Section 4 – Other Water Supply Models/Studies

Content

a. 2006 Region O Water Plan
b. 2004 Water Texas Study
c. 2001 Black and Veatch Study
d. 2001 Region O Water Plan
e. 1999 Staff Water Planning Documents
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g. 1975 Plan for Additional Water Supply
h. 1971 Report on Water Supply
i. 1968 Interim Report on Water Supply

Summary

The City of Lubbock has had a history of completing water supply plans with the assistance of professional engineering firms. It is important that city staff and community leaders understand and use these studies and their projections. A review of the reports shows that Lubbock has had projections for future water supply needs. The challenges are to read and to understand what has been documented. If these documents were adequately understood, the water transmission line, pump stations and water treatment facility for Lake Alan Henry may have been constructed by now instead of being in the preliminary engineering phase.

The engineering projections of the past generally follow the 2007 water supply model. The 1999 Staff Report and the 2001 Region O Water Supply Plan, however, show very little increase in water supply demand for over 50 years while population increases from 204,026 to 271,152. In 2006 the City of Lubbock used 42,682 acre-feet. The 2001 Region O Water Supply Plan projected annual water use of 44,041 acre-feet after 50 years of continued growth. The basis for these projections is that a water conservation goal of 1% a year could offset population growth if historical growth patterns continue. The math for these projections is feasible, but they do not consider the feasibility, technically of mandating a 1% decline in water use for 50 continuous years.

Such a policy direction would require a significant educational effort and extensive community support. For Lubbock, it would involve eliminating most existing yards and gardens and moving towards a xeriscape type landscape or the drilling of wells for each home to remove the water use from the City's system.

One other significant point to recognize is that the 1992 Groundwater Management Study did project that Lubbock would have adequate water through the 2040 planning period, but that recommendation assumed that i) Lake Alan Henry would be constructed, and ii) water use from the Bailey County Well Field would be reduced to 3,400 acre-feet annually. The 2040 projection for an adequate water supply appears to have been taken from this report to show Lubbock had an adequate water supply, while the Lake Alan Henry project and the reduction in pumping from the Bailey County Well Field recommendations were dropped out of the discussion.

Lubbock has had a strong history of water planning. That effort must continue. The City Council and the Lubbock Water Commission must ensure a policy of professional water supply planning on the part of staff and professional engineers.

Section 4 – Other Water Supply Models/Studies

a. 2006 Region O Water Plan

Addendum Number 1
Llano Estacado Regional Water Plan
(Region O)

Pursuant to a request by the City of Lubbock to reexamine population projections, it was discovered that the Texas State Data Center had published a correction to 0.5 migration scenario projections for Lubbock County, based on corrected birth and survival rates, and corrections to special populations. The City of Lubbock thus presented a request to the LERWPG to add these increases to the originally-approved City of Lubbock projections.

The City of Lubbock also presented a request to use the TWDB-published GPCD from the year 1998 (209) as the base for calculating future water demands. It has been confirmed that 1998 had less rainfall than 2000, thus meeting the standard criteria for revision.

The City of Lubbock presented the information cited above to the LERWPG at the LERWPG's December 15, 2005 meeting. The LERWPG concurred with the City, approved the revised projections, and by letter of December 28, 2005, the LERWPG requested that the TWDB approve the revised projections for use in the 2006 Regional Water Plan. The original and revised projections are listed below:

Population Projections (Numbers of People)

	2000	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Original	199,564	210,658	218,471	222,680	223,370	226,395	224,074
Additions	0	6,316	9,525	12,471	16,221	16,436	24,548
Revised	199,564	216,974	227,996	235,151	239,591	242,831	248,622

Water Demand Projections (Acre-Feet)

	2000	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Original	40,460	41,765	42,580	42,652	42,033	42,349	41,915
Additions	0	8,057	9,007	9,764	10,567	10,691	12,390
Revised	40,460	49,822	51,587	52,416	52,600	53,040	54,305

Per Capita Water Use Projections (GPCD)

	2000/Base	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Original	181	177	174	171	168	167	167
Additions	28	28	28	28	28	28	28
Revised	209	205	202	199	196	195	195

In separate action on December 15, 2005, the LERWPG approved the 2006 Regional Water Plan and directed the High Plains Underground Water Conservation District No. 1, and its Consultant, HDR Engineering, Inc. to prepare and submit the approved 2006 Regional Water Plan, together with an addendum for the City of Lubbock based upon the revised Population and

4.5.15.3 The City of Lubbock

4.5.15.3.1 Description of Supply

- **Source:** Ogallala Aquifer and Lake Meredith
- **Current Supply:** Adequate to meet demands through 2015.

4.5.15.3.2 Water Supply Plan

Working within the planning criteria established by the Llano Estacado RWPG and TWDB, the following water supply plan is recommended for the City of Lubbock.

- Municipal water conservation, and
- Lake Alan Henry Pipeline
- City of Lubbock Well Field
- Lubbock Expand Bailey County Well Field
- CRMWA Expand Capacity of Groundwater Supply
- Lubbock Brackish Groundwater Desalination
- Jim Bertram Lake System Expansion, and
- Lubbock North Fork Scalping Operation.

4.5.15.3.3 Costs

Costs of the recommended plan for the City of Lubbock are:

a. Municipal water conservation:
    - Cost Source: Section 4.4.1 (Revised), Table 4.4-7 (Revised)
    - Date to be Implemented: Prior to 2010
    - Annual Cost: See Table 4.5-61 (Revised) for a cost summary of this option.

b. Lake Alan Henry Pipeline:
    - Cost Source: Section 4.4.3.2, Table 4.4-50
    - Date to be Implemented: Prior to 2020
    - Total Project Cost: $174,909,000
    - Annual Cost: See Table 4.5-61 (Revised) for a cost summary of this option.

c. City of Lubbock Well Field:
    - Cost Source: Section 4.4.3.3, Table 4.4-51
    - Date to be Implemented: Prior to 2010
    - Total Project Cost: $7,718,000
    - Annual Cost: See Table 4.5-61(Revised) for a cost summary of this option.

d. Lubbock Expand Capacity of Bailey County Well Field
   - Cost Source: Section 4.4.3.4, Table 4.4-52
   - Date to be Implemented: Prior to 2010
   - Total Project Cost: $2,541,000
   - Annual Cost: See Table 4.5-61 (Revised) for a cost summary of this option.

e. CRMWA Expand Capacity of Groundwater Supply
   - Cost Source: Section 4.4.3.5, Table 4.4-53
   - Date to be Implemented: Prior to 2010
   - Total Project Cost: ($59,052,000 to expand 31,659 acft/yr; annual cost is $6,843,000; Lubbock share of expansion is 37.058 percent of cost and quantity.)
   - Annual Cost: See Table 4.5-61 for a cost summary of this option.

f. Lubbock Brackish Groundwater Desalination
   - Cost Source: Section 4.4.3.6, Table 4.4-54
   - Date to be Implemented: 2020
   - Total Project Cost: $10,051,230
   - Annual Cost: See Table 4.5-61 (Revised) for a cost summary of this option.

g. Lubbock Jim Bertram Lake System Expansion
   - Cost Source: Section 4.4.3.7. Table 4.4-57
   - Date to be Implemented: 2020
   - Total Project Cost: $150,759,000
   - Annual Cost: See Table 4.5-61 (Revised) for a cost summary of this option.

h. Lubbock North Fork Scalping Operation
   - Cost Source: Section 4.4.3.8. Table 4.4-63
   - Date to be Implemented: 2045
   - Total Project Cost: $50,055,000
   - Annual Cost: See Table 4.5-61 (Revised) for a cost summary of this option.

