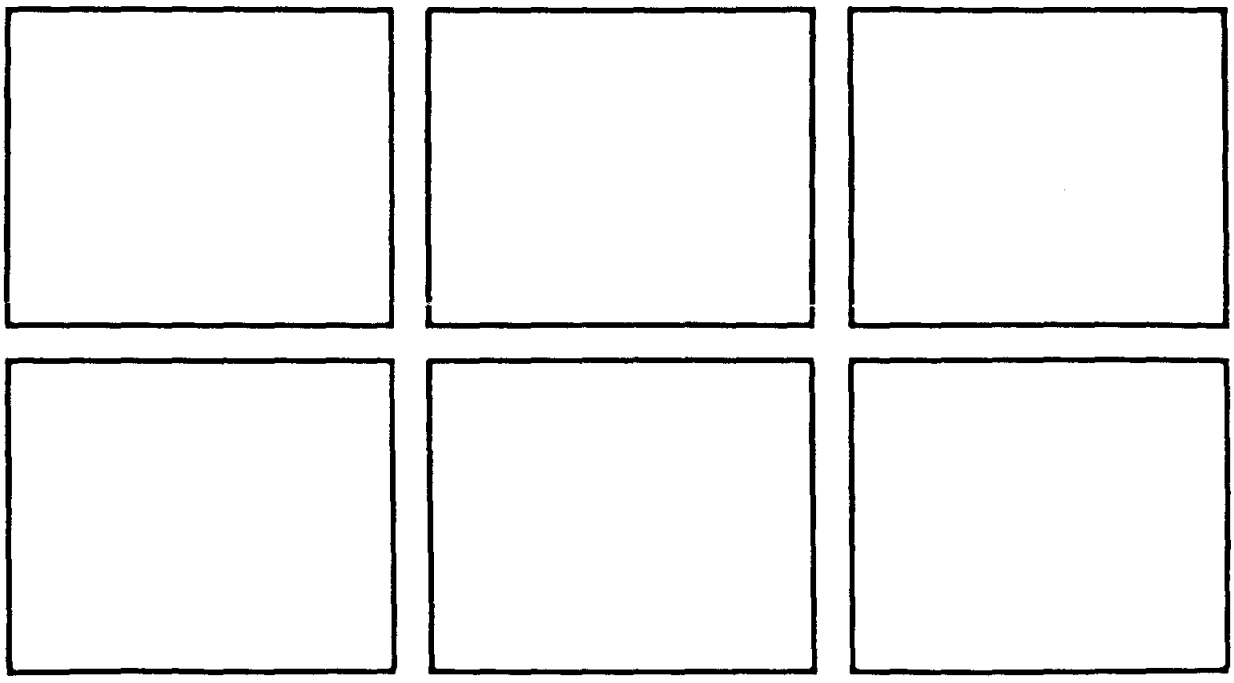
Adolphus Sterne House
Bayou Loco Reservoir - 41NA18, 20-23
Nacogdoches University (Old)
Oil Springs Oil Field Discovery Well
Washington Square Mound Site - 41NA49

WORKING WITH SECTION 106

36 CFR Part 800:

Protection of Historic Properties

Regulations of the
Advisory Council on Historic Preservation
Governing the Section 106 Review Process



Advisory Council on Historic Preservation

Effective October 1, 1986

36 CFR PART 800: PROTECTION OF HISTORIC PROPERTIES

The italicized marginal annotations are intended to aid the reader in locating regulatory topics. They are not a part of the formal regulations.

The text immediately below was published in the Federal Register *on September 2, 1986 (51 FR 31115), as 36 CFR Part 800, "Protection of Historic Properties." These regulations govern the Section 106 review process established by the National Historic Preservation Act of 1966, as amended.*

SUBPART A—BACKGROUND AND POLICY

800.1 Authorities, purposes, and participants.

What §106 requires of Federal agencies

(a) **Authorities.** Section 106 of the National Historic Preservation Act requires a Federal agency head with jurisdiction over a Federal, federally assisted, or federally licensed undertaking to take into acount the effects of the agency's undertakings on properties included in or eligible for the National Register of Historic Places and, prior to approval of an undertaking, to afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on the undertaking. Section 110(f) of the Act requires that Federal agency heads, to the maximum extent possible, undertake such planning and actions as may be necessary to minimize harm to any National Historic Landmark that may be directly and adversely affected by an undertaking and, prior to approval of such undertaking, afford the Council a reasonable opportunity to comment. These regulations define the process used by a Federal agency to meet these responsibilities, commonly called the Section 106 process.

What §110(f) requires of Federal agencies

Accommodation of historic preservation concerns and needs of Federal undertakings

(b) **Purposes of the Section 106 process.** The Council seeks through the Section 106 process to accommodate historic preservation concerns with the needs of Federal undertakings. It is designed to identify potential conflicts between the two and to help resolve such conflicts in the public interest. The Council encourages this accommodation through consultation among the Agency Official, the State Historic Preservation Officer, and other interested persons during the early stages of planning. The Council regards the consultation process as an effective means for reconciling the interests of the consulting parties.

Early integration of §106 into project planning

Integration of the Section 106 process into the normal administrative process used by agencies for project planning ensures early, systematic consideration of historic preservation issues. To this end, the Council encourages agencies to examine their administrative processes to see that they provide adequately for the efficient identification and consideration of historic properties, that they provide for participation by the State Historic Preservation Officer and others interested in historic preservation, that they provide for timely requests for Council comment, and that they promote cost-effective implementation of the Section 106 process. When impediments are found to exist in the agency's administrative process, the agency is encouraged to consult with the Council to develop special Section 106 procedures suited to the agency's needs.