Table 4.5-61. (Revised)
Recommended Plan Costs by Decade for the City of Lubbock

Plan Element	2010	2020	2030	2040	2050	2060
Projected Shortage (acft/yr)	0	557	2,853	4,855	6,886	9,681
Municipal Water Conservation (Strategy is included until the regional goal of 172 gpcd is reached)						
Quantity Available (acft/yr)	4,861	12,514	12,117	11,540	11,424	11,697
Annual Cost ($/yr) (millions)	$2.440	$5.925	$5.700	$5.389	$5.320	$5.447
Unit Cost ($/acft)	$502	$473	$470	$467	$465	$465
Lake Alan Henry Pipeline						
Quantity Available (acft/yr)	0	22,230	22,230	22,230	22,230	22,230
Annual Cost ($/yr) (millions)	—	$26.584	$26.584	$26.584	$26.584	$26.584
Unit Cost ($/acft)	—	$1,196	$1,196	$1,196	$1,196	$1,196
City of Lubbock Well Field						
Quantity Available (acft/yr)	5,600	5,600	5,600	5,600	5,600	5,600
Annual Cost ($/yr) (millions)	$1.644	$1.644	$1.644	$1.644	$1.644	$1.644
Unit Cost ($/acft)	$294	$294	$294	$294	$294	$294
Expand Bailey County Well Field						
Quantity Available (acft/yr)	5,600	5,600	5,600	5,600	5,600	5,600
Annual Cost ($/yr)	$213,000	$213,000	$213,000	$213,000	$213,000	$213,000
Unit Cost ($/acft)	$38	$38	$38	$38	$38	$38
CRMWA Expand Groundwater Supply (See 4.5.15.3.3e above)						
Quantity Available (acft/yr)	14,911	14,911	14,911	14,911	14,911	14,911
Annual Cost ($/yr) (millions)	$2.536	$2.536	$2.536	$2.536	$2.536	$2.536
Unit Cost ($/acft)*	$216	$216	$216	$216	$216	$216
Lubbock Brackish Groundwater Desalination						
Quantity Available (acft/yr)**	3,360	3,360	3,360	3,360	3,360	3,360
Annual Cost ($/yr) (millions)*	$1.700	$1.700	$1.700	$1.700	$1.700	$1.700
Unit Cost ($/acft)*	$506	$506	$506	$506	$506	$506
Lubbock Jim Bertram Lake System Expansion						
Quantity Available (acft/yr)**	0	21,200	21,200	21,200	21,200	21,200
Annual Cost ($/yr) (millions)*	—	$14.575	$14.575	$14.575	$14.575	$14.575
Unit Cost ($/acft)*	—	$688	$688	$688	$688	$688
Lubbock North Fork Scalping Operation						
Quantity Available (acft/yr)**	0	0	0	0	4,000	4,000
Annual Cost ($/yr) (millions)*	—	—	—	—	4.296	4.296
Unit Cost ($/acft)*	—	—	—	—	$1,074	$1,074

Table 4.5-90 (Revised).
Recommended Plan Costs by Decade for the City of Lubbock

Plan Element	2010	2020	2030	2040	2050	2060
Projected Shortage (acft/yr)	544	2,308	3,262	3,690	4,203	5,598
Municipal Water Conservation (Strategy is included until the regional goal of 172 gpcd is reached)						
Quantity Available (acft/yr)	4,861	12,514	12,117	11,540	11,424	11,697
Annual Cost ($/yr) (millions)	$2.440	$5.925	$5.700	$5.389	$5.320	$5.447
Unit Cost ($/acft)	$502	$473	$470	$467	$465	$465
Lake Alan Henry Pipeline						
Quantity Available (acft/yr)	0	22,230	22,230	22,230	22,230	22,230
Annual Cost ($/yr) (millions)	—	$26.584	$26.584	$26.584	$26.584	$26.584
Unit Cost ($/acft)	—	$1,196	$1,196	$1,196	$1,196	$1,196
City of Lubbock Well Field						
Quantity Available (acft/yr)	5,600	5,600	5,600	5,600	5,600	5,600
Annual Cost ($/yr) (millions)	$1.644	$1.644	$1.644	$1.644	$1.644	$1.644
Unit Cost ($/acft)	$294	$294	$294	$294	$294	$294
Expand Bailey County Well Field						
Quantity Available (acft/yr)	5,600	5,600	5,600	5,600	5,600	5,600
Annual Cost ($/yr)	$213,000	$213,000	$213,000	$213,000	$213,000	$213,000
Unit Cost ($/acft)	$38	$38	$38	$38	$38	$38
CRMWA Expand Groundwater Supply (See 4.5.15.3.3e above)						
Quantity Available (acft/yr)	14,911	14,911	14,911	14,911	14,911	14,911
Annual Cost ($/yr) (millions)	2.536	2.536	2.536	2.536	2.536	2.536
Unit Cost ($/acft)*	$216	$216	$216	$216	$216	$216
Lubbock Brackish Groundwater Desalination						
Quantity Available (acft/yr)**	3,360	3,360	3,360	3,360	3,360	3,360
Annual Cost ($/yr) (millions)*	1.700	1.700	1.700	1.700	1.700	1.700
Unit Cost ($/acft)*	$506	$506	$506	$506	$506	$506
Lubbock Jim Bertram Lake System Expansion						
Quantity Available (acft/yr)**	21,200	21,200	21,200	21,200	21,200	21,200
Annual Cost ($/yr) (millions)*	$14.575	$14.575	$14.575	$14.575	$14.575	$14.575
Unit Cost ($/acft)*	$688	$688	$688	$688	$688	$688
Lubbock North Fork Scalping Operation						
Quantity Available (acft/yr)**	0	0	0	0	4,000	4,000
Annual Cost ($/yr) (millions)*	—	—	—	—	$4.296	$4.296
Unit Cost ($/acft)*	—	—	—	—	$1,074	$1,074

Section 4 – Other Water Supply Models/Studies

b. 2004 Water Texas Study

WATERTEXAS™
Bridging resources and communities.

CITY OF LUBBOCK STRATEGIC WATER PLAN

MAY 10, 2004

WaterTexas, 5840 Balcones Drive, Suite 200, Austin, Texas 78731

INTRODUCTION

On March 5, 2003, the City of Lubbock engaged WaterTexas to evaluate and make recommendations on how the City of Lubbock can optimize existing and potential water supplies on a short-, mid-, and long-term basis.

Then, on July 24, 2003, the Lubbock City Council passed Resolution No. 2003-R0285 establishing the Lubbock Water Advisory Commission (Advisory Commission). Commensurate with the formation of the Advisory Commission, WaterTexas' scope of work was broadened to add an evaluation of the City's drought management capabilities in light of the current ongoing drought.

This Strategic Water Plan is the culmination of WaterTexas' work. It evaluates Lubbock's existing water supplies, associated infrastructure, and drought management capabilities, and proposes a strategy for the systematic and economical development of water supplies and infrastructure to meet Lubbock's needs over a 100-year period, starting with the immediate drought and moving forward, over the short-, mid-, and long-term.