§106 participants

(c) Participants in the Section 106 process.

Consulting parties

(1) *Consulting parties.* Consulting parties are the primary participants in the Section 106 process whose responsibilities are defined by these regulations. Consulting parties may include:

Federal agency's general responsibilities

(i) *Agency Official.* The Agency Official with jurisdiction over an undertaking has legal responsibility for complying with Section 106. It is the responsibility of the Agency Official to identify and evaluate affected historic properties, assess an undertaking's effect upon them, and afford the Council its comment opportunity. The Agency Official may use the services of grantees, applicants, consultants, or designees to prepare the necessary information and analyses, but remains responsible for Section 106 compliance. The Agency Official should involve applicants for Federal assistance or approval in the Section 106 process as appropriate in the manner set forth below.

SHPO's general responsibilities

(ii) *State Historic Preservation Officer.* The State Historic Preservation Officer coordinates State participation in the implementation of the National Historic Preservation Act and is a key participant in the Section 106 process. The role of the State Historic Preservation Officer is to consult with and assist the Agency Official when identifying historic properties, assessing effects upon them, and considering alternatives to avoid or reduce those effects. The State Historic Preservation Officer reflects the interests of the State and its citizens in the preservation of their cultural heritage and helps the Agency Official identify those persons interested in an undertaking and its effects upon historic properties. When the State Historic Preservation Officer declines to participate or does not respond within 30 days to a written request for participation, the Agency Official shall consult with the Council, without the State Historic Preservation Officer, to complete the Section 106 process. The State Historic Preservation Officer may assume primary responsibility for reviewing Federal undertakings in the State by agreement with the Council as prescribed in Section 800.7 of these regulations.

Council's general responsibilities

(iii) *Council.* The Council is responsible for commenting to the Agency Official on an undertaking that affects historic properties. The official authorized to carry out the Council's responsibilities under each provision of the regulations is set forth in a separate, internal delegation of authority.

Interested persons' participation

(2) *Interested persons.* Interested persons are those organizations and individuals that are concerned with the effects of an undertaking on historic properties. Certain provisions in these regulations require that particular interested persons be invited to become consulting parties under certain circumstances. In addition, whenever the Agency Official, the State Historic Preservation Officer, and the Council, if participating, agree that active participation of an interested person will advance the objectives of Section 106, they may invite that person to become a consulting party. Interested persons may include:

Local governments' participation

(i) *Local governments.* Local governments are encouraged to take an active role in the Section 106 process when undertakings affect historic properties within their jurisdiction. When a local government has legal responsibility for Section 106 compliance under programs such as the Community Development Block Grant Program, participation as a consulting party is required. When no

such legal responsibility exists, the extent of local government participation is at the discretion of local government officials. If the State Historic Preservation Officer, the appropriate local government, and the Council agree, a local government whose historic preservation program has been certified pursuant to Section 101(c)(1) of the Act may assume any of the duties that are given to the State Historic Preservation Officer by these regulations or that originate from agreements concluded under these regulations.

Federal applicants' participation

(ii) *Applicants for Federal assistance, permits, and licenses.* When the undertaking subject to review under Section 106 is proposed by an applicant for Federal assistance or for a Federal permit or license, the applicant may choose to participate in the Section 106 process in the manner prescribed in these regulations.

Indian tribes' participation

(iii) *Indian tribes.* The Agency Official, the State Historic Preservation Officer, and the Council should be sensitive to the special concerns of Indian tribes in historic preservation issues, which often extend beyond Indian lands to other historic properties. When an undertaking will affect Indian lands, the Agency Official shall invite the governing body of the responsible tribe to be a consulting party and to concur in any agreement. When an Indian tribe has established formal procedures relating to historic preservation, the Agency Official, State Historic Preservation Officer, and Council shall, to the extent feasible, carry out responsibilities under these regulations consistent with such procedures. An Indian tribe may participate in activities under these regulations in lieu of the State Historic Preservation Officer with respect to undertakings affecting its lands, provided the Indian tribe so requests, the State Historic Preservation Officer concurs, and the Council finds that the Indian tribe's procedures meet the purposes of these regulations. When an undertaking may affect properties of historic value to an Indian tribe on non-Indian lands, the consulting parties shall afford such tribe the opportunity to participate as interested persons. Traditional cultural leaders and other Native Americans are considered to be interested persons with respect to undertakings that may affect historic properties of significance to such persons.

Public participation

(iv) *The public.* The Council values the views of the public on historic preservation questions and encourages maximum public participation in the Section 106 process. The Agency Official, in the manner described below, and the State Historic Preservation Officer should seek and consider the views of the public when taking steps to identify historic properties, evaluate effects, and develop alternatives. Public participation in the Section 106 process may be fully coordinated with, and satisfied by, public participation programs carried out by Agency Officials under the authority of the National Environmental Policy Act and other pertinent statutes. Notice to the public under these statutes should adequately inform the public of preservation issues in order to elicit public views on such issues that can then be considered and resolved, when possible, in decisionmaking. Members of the public with interests in an undertaking and its effects on historic properties should be given reasonable opportunity to have an active role in the Section 106 process.

Definitions

800.2 Definitions.

"Act"

(a) "Act" means the National Historic Preservation Act of 1966, as amended, 16 U.S.C. §§ 470-470w-6.

"Agency Official"

(b) "Agency Official" means the Federal agency head or a designee with authority over a specific undertaking, including any State or local government official who has been delegated legal responsibility for compliance with Section 106 and Section 110(f) in accordance with law.

"Area of potential effects"

(c) "Area of potential effects" means the geographic area or areas within which an undertaking may cause changes in the character or use of historic properties, if any such properties exist.

"Council"

(d) "Council" means the Advisory Council on Historic Preservation or a Council member or employee designated to act for the Council.

"Historic property"

(e) "Historic property" means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register. This term includes, for the purposes of these regulations, artifacts, records, and remains that are related to and located within such properties. The term "eligible for inclusion in the National Register" includes both properties formally determined as such by the Secretary of the Interior and all other properties that meet National Register listing criteria.

"Indian lands"

(f) "Indian lands" means all lands under the jurisdiction or control of an Indian tribe.

"Indian tribe"

(g) "Indian tribe" means the governing body of any Indian tribe, band, nation, or other group that is recognized as an Indian tribe by the Secretary of the Interior and for which the United States holds land in trust or restricted status for that entity or its members. Such term also includes any Native village corporation, regional corporation, and Native Group established pursuant to the Alaska Native Claims Settlement Act, 43 U.S.C. §1601, *et seq.*

"Interested person"

(h) "Interested person" means those organizations and individuals that are concerned with the effects of an undertaking on historic properties.

"Local government"

(i) "Local government" means a city, county, parish, township, municipality, borough, or other general purpose political subdivision of a State.

"National Historic Landmark"

(j) "National Historic Landmark" means a historic property that the Secretary of the Interior has designated a National Historic Landmark.

"National Register"

(k) "National Register" means the National Register of Historic Places maintained by the Secretary of the Interior.

"National Register Criteria"

(l) "National Register Criteria" means the criteria established by the Secretary of the Interior for use in evaluating the eligibility of properties for the National Register (36 CFR Part 60).

"Secretary"

(m) "Secretary" means the Secretary of the Interior.

"SHPO"

(n) "State Historic Preservation Officer" means the official appointed or designated pursuant to Section 101(b)(1) of the Act to administer the State historic preservation program or a representative designated to act for the State Historic Preservation Officer.

"Undertaking"

(o) "Undertaking" means any project, activity, or program that can result in changes in the character or use of historic properties, if any such historic properties are located in the area of potential effects. The project, activity, or program must be under the direct or indirect jurisdiction of a Federal agency or licensed or assisted by a Federal agency. Undertakings include new and continuing projects, activities, or programs and any of their elements not previously considered under Section 106.

How the §106 process works

SUBPART B—THE SECTION 106 PROCESS

800.3 General.

Scope of the regulations; alternative methods of meeting §106 requirements

(a) **Scope.** The procedure in this subpart guides Agency Officials, State Historic Preservation Officers, and the Council in the conduct of the Section 106 process. Alternative methods of meeting Section 106 obligations are found in Section 800.7, governing review of untertakings in States that have entered into agreements with the Council for Section 106 purposes, and Section 800.13, governing Programmatic Agreements with Federal agencies that pertain to specific programs or activities. Under each of these methods, the Council encourages Federal agencies to reach agreement on developing alternatives or measures to avoid or reduce effects on historic properties that meet both the needs of the undertaking and preservation concerns.

Procedural flexibility

(b) **Flexible application.** The Council recognizes that the procedures for the Agency Official set forth in these regulations may be implemented by the Agency Official in a flexible manner reflecting differing program requirements, as long as the purposes of Section 106 of the Act and these regulations are met.

Timing of the §106 process

(c) **Timing.** Section 106 requires the Agency Official to complete the Section 106 process prior to the approval of the expenditure of any Federal funds on the undertaking or prior to the issuance of any license or permit. The Council does not interpret this language to bar an Agency Official from expending funds on or authorizing nondestructive planning activities preparatory to an undertaking before complying with Section 106, or to prohibit phased compliance at different stages in planning. The Agency Official should ensure that the Section 106 process is initiated early in the planning stages of the undertaking, when the widest feasible range of alternatives is open for consideration. The Agency Official should establish a schedule for completing the Section 106 process that is consistent with the planning and approval schedule for the undertaking.

Allowance for nondestructive planning before the §106 process is completed

Steps of the §106 process

800.4 Identifying historic properties.

Agency's determination of what information will be needed to complete the §106 process

(a) **Assessing information needs.**

(1) Following a determination by the Agency Official that a proposed project, activity, or program constitutes an undertaking and after establishing the undertaking's area of potential effects, the Agency Official shall:

(i) Review existing information on historic properties potentially affected by the undertaking, including any data concerning the likelihood that unidentified historic properties exist in the area of potential effects;

(ii) Request the views of the State Historic Preservation Officer on further actions to identify historic properties that may be affected; and

(iii) Seek information in accordance with agency planning processes from local governments, Indian tribes, public and private organizations, and other parties likely to have knowledge of or concerns with historic properties in the area.

(2) Based on this assessment, the Agency Official should determine any need for further actions, such as field surveys and predictive modeling, to identify historic properties.

Agency's location of historic properties in the project area

(b) **Locating historic properties.** In consultation with the State Historic Preservation Officer, the Agency Official shall make a reasonable and good faith effort to identify historic properties that may be affected by the undertaking and gather sufficient information to evaluate the eligibility of these properties for the National Register. Efforts to identify historic properties should follow the Secretary's "Standards and Guidelines for Archeology and Historic Preservation" (48 FR 44716) and agency programs to meet the requirements of Section 110(a)(2) of the Act.