In sum, the City of Lubbock is in good shape from a water resource standpoint for the 100–year period *if* it does the following:

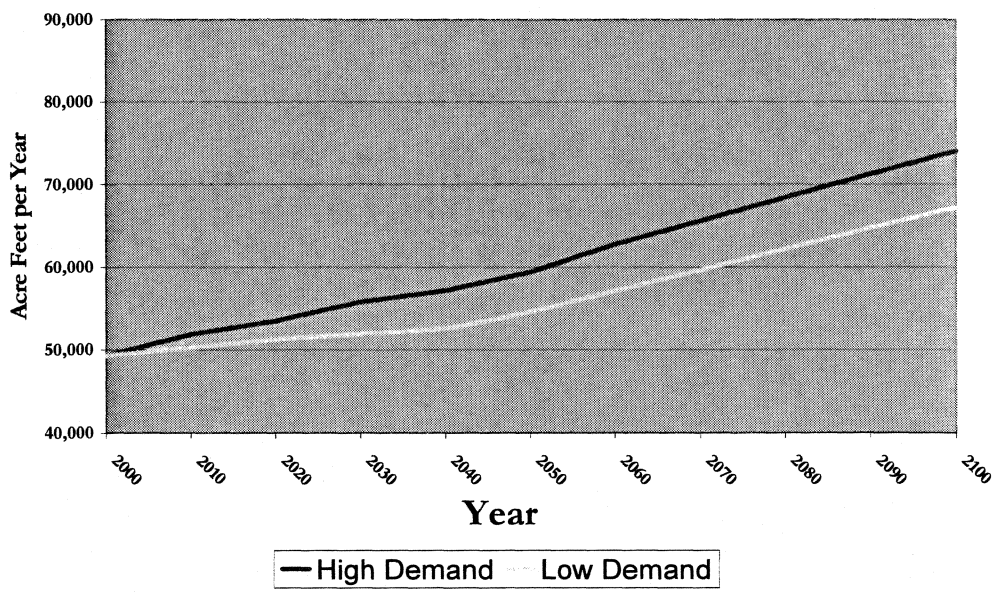
1. Addresses its maximum day capacity limitations;
2. Addresses its ability to respond readily to drought conditions at Lake Meredith; and,
3. Strategically develops additional supplies giving due consideration to demand, cost, opportunity, and competing budgetary needs.

PROJECTED WATER DEMAND

The Strategic Water Plan presents both a high water demand scenario and a low water demand scenario. The high water demand scenario represents the product of the high population projection multiplied by 220 GPCPD adjusted for the lower conservation rate of 7.7%. The low water demand scenario represents the product of the low population projection multiplied by 220 GPCPD adjusted for the higher conservation rate of 15%.

PROJECTED WATER DEMAND[4]				
Demand Calculations	2000	2020	2050	2100
High Population x GPCPD x 7.7% Conservation	49,307 af/yr	53,502 af/yr	59,434 af/yr	74,064 af/yr
Low Population x GPCPD x 15% Conservation	49,307 af/yr	51,226 af/yr	54,552 af/yr	67,168 af/yr

PROJECTED WATER DEMAND



[4] Unlike per capita use, projected water demand is traditionally calculated in acre-feet per year (af/yr).

Both the high and low water demand scenarios were evaluated as part of the preparation of the Strategic Water Plan. However, for the most part, the range between the two is insignificant. Therefore, the high water demand scenario is used in the Strategic Water Plan, except in a few of instances where inclusion of both scenarios is important to make a point.

SUMMARY OF RECOMMENDATIONS

The Strategic Water Plan recommends that the City of Lubbock take the following actions:

1. Conservation

- Implement conservation goals that are consistent with state water planning standards, and appropriate for a region experiencing a "drought of record."

- Initiate water conservations efforts that will enable Lubbock to reduce per capita water use, including strict conservation enforcement to prevent wasteful water use practices and the implementation of a conservation water rate structure.

2. Lake Meredith

- As the current drought progresses, monitor Lake Meredith lake levels and, if they continue to decline, work to recalculate Lake Meredith's firm annual yield to determine if more aggressive action is necessary.

3. Bailey County

- Prepare to increase production from the Bailey County well field.

- Immediately assess its ability to produce regularly at greater levels of longer duration and implement an appropriate repair and replacement program to ensure optimum operation during periods of increased production.

- Within the next 5 years, reevaluate the longevity of the Bailey County well field (e.g., verify the estimate of a 50 year life) and perform a cost-benefit analysis of adding or reworking wells to increase or maintain production over time.

- Within the next 5 years, study the possibility and feasibility of developing other groundwater resources in areas accessible to the Bailey County system's infrastructure.

4. Carson and Potter Counties (CRMWA)

- Immediately pursue through CRMWA the acquisition of up to 28,587 af/yr of groundwater rights along the CRMWA system in Carson and Potter Counties (Lubbock's share = 10,594 af/yr).

- If the groundwater rights are acquired, install the related infrastructure on an "as needed basis" probably between 2005 and 2012, but as soon as possible if the drought progresses.

5. Roberts County Phase I (CRMWA)

- If groundwater rights in Carson and Potter Counties are *not* timely acquired, immediately pursue through CRMWA the acquisition of up to 31,659 af/yr of additional groundwater rights in Roberts County (Lubbock's share = 11,733 af/yr).

- If groundwater rights in Carson and Potter Counties are timely acquired, delay the acquisition of additional groundwater rights in Roberts County for up to 15 years.

6. Local Groundwater

- Immediately convert all non-potable demands (e.g., parks, LISD) to local groundwater to the greatest extent economically feasible.

- By 2005, install membrane treatment at the Memphis & 82nd Reverse Osmosis Project Plant (PS 10) to develop at least 5 mgd of local groundwater as a potable supply.

- By 2005, develop a process whereby the City of Lubbock can obtain groundwater rights associated with new development.

- Within the next 5 years, determine the amount of recharge to local groundwater supplies, and evaluate the possibility of recharge enhancement and/or ASR.

7. Reuse

- By the end of 2004, seek to permit for reuse all of Lubbock's "developed water."

- Within the next five years, evaluate the improvements needed to achieve 100% reuse and the feasibility of implementing the Canyon Lakes Water Reuse Project.

8. Lake Alan Henry

- No later than 2012, conduct an evaluation process and commission a study to evaluate the necessity and feasibility of using Lake Alan Henry as a water supply in light of Lubbock's success at developing other water supplies in accordance with this Strategic Water Plan.

- If it is determined that Lubbock does not need the resource, immediately work to find a customer or buyer for the water and/or the lake.

- If it is determined that Lubbock needs the resource, commence the process of connecting it to the City's system with a lead time of at least 10 years.

- In either event, evaluate whether it is necessary and feasible to increase the lake's firm annual yield (e.g., by augmenting with return flows or groundwater from the Hancock Land Application Site).

9. Roberts County Phase II (CRMWA)

- If additional CRMWA supplies are not acquired to the point that CRWMA can maximize its system at all times, pursue through CRMWA the acquisition of enough additional groundwater rights in Roberts County to make up for any water supply deficits projected over the 100-year planning horizon, bearing in mind the capacity limitations of CRMWA's system.