Agency's evaluation of whether properties found are "historic"

(c) **Evaluating historical significance.**

(1) In consultation with the State Historic Preservation Officer and following the Secretary's Standards and Guidelines for Evaluation, the Agency Official shall apply the National Register Criteria to properties that may be affected by the undertaking and that have not been previously evaluated for National Register eligibility. The passage of time or changing perceptions of significance may justify reevaluation of properties that were previously determined to be eligible or ineligible.

Agency/SHPO agreement about National Register eligibility of properties found

(2) If the Agency Official and the State Historic Preservation Officer agree that a property is eligible under the criteria, the property shall be considered eligible for the National Register for Section 106 purposes.

(3) If the Agency Official and the State Historic Preservation Officer agree that the criteria are not met, the property shall be considered not eligible for the National Register for Section 106 purposes.

Disagreement about National Register eligibility of properties found

(4) If the Agency Official and the State Historic Preservation Officer do not agree, or if the Council or the Secretary so request, the Agency Official shall obtain a determination from the Secretary of the Interior pursuant to applicable National Park Service regulations.

(5) If the State Historic Preservation Officer does not provide views, then the State Historic Preservation Officer is presumed to agree with the Agency Official's determination for the purpose of this subsection.

Agency's actions if no historic properties are found

(d) When no historic properties are found. If the Agency Official determines in accordance with Sections 800.4(a)-(c) that there are no historic properties that may be affected by the undertaking, the Agency Official shall provide documentation of this finding to the State Historic Preservation Officer. The Agency Official should notify interested persons and parties known to be interested in the undertaking and its possible effects on historic properties and make the documentation available to the public. In these circumstances, the Agency Official is not required to take further steps in the Section 106 process.

Agency's actions if historic properties are found

(e) When historic properties are found. If there are historic properties that the undertaking may affect, the Agency Official shall assess the effects in accordance with Section 800.5.

Agency's assessment of project effects on historic properties found

800.5 Assessing effects.

Agency's use of Criteria of Effect

(a) Applying the Criteria of Effect. In consultation with the State Historic Preservation Officer, the Agency Official shall apply the Criteria of Effect (Section 800.9(a)) to historic properties that may be affected, giving consideration to the views, if any, of interested persons.

Agency's actions if no effect is found

(b) When no effect is found. If the Agency Official finds the undertaking will have no effect on historic properties, the Agency Official shall notify the State Historic Preservation Officer and interested persons who have made their concerns known to the Agency Official and document the finding, which shall be available for public inspection. Unless the State Historic Preservation Officer objects within 15 days of receiving such notice, the Agency Official is not required to take any further steps in the Section 106 process. If the State Historic Preservation Officer files a timely objection, then the procedures described in Section 800.5(c) are followed.

Agency's use of Criteria of Adverse Effect

(c) When an effect is found. If an effect on historic properties is found, the Agency Official, in consultation with the State Historic Preservation Officer, shall apply the Criteria of Adverse Effect (Section 800.9(b)) to determine whether the effect of the undertaking should be considered adverse.

Agency's actions if effects are not adverse

(d) When the effect is not considered adverse.

(1) If the Agency Official finds the effect is not adverse, the Agency Official shall:

(i) Obtain the State Historic Preservation Officer's concurrence with the finding and notify and submit to the Council summary documentation, which shall be available for public inspection; or

(ii) Submit the finding with necessary documentation (Section 800.8(a)) to the Council for a 30-day review period and notify the State Historic Preservation Officer.

(2) If the Council does not object to the finding of the Agency Official within 30 days of receipt of notice, or if the Council objects but proposes changes that the Agency Official accepts, the Agency Official is not required to take any further steps in the Section 106 process other than to comply with any agreement with the State Historic Preservation Officer or Council concerning the undertaking. If the Council objects and the Agency Official does not agree with changes proposed by the Council, then the effect shall be considered as adverse.

Agency's actions if effects are adverse

(e) When the effect is adverse. If an adverse effect on historic properties is found, the Agency Official shall notify the Council and shall consult with the State Historic Preservation Officer to seek ways to avoid or reduce the effects on historic properties. Either the Agency Official or the State Historic Preservation Officer may request the Council to participate. The Council may participate in the consultation without such a request.

Consultation to avoid or reduce adverse effects; Council participation is optional

Invitation to interested persons to join in consultation

(1) *Involving interested persons.* Interested persons shall be invited to participate as consulting parties as follows when they so request:

(i) The head of a local government when the undertaking may affect historic properties within the local government's jurisdiction;

(ii) The representative of an Indian tribe in accordance with Section 800.1(c)(2)(iii);

(iii) Applicants for or holders of grants, permits, or licenses, and owners of affected lands; and

(iv) Other interested persons when jointly determined appropriate by the Agency Official, the State Historic Preservation Officer, and the Council, if participating.

Documentation needed for consultation

(2) *Documentation.* The Agency Official shall provide each of the consulting parties with the documentation set forth in Section 800.8(b) and such other documentation as may be developed in the course of consultation.

Public notification about consultation

(3) *Informing the public.* The Agency Official shall provide an adequate opportunity for members of the public to receive information and express their views. The Agency Official is encouraged to use existing agency public involvement procedures to provide this opportunity. The Agency Official, State Historic Preservation Officer, or the Council may meet with interested members of the public or conduct a public information meeting for this purpose.