Section 4 – Other Water Supply Models/Studies

c. 2001 Black and Veatch Study (Mesa Water)

CITY OF LUBBOCK

WATER SUPPLY EVALUATION

STATE OF TEXAS
GREGORY DEAN NELSON
60859
REGISTERED
PROFESSIONAL ENGINEER

Gregory Dean Nelson
4/12/01

STATE OF TEXAS
ROBERT HARDEN
79290
LICENSED
PROFESSIONAL ENGINEER

Robert Harden
4/12/01
(groundwater portions)

BLACK & VEATCH

APRIL 2001

PN 096216

1.3 Need for Additional Water Supply

The 2001 Water Distribution System Study included population and water use projections for Lubbock through the year 2050. As discussed in the Water Distribution Study, these projections are "design" projections for planning purposes and represent estimates of future water use during high demand (drought) years. Water use during normal years will be less than the "design" projections. This is considered reasonable for planning purposes, since water systems are generally designed to meet demands during drought-type conditions.

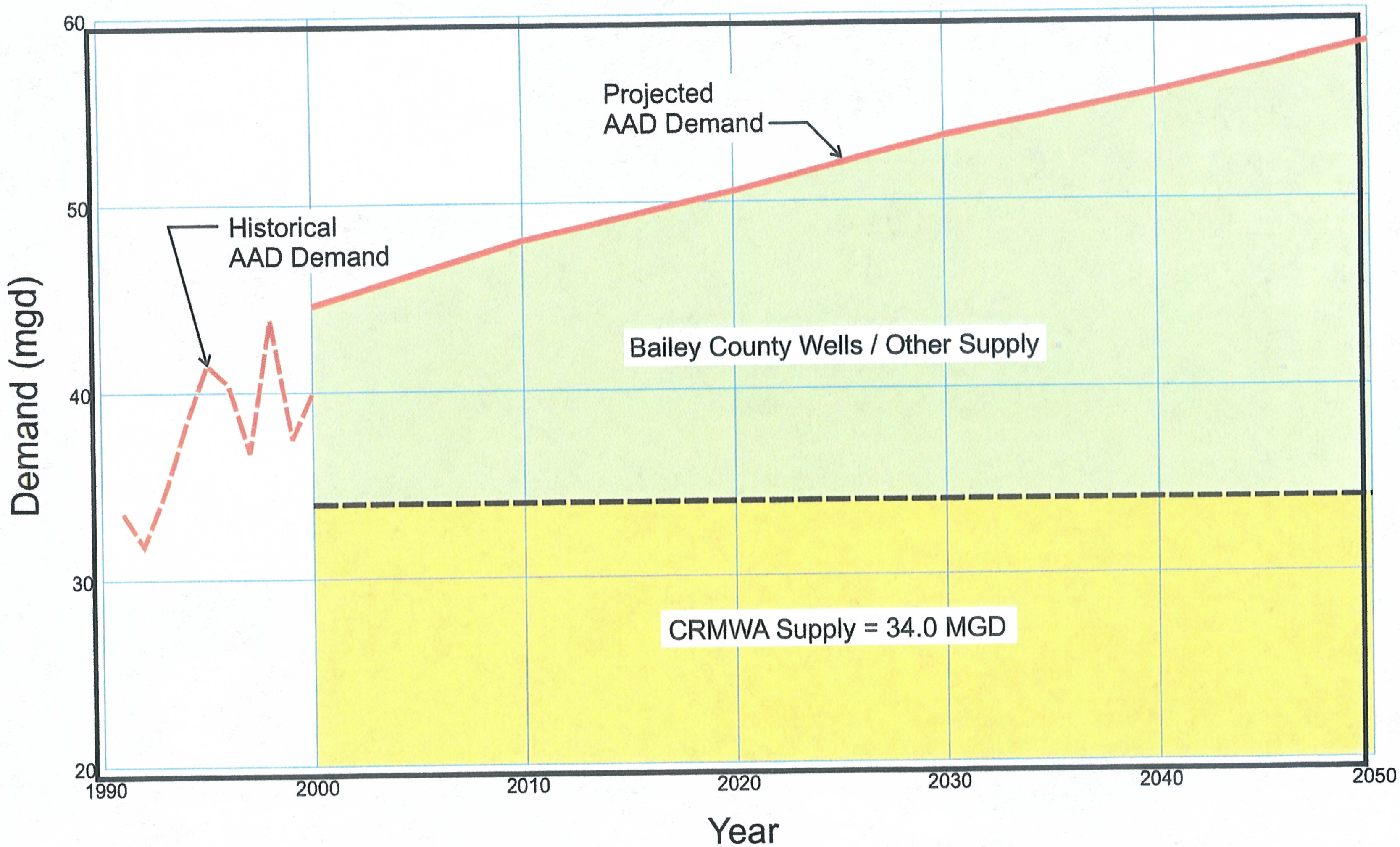
The projected AAD water use for Lubbock (from the 2001 Water Distribution Study) is shown in Table 1-2. These projections were based on a per capita use rate of 220 gallon per capita per day and do not include the long-term impacts (which are difficult to predict) of any conservation efforts to reduce per capita water use. As shown in Table 1-2, the projected AAD water use is 58.3 mgd by the year 2050.

Table 1-2
Projected AAD Water Use

Year	AAD Water Use (mgd)
2010	48.0
2020	50.5
2030	53.4
2040	55.8
2050	58.3

Figure 1-1 shows the projected AAD demands, along with the AAD supply capacity (34.0 mgd) available from CRMWA. As shown on Figure 1-1, the projected water use for year 2050 will exceed the CRMWA supply capacity by about 24.3 mgd. This means that the Bailey County wells (or other supply sources such as local wells) must supply 24.3 mgd (on an AAD basis) to meet projected water demands in 2050. Without obtaining water from new sources, the City would have to meet future AAD use by increasing pumpage from the Bailey County well field.

KEELING DISK1104 LUBBOCK
PROJECTED AAD DEMANDS AND WATER SUPPLY CAPACITIES.CDR 04/1101



BLACK & VEATCH

Projected Annual Average Day Demands and Water Supply Capacities

Figure No. 1-1

Section 4 – Other Water Supply Models/Studies

d. 2001 Region O Water Plan

Llano Estacado Regional Water Planning Area

Regional Water Plan

Prepared for

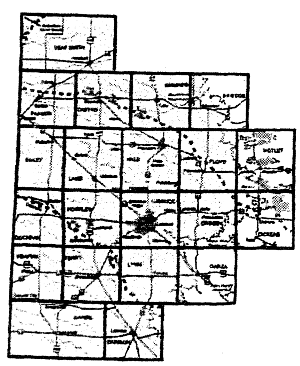
Texas Water Development Board

Prepared by

Llano Estacado Regional Water Planning Group

With administration by

High Plains Underground Water Conservation District No. 1



With technical assistance by

HDR

HDR Engineering, Inc.
Austin, Texas

January 2001

1.10.3.5 City of Littlefield [62]

The City of Littlefield owns, operates, and manages the water works system. The city's waterworks system serves approximately 2,921 connections. The majority of these connections are within the city limits of Littlefield. However, a few of the customers live outside the corporate limits of the city. The waterworks system covers approximately 3.5 square miles. Over the past several years the city has experienced moderate growth. The city's water works system has not been exceeded in its available capacity to supply the customers' demand. Littlefield is considering obtaining additional water rights to assure future water for its customers. From the Utility Evaluation, the City of Littlefield has set a goal of per capita water use reduction of 15 percent.

The City of Littlefield's Emergency Water Demand Management Plan contains trigger conditions to stipulate when water use should be curtailed. The plan includes restrictions on lawn watering, car washing, and certain public water uses that are not essential for public health or safety.

1.10.3.6 City of Lubbock [63]

The purpose of the City of Lubbock's Water Conservation Plan is to promote the responsible use of water by (1) supporting public education programs, (2) maintaining policies that support wise use of water, and (3) providing for enforcement of water conservation policies and practices. It is the goal of the Plan to reduce water usage by 20 gpcd by the year 2014. To achieve this goal, the City of Lubbock will continue its programs for universal metering and controlling unaccounted-for uses of water, as well as continue the city's program of continuing education regarding water conservation.

The City of Lubbock's Drought Contingency Plan outlines the city's drought and emergency contingency procedures and identifies the triggering criteria for initiation and termination of the four water shortage conditions, as well as the water use restrictions in effect during times of water shortages. The plan contains restrictions on water use to be in effect

[62] Oller Engineering, Inc. for the City of Littlefield, "Water Conservation Plan and Drought Contingency Plan," March 1997.
[63] City of Lubbock, "Water Conservation Plan," August 26, 1999, and "Drought Contingency Plan," August 26, 1999.

during water shortages that include irrigation of landscaped areas, use of water to wash any motor vehicle, operation of any ornamental fountain or pond, and other restrictions on outdoor water use. Water uses regulated or prohibited under this plan are considered to be non-essential and continuation of such uses during times of water shortage or other emergency water supply conditions are deemed to constitute a waste of water which subjects the offender to penalties such as fines or discontinuance by the city of water services to water utility customers or other users.

1.10.3.7 City of Plainview [64]

The City of Plainview's Conservation and Drought Contingency Plan outlines ordinances the city has put into effect to reduce per capita use and to curtail water use during times of drought. In order to lower the city's per capita water use the city has adopted a plumbing code that limits residential meters to 1-inch or smaller, has initiated a water meter retrofit program, provides educational materials on water conserving landscaping, and maintains a leak detection and repair program.

The city's drought contingency plan outlines the city's drought response procedures. The plan contains restrictions on water use to be in effect during water shortages that include irrigation of landscaped areas, use of water to wash any motor vehicle, and other restrictions on outdoor water use.

1.10.3.8 City of Seminole [65]

The City of Seminole operates a water system for approximately 2,400 utility customers. It has the capability of producing 5.5 mgd of potable water from 18 wells in the Ogallala Aquifer system. Seven of these wells are located inside the city limits with the other eleven scattered over five sections of land. All wells are included in a computerized water automation system in which radio signals sent to a computer control the levels of water in the groundwater storage and elevated storage tanks along with the operation of the wells. This system also allows the city to sequence the wells desired so that different wells turn on at different times and under different conditions.

[64] Freese & Nichols for the City of Plainview, "Drought Contingency Plan," July 26, 1994.
[65] Information transmitted in a letter received from the City of Seminole dated October 26, 1999.

Table 2-3 (continued)

Basin/County/City/Rural	Total in 1990	Total in 1996	Projections 2000	2010	2020	2030	2040	2050
Floyd (part)								
Floydada	3,896	3,875	4,051	4,297	4,437	4,435	4,319	4,195
Lockney	2,207	2,131	2,286	2,418	2,485	2,408	2,262	2,125
Rural	1,496	1,495	1,532	1,628	1,689	1,737	1,742	1,738
Total	7,599	7,501	7,869	8,343	8,611	8,580	8,323	8,058
Garza (part)								
Post	3,768	3,611	3,924	4,126	4,204	4,108	3,986	3,868
Rural	1,370	1,338	1,373	1,442	1,467	1,432	1,386	1,294
Total	5,138	4,949	5,297	5,568	5,671	5,540	5,372	5,162
Hale (part)								
Abernathy (part)	2,132	2,082	2,279	2,424	2,567	2,668	2,705	2,742
Hale Center	2,067	2,088	2,157	2,292	2,426	2,521	2,457	2,395
Petersburg	1,292	1,287	1,514	1,743	1,944	2,145	2,306	2,479
Plainview	21,700	22,063	22,469	23,055	23,805	23,959	23,465	22,981
Rural	7,434	8,762	8,773	10,026	11,136	12,230	13,180	14,114
Total	34,625	36,282	37,192	39,540	41,878	43,523	44,113	44,711
Hockley (part)								
Anton	1,212	1,253	1,350	1,397	1,474	1,478	1,455	1,432
Levelland	13,986	13,998	15,609	16,271	16,744	16,505	16,056	15,619
Rural	6,806	6,770	7,136	7,579	7,894	7,881	7,764	7,260
Total	22,004	22,021	24,095	25,247	26,112	25,864	25,275	24,311
Lamb (all)								
Amherst	742	748	722	684	634	587	568	554
Earth	1,228	1,352	1,282	1,373	1,446	1,492	1,539	1,587
Littlefield	6,489	6,395	6,751	7,232	7,584	7,772	7,940	8,112
Olton	2,116	2,107	2,177	2,331	2,449	2,516	2,580	2,625
Sudan	983	971	1,020	1,090	1,141	1,163	1,169	1,175
Rural	3,514	3,589	3,749	4,102	4,412	4,620	4,817	4,881
Total	15,072	15,162	15,701	16,812	17,666	18,150	18,613	18,934
Lubbock (all)								
Abernathy (part)	588	649	852	966	1,069	1,159	1,238	1,322
Idalou	2,074	2,116	2,286	2,507	2,789	3,166	3,310	3,461
Lubbock	186,206	194,188	204,026	220,707	236,144	249,249	259,970	271,152
New Deal	521	609	586	605	611	640	678	715
Ransom Canyon	763	888	942	1,008	1,060	1,138	1,238	1,338
Reese AFB	1,263	1,319	1,263	1,263	1,263	1,263	1,263	1,263
Shallowater	1,708	2,001	2,018	2,213	2,462	2,792	2,918	3,050
Slaton	6,078	6,199	6,481	6,683	6,884	7,816	8,316	8,848
Wolfforth	1,941	2,372	2,390	2,621	2,916	3,309	3,458	3,614
Rural	21,494	23,155	21,993	23,122	24,025	23,512	23,649	21,021
Total	222,636	233,496	242,837	261,695	279,223	294,044	306,038	315,784

Continued on next page

Table 2-21 (continued)