Memorandum of Agreement (MOA) reached through consultation; MOA signatories

(4) *Agreement.* If the Agency Official and the State Historic Preservation Officer agree upon how the effects will be taken into account, they shall execute a Memorandum of Agreement. When the Council participates in the consultation, it shall execute the Memorandum of Agreement along with the Agency Official and the State Historic Preservation Officer. When the Council has not participated in consultation, the Memorandum of Agreement shall be submitted to the Council for comment in accordance with Section 800.6(a). As appropriate, the Agency Official, the State Historic Preservation Officer, and the Council, if participating, may agree to invite other consulting parties to concur in the agreement.

Amendments to MOA's

(5) *Amendments.* The Agency Official, the State Historic Preservation Officer, and the Council, if it was a signatory to the original agreement, may subsequently agree to an amendment to the Memorandum of Agreement. When the Council is not a party to the Memorandum of Agreement, or the Agency Official and the State Historic Preservation Officer cannot agree on changes to the Memorandum of Agreement, the proposed changes shall be submitted to the Council for comment in accordance with Section 800.6.

Ending consultation

(6) *Ending consultation.* The Council encourages Agency Officials and State Historic Preservation Officers to utilize the consultation process to the fullest extent practicable. After initiating consultation to seek ways to reduce or avoid effects on historic properties, the State Historic Preservation Officer, the Agency Official, or the Council, at its discretion, may state that further consultation will not be productive and thereby terminate the consultation process. The Agency Official shall then request the Council's comments in accordance with Section 800.6(b) and notify all other consulting parties of its requests.

800.6 Affording the Council an opportunity to comment.

Council review of an MOA

(a) Review of a Memorandum of Agreement.

Documentation for MOA review

(1) When an Agency Official submits a Memorandum of Agreement accompanied by the documentation specified in Section 800.8(b) and (c), the Council shall have 30 days from receipt to review it. Before this review period ends, the Council shall:

(i) Accept the Memorandum of Agreement, which concludes the Section 106 process, and inform all consulting parties; or

(ii) Advise the Agency Official of changes to the Memorandum of Agreement that would make it acceptable; subsequent agreement by the Agency Official, the State Historic Preservation Officer, and the Council concludes the Section 106 process; or

(iii) Decide to comment on the undertaking, in which case the Council shall provide its comments within 60 days of receiving the Agency Official's submission, unless the Agency Official agrees otherwise.

(2) If the Agency Official, the State Historic Preservation Officer, and the Council do not reach agreement in accordance with Section 800.6(a)(1)(ii), the Agency Official shall notify the Council, which shall provide its comments within 30 days of receipt of notice.

Council comment, absent an MOA

(b) Comment when there is no agreement.

Documentation for Council comment, absent an MOA

(1) When no Memorandum of Agreement is submitted, the Agency Official shall request Council comment and provide the documentation specified in Section 800.8(d). When requested by the Agency Official, the Council shall provide its comments within 60 days of receipt of the Agency Official's request and the specified documentation.

Additional information, onsite inspection, public meeting, absent an MOA

(2) The Agency Official shall make a good faith effort to provide reasonably available additional information concerning the undertaking and shall assist the Council in arranging an onsite inspection and public meeting when requested by the Council.

How the Council provides comments, absent an MOA

(3) The Council shall provide its comments to the head of the agency requesting comment. Copies shall be provided to the State Historic Preservation Officer, interested persons, and others as appropriate.

Agency's response to Council comment

(c) Response to Council comment.

(1) When a Memorandum of Agreement becomes final in accordance with Section 800.6(a)(1)(i) or (ii), the Agency Official shall carry out the undertaking in accordance with the terms of the agreement. This evidences fulfillment of the agency's Section 106 responsibilities. Failure to carry out the terms of a Memorandum of Agreement requires the Agency Official to resubmit the undertaking to the Council for comment in accordance with Section 800.6.

Failure to carry out terms of an MOA

Agency's consideration of Council comment

(2) When the Council has commented pursuant to Section 800.6(b), the Agency Official shall consider the Council's comments in reaching a final decision on the proposed undertaking. The Agency Official shall report the decision to the Council, and if possible, should do so prior to initiating the undertaking.

Agency actions that preempt reasonable opportunity for Council comment

(d) Foreclosure of the Council's opportunity to comment.

(1) The Council may advise an Agency Official that it considers the agency has not provided the Council a reasonable opportunity to comment. The decision to so advise the Agency Official will be reached by a majority vote of the Council or by a majority vote of a panel consisting of three or more Council members with the concurrence of the Chairman.

(2) The Agency Official will be given notice and a reasonable opportunity to respond prior to a proposed Council determination that the agency has foreclosed the Council's opportunity to comment.

Public objection to agency determinations about whether historic properties or effects are present

(e) Public requests to the Council.

(1) When requested by any person, the Council shall consider an Agency Official's finding under Sections 800.4(b), 800.4(c), 800.4(d), or 800.5(b) and, within 30 days of receipt of the request, advise the Agency Official, the State Historic Preservation Officer, and the person making the request of its views of the Agency Official's finding.

(2) In light of the Council views, the Agency Official should reconsider the finding. However, an inquiry to the Council will not suspend action on an undertaking.

(3) When the finding concerns the eligibility of a property for the National Register, the Council shall refer the matter to the Secretary.

Substitute review processes developed by States for §106 review

800.7 Agreements with States for Section 106 reviews.

(a) Establishment of State agreements.

(1) Any State Historic Preservation Officer may enter into an agreement with the Council to substitute a State review process for the procedures set forth in these regulations, provided that:

(i) The State historic preservation program has been approved by the Secretary pursuant to Section 101(b)(1) of the Act; and

(ii) The Council, after analysis of the State's review process and consideration of the views of Federal and State agencies, local governments, Indian tribes, and the public, determines that the State review process is at least as effective as, and no more burdensome than, the procedures set forth in these regulations in meeting the requirements of Section 106.