Basin/County/City/Rural	Total in 1990 (acft)	Total in 1996 (acft)	Projections (acft)					
			2000	2010	2020	2030	2040	2050
Hockley County (part)								
Anton (Municipal)	200	201	263	258	258	253	243	237
Levelland (Municipal)	2,377	1,954	2,518	2,479	2,401	2,311	2,176	2,099
Rural (Municipal)	771	896	895	891	867	830	791	732
Total Municipal Demand	3,348	3,051	3,676	3,628	3,526	3,394	3,210	3,068
Industrial Demand	67	55	82	98	117	138	161	188
Steam-Electric Power Demand	0	0	0	0	0	0	0	0
Irrigation Demand	83,764	155,345	87,554	84,130	80,840	77,680	74,641	71,723
Mining Demand	2,465	3,953	4,770	4,088	3,435	2,890	2,446	2,032
Beef Feedlot Livestock Demand	331	269	281	326	379	418	462	510
Range & All Other Livestock Demand	199	204	207	219	229	240	252	265
Total Demand	90,174	162,877	96,570	92,489	88,526	84,760	81,172	77,786
Lamb County (all)								
Amherst (Municipal)	147	152	155	140	124	112	106	102
Earth (Municipal)	312	277	320	325	326	331	334	343
Littlefield (Municipal)	1,010	1,430	1,165	1,175	1,164	1,158	1,156	1,172
Olton (Municipal)	457	513	585	598	598	606	610	617
Sudan (Municipal)	283	207	313	320	320	322	318	319
Rural (Municipal)	443	498	487	504	514	523	532	536
Total Municipal Demand	2,652	3,077	3,025	3,062	3,046	3,052	3,056	3,089
Industrial Demand	753	448	711	655	593	593	593	593
Steam-Electric Power Demand	12,587	13,686	18,000	18,000	25,000	25,000	25,000	30,000
Irrigation Demand	351,050	381,379	288,370	277,244	266,546	256,261	246,373	236,867
Mining Demand	76	125	138	107	97	94	92	95
Beef Feedlot Livestock Demand	1,502	1,747	1,827	2,121	2,461	2,718	3,003	3,317
Range & All Other Livestock Demand	400	423	432	467	504	537	572	612
Total Demand	369,020	400,885	312,503	301,656	298,247	288,255	278,689	274,573
Lubbock County (all)								
Abernathy (part) (Municipal)	109	133	149	159	168	177	184	195
Idalou (Municipal)	356	380	423	438	459	507	523	543
Lubbock (Municipal)	36,656	40,225	38,394	39,556	40,206	41,600	42,516	44,041
New Deal (Municipal)	96	105	106	104	100	102	105	110
Ransom Canyon (Municipal)	162	222	215	220	221	232	247	265
Reese AFB (Municipal)	657	750	662	638	615	610	606	603
Shallowater (Municipal)	325	352	364	377	397	438	448	468
Slaton (Municipal)	865	756	915	891	864	946	969	1,021
Wolfforth (Municipal)	337	375	391	402	421	467	476	494
Rural (Municipal)	2,779	4,587	2,619	2,562	2,495	2,328	2,222	1,945
Total Municipal Demand	42,342	47,885	44,238	45,347	45,946	47,407	48,296	49,685
Industrial Demand	1,469	1,797	1,704	2,071	2,106	2,230	2,572	2,923
Steam-Electric Power Demand	1,715	1,171	2,000	2,000	5,000	5,000	5,000	5,000
Irrigation Demand	230,717	242,533	158,078	149,158	140,785	132,881	125,421	118,381
Mining Demand	191	1,255	446	364	298	243	199	162
Beef Feedlot Livestock Demand	689	807	843	979	1,136	1,255	1,386	1,531
Range & All Other Livestock Demand	503	562	588	817	893	979	1,078	1,191
Total Demand	277,626	296,010	207,897	200,736	196,164	189,995	183,952	178,873

Table 4-15
Projected Water Demands, Supplies, and Needs
Lubbock County
Llano Estacado Region

Basin		Source	Total in 1990 (acft)	Total in 1996 (acft)	Projections 2000 (acft)	2010 (acft)	2020 (acft)	2030 (acft)	2040 (acft)	2050 (acft)
WATER SUPPLIES										
	Brazos Basin									
	Aquifer Natural Recharge/Irrig. Recirculation[1]				125,753	125,753	125,753	125,753	125,753	125,753
	Aquifer Storage[2]	Net Depletion			46,536	41,882	37,694	33,925	30,532	27,479
	Subtotal GW (Ogallala)[3]				172,289	167,635	163,447	159,678	156,285	153,232
	Other Ground	Ogallala (CRMWA - Roberts Co.)			15,453	15,453	15,453	15,453	15,453	15,453
	Local Surface	Stock Tanks and Windmills			587	819	894	978	1,081	1,192
	Other Surface	Lake Meredith (CRMWA)			29,362	29,362	29,362	29,362	29,362	29,362
	Other Surface	Lake Alan Henry			0	0	0	0	29,900	29,900
	Reclaimed Water (Lubbock-Electric Power)[4]				4,799	4,944	5,025	5,200	5,314	5,505
	Reclaimed Water (Lubbock-Irrigation)[4]				9,599	9,890	10,053	10,400	10,630	11,010
	Reclaimed Water[7]				3,173	3,173	3,173	3,173	3,173	3,173
	Total Supply				235,262	231,276	227,407	224,244	251,198	248,827
	Total Demand from Ogallala				152,826	144,002	134,209	125,974	118,603	111,362
WATER DEMANDS										
Municipal Demand										
Brazos Basin										
Abernathy (part)			109	133	149	159	168	177	184	195
Idalou			356	380	423	438	459	507	523	543
Lubbock			36,656	40,225	38,394	39,556	40,206	41,600	42,516	44,041
New Deal			96	105	106	104	100	102	105	110
Ransom Canyon			162	222	215	220	221	232	247	265
Reese AFB Community			657	750	662	638	615	610	606	603
Shallowater			325	352	364	377	397	438	448	468
Slaton			865	756	915	891	864	946	969	1,021
Wolfforth			337	375	391	402	421	467	476	494
Rural			2,779	4,587	2,619	2,562	2,495	2,328	2,222	1,945
	Subtotal		42,342	47,885	44,238	45,347	45,946	47,407	48,296	49,685
Total Municipal Demand			42,342	47,885	44,238	45,347	45,946	47,407	48,296	49,685
Municipal Existing Supply										
Brazos Basin										
Abernathy (part)		Ogallala			149	159	0	0	0	0
Idalou		Ogallala			423	438	0	0	0	0
Lubbock		Lake Meredith (CRMWA)[5]			27,712	27,712	27,712	27,712	27,712	27,712
		Ogallala (CRMWA - Roberts Co.)[5]			14,823	14,823	14,823	14,823	14,823	14,823
		Lake Alan Henry			0	0	0	0	29,900	29,900
		Ogallala (Bailey County)[6]			7,016	7,273	7,426	7,710	7,897	8,205
Lubbock Subtotal					49,551	49,808	49,961	50,245	80,332	80,640
New Deal		Ogallala			106	104	0	0	0	0
Ransom Canyon		Lubbock (Lake Meredith)			265	265	265	265	265	265
Reese Center		Lubbock (Ogallala)			662	638	615	610	606	603
Shallowater		Lubbock (Lake Meredith)			187	187	187	187	187	187
		Ogallala			177	190	0	0	0	0
Shallowater Subtotal					364	377	187	187	187	187
Slaton		Lake Meredith (CRMWA)[5]			1,198	1,198	1,198	1,198	1,198	1,198
		Ogallala (CRMWA - Roberts Co.)[5]			630	630	630	630	630	630
Slaton Subtotal					1,828	1,828	1,828	1,828	1,828	1,828
Wolfforth		Ogallala			391	402	0	0	0	0
Rural		Ogallala			2,619	2,562	2,495	2,328	2,222	1,945
	Subtotal				56,358	56,581	55,351	55,463	85,440	85,468
Total Municipal Existing Supply					56,358	56,581	55,351	55,463	85,440	85,468
Municipal Surplus/Shortage										
Brazos Basin										
Abernathy (part)					0	0	-168	-177	-184	-195
Idalou					0	0	-459	-507	-523	-543
Lubbock					11,157	10,252	9,755	8,645	37,816	36,599
New Deal					0	0	-100	-102	-105	-110
Ransom Canyon					50	45	44	33	18	0
Reese Center					0	0	0	0	0	0
Shallowater					0	0	-210	-251	-261	-281
Slaton					913	937	964	882	859	807
Wolfforth					0	0	-421	-467	-476	-494
Rural					0	0	0	0	0	0
	Subtotal				12,120	11,234	9,405	8,056	37,144	35,783
Total Municipal Surplus/Shortage					12,120	11,234	9,405	8,056	37,144	35,783

5.2 Long-term Water Management Strategies

5.2.1 Interconnect Cities and Industries (Sources of Water to Include Lake Alan Henry and Post Reservoir)

5.2.1.1 Description of Option

This option would include the construction of a pipeline from Lake Alan Henry, which has a firm yield of 29,900 acft/yr, to the City of Lubbock (Figure 5-10). A second pipeline would be constructed from the proposed Post Reservoir, which would have a firm yield of approximately 9,500 acft/yr, and tie into the pipeline from Lake Alan Henry to Lubbock (Figure 5-10). A new 36-MGD surface water treatment plant would need to be constructed to treat this new supply (Figure 5-10). For purposes of this evaluation, the water treatment is assumed to be located near the southeast corner of Lubbock. The treated water could be utilized by the City of Lubbock as an additional source, or the city could sell this water to its existing customers or new customers within the Lubbock general area. This pipeline could be interconnected with the Mackenzie Municipal Water Authority distribution line and/or the White River Municipal Water District distribution line, in which case the water treatment plant would need to be located at the lakes. However, for this option the pipeline is assumed to terminate at a new water treatment plant near Lubbock.

5.2.1.2 Quantity of Water Available

The quantity available for this option is the sum of the yields of Lake Alan Henry and the proposed Post Reservoir, which is 38,500 acft/yr (29,000 + 9,500).

5.2.1.3 Environmental Issues

The environmental issues associated with this option are for pipeline rights-of-way and sites for water treatment plant and storage facilities. Since routes and sites can be selected to avoid sensitive wildlife habitat and cultural resources, there would be very little, if any, environmental issues of significant concern.

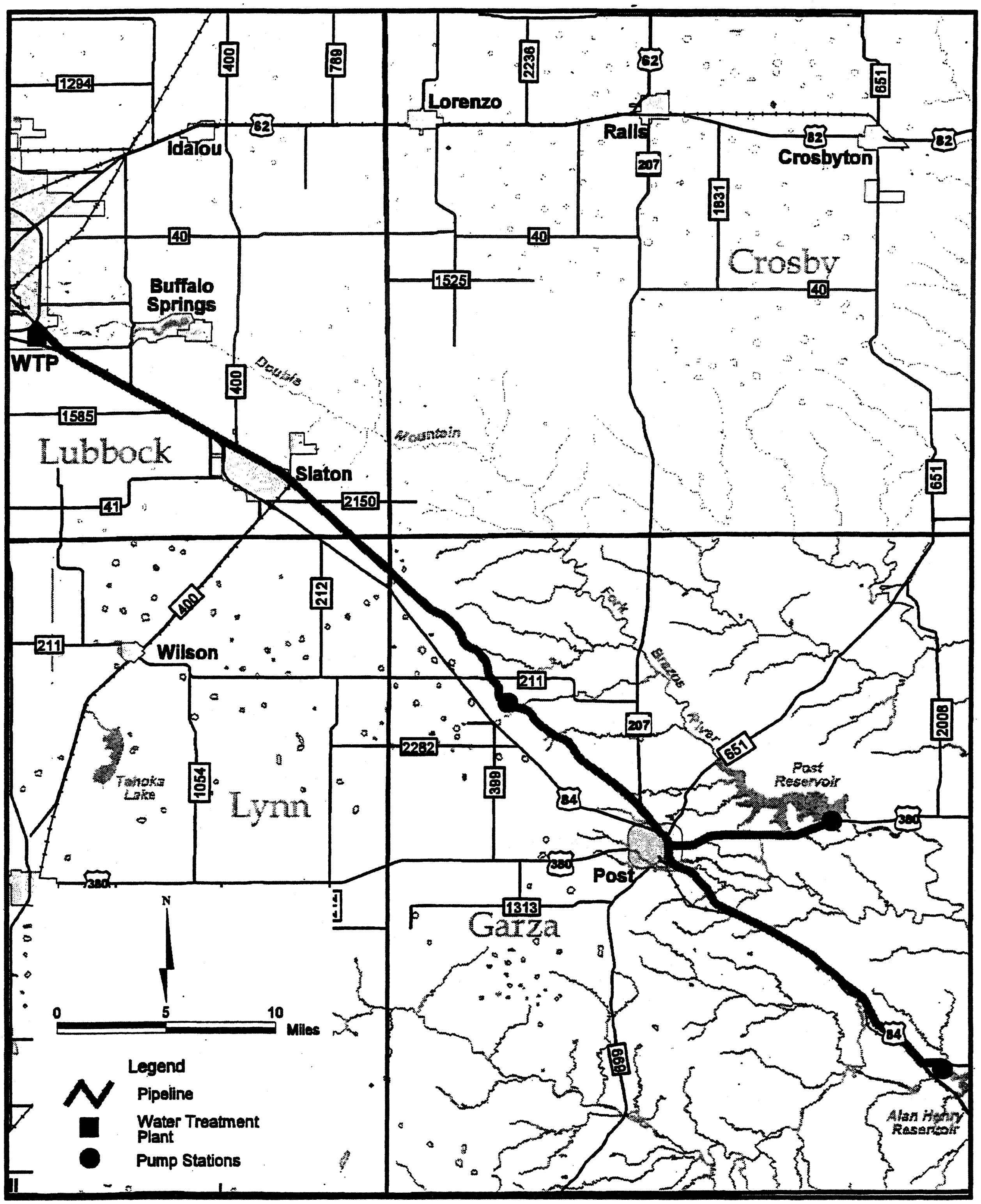


Figure 5-10. Lake Alan Henry/Post Reservoir Pipeline

5.2.1.4 Costing

Costs for this option include the raw water transmission pipeline, surface water treatment plant, and other project costs that include engineering costs, land acquisition, and interest during construction. The following assumptions and conditions were used in the costing of this option.

- The firm yield of Lake Alan Henry is 29,000 acft. The pipeline from Lake Alan Henry to near Post Reservoir is sized to transport the full firm yield amount.
- The firm yield of the proposed Post Reservoir is approximately 9,500 acft/yr. The pipeline from Post Reservoir to the Lake Alan Henry pipeline is sized to transport the full firm yield amount.
- The new surface water treatment plant has a capacity of 36 MGD (sized to treat the firm yield of both reservoirs).
- Cost of land for pipeline easements is $8,712 per acre. Cost of land for pump stations, storage tanks, and a water treatment plant is $1,500 per acre.
- The costs given are for treated water at the new water treatment plant and do not include costs associated with transporting the treated water from the water treatment plant to the end users.
- The costs for raw water from Lake Alan Henry are $148 per acft.
- The costs for raw water from Post Reservoir are $214 per acft.
- Engineering, legal costs, and contingencies are calculated as 30 percent of the construction costs for pipelines and 35 percent for all other facilities.
- Environmental and archeological studies, mitigation, and permitting costs are calculated as 100 percent of the land cost.
- Interest during construction is calculated with a 6 percent interest rate and a 4 percent annual rate of return for a period of 5 years.