Council review of a proposed substitute State review process

(2) The Council, in analyzing a State's review process pursuant to Section 800.7(a)(1)(ii), shall:

(i) Review relevant State laws, Executive Orders, internal directives, standards, and guidelines;

(ii) Review the organization of the State's review process;

(iii) Solicit and consider the comments of Federal and State agencies, local governments, Indian tribes, and the public;

(iv) Review the results of program reviews carried out by the Secretary; and

(v) Review the record of State participation in the Section 106 process.

(3) The Council will enter into an agreement with a State under this section only upon determining, at minimum, that the State has a demonstrated record of performance in the Section 106 process and the capability to administer a comparable process at the State level.

SHPO/Council consultation about a proposed substitute State review process

(4) A State agreement shall be developed through consultation between the State Historic Preservation Officer and the Council and concurred in by the Secretary before submission to the Council for approval. The Council may invite affected Federal and State agencies, local governments, Indian tribes, and other interested persons to participate in this consultation. The agreement shall:

(i) Specify the historic preservation review process employed in the State, showing that this process is at least as effective as, and no more burdensome than, that set forth in these regulations;

(ii) Establish special provisions for participation of local governments or Indian tribes in the review of undertakings falling within their jurisdiction, when appropriate;

(iii) Establish procedures for public participation in the State review process;

(iv) Provide for Council review of actions taken under its terms, and for appeal of such actions to the Council; and

(v) Be certified by the Secretary as consistent with the Secretary's "Standards and Guidelines for Archeology and Historic Preservation."

(5) Upon concluding a State agreement, the Council shall publish notice of its execution in the *Federal Register* and make copies of the State agreement available to all Federal agencies.

Agency's use of substitute State review processes

(b) Review of undertakings when a State agreement is in effect.

(1) When a State agreement under Section 800.7(a) is in effect, an Agency Official may elect to comply with the State review process in lieu of compliance with these regulations.

(2) At any time during review of an undertaking under a State agreement, an Agency Official may terminate such review and comply instead with Sections 800.4 through 800.6 of these regulations.

(3) At any time during review of an undertaking under a State agreement, the Council may participate. Participants are encouraged to draw upon the Council's expertise as appropriate.

Monitoring or terminating substitute State review processes

(c) Monitoring and termination of State agreements.

(1) The Council shall monitor activities carried out under State agreements, in coordination with the Secretary of the Interior's approval of State programs under Section 101(b)(1) of the Act. The Council may request that the Secretary monitor such activities on its behalf.

(2) The Council may terminate a State agreement after consultation with the State Historic Preservation Officer and the Secretary.

(3) An agreement may be terminated by the State Historic Preservation Officer.

(4) When a State agreement is terminated pursuant to Section 800.7(c)(2) and (3), such termination shall have no effect on undertakings for which review under the agreement was complete or in progress at the time the termination occurred.

800.8 Documentation requirements.

Documentation for finding of no adverse effect

(a) Finding of no adverse effect. The purpose of this documentation is to provide sufficient information to explain how the Agency Official reached the finding of no adverse effect. The required documentation is as follows:

(1) A description of the undertaking, including photographs, maps, and drawings, as necessary;

(2) A description of historic properties that may be affected by the undertaking;

(3) A description of the efforts used to identify historic properties;

(4) A statement of how and why the Criteria of Adverse Effect were found inapplicable;

(5) The views of the State Historic Preservation Officer, affected local governments, Indian tribes, Federal agencies, and the public, if any were provided, as well as a description of the means employed to solicit those views.

Documentation required for consultation

(b) **Finding of adverse effect.** The required documentation is as follows:

(1) A description of the undertaking, including photographs, maps, and drawings, as necessary;

(2) A description of the efforts to identify historic properties;

(3) A description of the affected historic properties, using materials already compiled during the evaluation of significance, as appropriate; and

(4) A description of the undertaking's effects on historic properties.

Documentation required for submitting a signed MOA for Council review

(c) **Memorandum of Agreement.** When a memorandum is submitted for review in accordance with Section 800.6(a)(1), the documentation, in addition to that specified in Section 800.8(b), shall also include a description and evaluation of any proposed mitigation measures or alternatives that were considered to deal with the undertaking's effects and a summary of the views of the State Historic Preservation Officer and any interested persons.

Documentation required for requesting written Council comment, absent an MOA

(d) **Requests for comment when there is no agreement.** The purpose of this documentation is to provide the Council with sufficient information to make an independent review of the undertaking's effects on historic properties as the basis for informed and meaningful comments to the Agency Official. The required documentation is as follows:

(1) A description of the undertaking, with photographs, maps, and drawings, as necessary;

(2) A description of the efforts to identify historic properties;

(3) A description of the affected historic properties, with information on the significant characteristics of each property;

(4) A description of the effects of the undertaking on historic properties and the basis for the determinations;

(5) A description and evaluation of any alternatives or mitigation measures that the Agency Official proposes for dealing with the undertaking's effects;

(6) A description of any alternatives or mitigation measures that were considered but not chosen and the reasons for their rejection;

(7) Documentation of consultation with the State Historic Preservation Officer regarding the identification and evaluation of historic properties, assessment of effect, and any consideration of alternatives or mitigation measures;

(8) A description of the Agency Official's efforts to obtain and consider the views of affected local governments, Indian tribes, and other interested persons;

(9) The planning and approval schedule for the undertaking; and

(10) Copies or summaries of any written views submitted to the Agency Official concerning the effects of the undertaking on historic properties and alternatives to reduce or avoid those effects.

800.9 Criteria of Effect and Adverse Effect.

Criteria of Effect

(a) An undertaking has an effect on a historic property when the undertaking may alter characteristics of the property that may qualify the property for inclusion in the National Register. For the purpose of determining effect, alteration to features of the property's location, setting, or use may be relevant depending on a property's significant characteristics and should be considered.

Criteria of Adverse Effect

(b) An undertaking is considered to have an adverse effect when the effect on a historic property may diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Adverse effects on historic properties include, but are not limited to:

(1) Physical destruction, damage, or alteration of all or part of the property;

(2) Isolation of the property from or alteration of the character of the property's setting when that character contributes to the property's qualification for the National Register;

(3) Introduction of visual, audible, or atmospheric elements that are out of character with the property or alter its setting;

(4) Neglect of a property resulting in its deterioration or destruction; and

(5) Transfer, lease, or sale of the property.

Exceptions to the Criteria of Adverse Effect

(c) Effects of an undertaking that would otherwise be found to be adverse may be considered as being not adverse for the purpose of these regulations:

(1) When the historic property is of value only for its potential contribution to archeological, historical, or architectural research, and when such value can be substantially preserved through the conduct of appropriate research, and such research is conducted in accordance with applicable professional standards and guidelines;

(2) When the undertaking is limited to the rehabilitation of buildings and structures and is conducted in a manner that preserves the historical and architectural value of affected historic property through conformance with the Secretary's "Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings"; or

(3) When the undertaking is limited to the transfer, lease, or sale of a historic property, and adequate restrictions or conditions are included to ensure preservation of the property's significant historic features.

SUBPART C—SPECIAL PROVISIONS

Special agency requirements for National Historic Landmarks

800.10 Protecting National Historic Landmarks.

Section 110(f) of the Act requires that the Agency Official, to the maximum extent possible, undertake such planning and actions as may be necessary to minimize harm to any National Historic Landmark that may be directly and adversely affected by an undertaking. When commenting on such undertakings, the Council shall use the process set forth in Sections 800.4 through 800.6 and give special consideration to protecting National Historic Landmarks as follows:

(a) Any consultation conducted under Section 800.5(e) shall include the Council;

(b) The Council may request the Secretary under Section 213 of the Act to provide a report to the Council detailing the significance of the property, describing the effects of the undertaking on the property, and recommending measures to avoid, minimize, or mitigate adverse effects; and

(c) The Council shall report its comments, including Memoranda of Agreement, to the President, the Congress, the Secretary, and the head of the agency responsible for the undertaking.

Discovery of historic properties after a project has begun

800.11 Properties discovered during implementation of an undertaking.

Prior agency planning for discoveries

(a) Planning for discoveries.

When the Agency Official's identification efforts in accordance with Section 800.4 indicate that historic properties are likely to be discovered during implementation of an undertaking, the Agency Official is encouraged to develop a plan for the treatment of such properties if discovered and include this plan in any documentation prepared to comply with Section 800.5.

(b) Federal agency responsibilities.

(1) When an Agency Official has completed the Section 106 process and prepared a plan in accordance with Section 800.11(a), the Agency Official shall satisfy the requirements of Section 106 concerning properties discovered during implementation of an undertaking by following the plan.

Agency responsibilities absent a plan for discoveries

(2) When an Agency Official has completed the Section 106 process without preparing a plan in accordance with Section 800.11(a) and finds after beginning to carry out the undertaking that the undertaking will affect a previously unidentified property that may be eligible for inclusion in the National Register, or affect a known historic property in an unanticipated manner, the Agency Official shall afford the Council an opportunity to comment by choosing one of the following courses of action:

(i) Comply with Section 800.6;

(ii) Develop and implement actions that take into account the effects of the undertaking on the property to the extent feasible and the comments from the State Historic Preservation Officer and the Council pursuant to Section 800.11(c); or

(iii) If the property is principally of archeological value and subject to the requirements of the Archeological and Historic Preservation Act, 16 U.S.C. §§ 469 (a)-(c), comply with that Act and implementing regulations instead of these regulations.

(3) Section 106 and these regulations do not require the Agency Official to stop work on the undertaking. However, depending on the nature of the property and the undertaking's apparent effects on it, the Agency Official should make reasonable efforts to avoid or minimize harm to the property until the requirements of this section are met.

Council comments when historic properties are discovered after a project has begun

(c) Council Comments.

(1) When comments are requested pursuant to Section 800.11(b)(2)(i), the Council will provide its comments in a time consistent with the Agency Official's schedule, regardless of longer time periods allowed by these regulations for Council review.

(2) When an Agency Offical elects to comply with Section 800.11(b)(2)(ii), the Agency Official shall notify the State Historic Preservation Officer and the Council at the earliest possible time, describe the actions proposed to take effects into account, and request the Council's comments. The Council shall provide interim comments to the Agency Official within 48 hours of the request and final comments to the Agency Official within 30 days of the request.

(3) When an Agency Official complies with Section 800.11(b)(2)(iii), the Agency Official shall provide the State Historic Preservation Officer an opportunity to comment on the work undertaken and provide the Council with a report on the work after it is undertaken.

Agency actions to determine National Register eligibility of newly discovered properties

(d) Other considerations.

(1) When a newly discovered property has not previously been included in or determined eligible for the National Register, the Agency Official may assume the property to be eligible for purposes of Section 106.

Discovery of properties on Indian lands

(2) When a discovery occurs and compliance with this section is necessary on lands under the jurisdiction of an Indian tribe, the Agency Official shall consult with the Indian tribe during implementation of this section's requirements.

Waiver of §106 requirements during disasters or declared emergencies

800.12 Emergency undertakings.

(a) When a Federal agency head proposes an emergency action and elects to waive historic preservation responsibilities in accordance with 36 CFR § 78.2, the Agency Official may comply with the requirements of 36 CFR Part 78 in lieu of these regulations. An Agency Official should develop plans for taking historic properties into account during emergency operations. At the request of the Agency Official, the Council will assist in the development of such plans.

(b) When an Agency Official proposes an emergency undertaking as an essential and immediate response to a disaster declared by the President or the appropriate Governor, and Section 800.12(a) does not apply, the Agency Official may satisfy Section 106 by notifying the Council and the appropriate State Historic Preservation Officer of the emergency undertaking and affording them an opportunity to comment within seven days if the Agency Official considers that circumstances permit.

(c) For the purposes of activities assisted under Title I of the Housing and Community Development Act of 1974, as amended, Section 800.12(b) also applies to an imminent threat to public health or safety as a result of natural disaster or emergency declared by a local government's chief executive officer or legislative body, provided that if the Council or the State Historic Preservation Officer objects, the Agency Official shall comply with Sections 800.4 through 800.6.

30-day timeframe for §106 waiver in disaster situations

(d) This section does not apply to undertakings that will not be implemented within 30 days after the disaster or emergency. Such undertakings shall be reviewed in accordance with Sections 800.4 through 800.6.

Agency's use of Programmatic Agreements

800.13 Programmatic Agreements.

(a) Application. An Agency Official may elect to fulfill an agency's Section 106 responsibilities for a particular program, a large or complex project, or a class of undertakings that would otherwise require numerous individual requests for comments, through a Programmatic Agreement. Programmatic Agreements are appropriate for programs or projects:

Examples of projects or programs suitable for Programmatic Agreements

(1) When effects on historic properties are similar and repetitive or are multi-State or national in scope;

(2) When effects on historic properties cannot be fully determined prior to approval;

(3) When non-Federal parties are delegated major decisionmaking responsibilities;

(4) That involve development of regional or land-management plans; or

(5) That involve routine management activities at Federal installations.

Agency/Council consultation to reach a Programmatic Agreement

(b) **Consultation process.** The Council and the Agency Official shall consult to develop a Programmatic Agreement. When a particular State is affected, the appropriate State Historic Preservation Officer shall be a consulting party. When the agreement involves issues national in scope, the President of the National Conference of State Historic Preservation Officers or a designated representative shall be invited to be a consulting party by the Council. The Council and the Agency Official may agree to invite other Federal agencies or others to be consulting parties or to participate, as appropriate.

Public involvement in Programmatic Agreement consultation

(c) **Public involvement.** The Council, with the assistance of the Agency Official, shall arrange for public notice and involvement appropriate to the subject matter and the scope of the program. Views from affected units of State and local government, Indian tribes, industries, and organizations will be invited.

Signatories of a Programmatic Agreement

(d) **Execution of the Programmatic Agreement.** After consideration of any comments received and reaching final agreement, the Council and the Agency Official shall execute the agreement. Other consulting parties may sign the Programmatic Agreement as appropriate.

Effect of a Programmatic Agreement

(e) **Effect of the Programmatic Agreement.** An approved Programmatic Agreement satisfies the Agency's Section 106 responsibilities for all individual undertakings carried out in accordance with the agreement until it expires or is terminated.

Public notification of a Programmatic Agreement

(f) **Notice.** The Council shall publish notice of an approved Programmatic Agreement in the *Federal Register* and make copies readily available to the public.

Failure to carry out terms of a Programmatic Agreement

(g) **Failure to carry out a Programmatic Agreement.** If the terms of a Programmatic Agreement are not carried out or if such an agreement is terminated, the Agency Official shall comply with Sections 800.4 through 800.6 with regard to individual undertakings covered by the agreement.

Coordination of §106 with other authorities

800.14 Coordination with other authorities.

To the extent feasible, Agency Officials, State Historic Preservation Officers, and the Council should encourage coordination of implementation of these regulations with the steps taken to satisfy other historic preservation and environmental authorities by:

Coordination with NEPA environmental studies

(a) Integrating compliance with these regulations with the processes of environmental review carried out pursuant to the National Environmental Policy Act, and coordinating any studies needed to comply with these regulations with studies of related natural and social aspects;

Multipurpose determinations and agreements

(b) Designing determinations and agreements to satisfy the terms not only of Section 106 and these regulations, but also the requirements of such other historic preservation authorities as the Archeological and Historic Preservation Act, the Archeological Resources Protection Act, Section 110 of the National Historic Preservation Act, and Section 4(f) of the Department of Transportation Act, as applicable, so that a single document can be used for the purposes of all such authorities;

Multipurpose studies and surveys

(c) Designing and executing studies, surveys, and other information-gathering activities for planning and undertaking so that the resulting information and data is adequate to meet the requirements of all applicable Federal historic preservation authorities; and

Coordinated public involvement

(d) Using established agency public involvement processes to elicit the views of the concerned public with regard to an undertaking and its effects on historic properties.

Agency's use of counterpart regulations to substitute for 36 CFR Part 800

800.15 Counterpart regulations.

In consultation with the Council, agencies may develop counterpart regulations to carry out the Section 106 process. When concurred in by the Council, such counterpart regulations shall stand in place of these regulations for the purposes of the agency's compliance with Section 106.