The total project cost for this option was estimated at $117,248,000 (Table 5-67). Financing the project for 30 years at 6 percent annual interest results in an annual expense of $8,518,000 for debt service (Table 5-67). Annual O&M costs total $14,871,000 (Table 5-67). The total annual cost, including debt service, raw water cost, O&M cost, and power cost, totals $23,389,000 (Table 5-67). For an annual delivery of 39,400 acft/yr, the resulting cost of treated water at the water treatment plant is $594 per acft (Table 5-67). This is the cost of treated water at the water treatment plant and does not include costs associated with transporting the water from the water treatment plant.

Table 5-67.
Cost Estimate Summary for
Lake Alan Henry and Post Reservoir Regional Pipeline (39,400 acft/yr)
Llano Estacado Region

Item	Estimated Cost for Facilities (2nd quarter 1999)
Capital Costs	
Pump Stations (4)	$13,450,000
Pump Station Power Connection Cost	1,621,000
Intake Stations (2)	2,282,000
Transmission Pipeline (48 in dia, 47.5 miles)	19,076,000
Transmission Pipeline (42 in dia, 41.0 miles)	15,922,000
Transmission Pipeline (20 in dia, 33.0 miles)	1,830,000
Water Treatment Plant (36 MGD)	15,146,000
Water Storage Tanks (4)	3,249,000
Road Crossings	13,000
Total Capital Cost	**$72,589,000**
Engineering, Legal Costs and Contingencies	$23,565,000
Environmental Studies and Permitting	2,344,000
Land Acquisition and Surveying (284 acres)	2,578,000
Interest During Construction (4 years)	16,172,000
Total Project Cost	**$117,248,000**
Annual Costs	
Debt Service (6 percent for 30 years)	$8,518,000
Pipeline and Storage Tank Operation and Maintenance	401,000
Pump Station Operation and Maintenance	336,000
Water Treatment Plant Operation and Maintenance	2,590,000
Purchase of Water (39,400 acft/yr)[1]	6,458,000
Pumping Energy Costs (84,761,700 kW-hr @ $0.06/kW-hr)	5,086,000
Total Annual Cost[1]	**$23,389,000**
Available Project Yield (acft/yr)	**39,400**
Annual Cost of Water ($ per acft)[2]	**$594**
Annual Cost of Water ($ per 1,000 gallons)[2]	**$1.82**

[1] Cost of raw water at Lake Alan Henry is $148 per acft, and at Post Reservoir is $214 per acft.
[2] Reported Annual Cost of Water is for treated water at the water treatment plant and does not include costs associated with distribution within municipal systems.

5.2.1.5 Implementation Issues

Implementation of this option will require the development of a regional water supply system, including customers and terms and conditions between customers and the regional supplier. The regional supplier will need to arrange financing, secure the water from the owners of the reservoirs, obtain rights-of-way and sites for facilities, secure state and federal permits for stream crossings, perform environmental and cultural resources studies, and provide mitigation for any environmental and cultural resources that might be affected.

5.2.2 Import Water[61]

5.2.2.1 Description of Option

This option would divert water from as many as six sources located in Arkansas and Texas and transport this water via an open canal to a terminal storage facility located on the White River in Blanco Canyon about five miles south of U.S. Highway 82 near Crosbyton, Texas.[62] The proposed pipeline alignment is shown in Figure 5-11. Four of the potential water supply sources are located in Arkansas (White River at Clarendon, Arkansas River at Pine Bluff, Ouachita River at Camden, and the Red River at Fulton) and two potential water supply sources are located in Texas (Sabine River at Tatum and the Sulphur River at Darden). This water would primarily be used as a new source of irrigation supply for parts of Texas, New Mexico, and Oklahoma. The amount of water needed by each state to restore and maintain lands that would go out of irrigated production between 1977 and 2020 due to a declining water level in the Ogallala Aquifer was used as a target delivery rate for this option. The states of Texas, New Mexico, and Oklahoma have a combined quantity of 1.16 million acft/yr needed to restore and maintain those irrigation lands which would go out of production by 2020.

[61] This report section is a summary of information contained in the "Six-State High Plains-Ogallala Aquifer Regional Resources Study – A Report to the U.S. Department of Commerce and the High Plains Study Council" conducted by Camp Dresser & McKee, Inc., Black & Veatch, and Arthur D. Little, Inc., March 1982.
[62] Mr. Fred Kuntz, of Dimmitt, Texas has identified an import strategy that would move water from Toledo Bend Reservoir of the Sabine River Basin to the Llano Estacado Region. However, this strategy has not been analyzed due to lack of technical data needed to make cost, environmental, and implementation analyses.

5.3.15 Lubbock County Water Supply Plan

Table 5-129 lists each water user group in Lubbock County and its corresponding surplus or shortage in years 2030 and 2050. For each water user group with a projected shortage, a water supply plan has been developed and is presented in the following subsections.

Table 5-129.
Lubbock County Surplus/Shortage

Water User Group	Surplus/Shortage[1]		Comment
	2030 (acft/yr)	2050 (acft/yr)	
City of Abernathy			See Hale County
City of Idalou	-507	-543	Projected shortage – see plan below
City of Lubbock	9,255	37,202	Projected surplus
City of New Deal	-102	-110	Projected shortage – see plan below
City of Ransom Canyon	33	0	Projected surplus
City of Reese Center	0	0	No projected surplus/shortage
City of Shallowater	-251	-281	Projected shortage – see plan below
City of Slaton	882	807	Projected surplus
City of Wolfforth	-467	-494	Projected shortage – see plan below
County Other	0	0	No projected surplus/shortage
Industrial	0	0	No projected surplus/shortage
Steam Electric	200	505	Projected surplus
Mining	0	0	No projected surplus/shortage
Irrigation	0	0	No projected surplus/shortage
Beef Feedlot Livestock	0	0	No projected surplus/shortage
Range & All Other Livestock	0	0	No projected surplus/shortage

[1] From Table 4-15, Section 4.1 – Water Needs Projections by Water User Group.

* Computations are at the county level of detail, and although the county data show a surplus or shortage, there no doubt are individual water users of each county who have a shortage when the county shows an overall surplus; e.g., the projected surplus water is not located such that those who have shortages can obtain it.

Section 4 – Other Water Supply Models/Studies

e. 1999 Staff Water Planning Documents

CITY OF LUBBOCK 50-YEAR WATER PLAN
YEAR 2000 - YEAR 2050

HIGH PROJECTIONS - WITH NO WATER CONSERVATION MEASURES

YEAR	LUBBOCK POPULATION PROJECTIONS	GALLONS PER CAPITA PER DAY (GPCD)	PROJECTED WATER DEMAND		SOURCES TO MEET DEMAND							
					CRMWA*		SANDHILLS WELL FIELD		LAKE ALAN HENRY		LOCAL WELL FIELDS	
			GALLONS	ACRE-FEET	GALLONS	ACRE-FEET	GALLONS	ACRE-FEET	GALLONS	ACRE-FEET	GALLONS	ACRE-FEET
2000	199,564	198	14,644,609,000	44,943	12,223,065,000	37,511	2,424,057,000	7,439	0	0	0	0
2010	214,982	192	15,293,064,464	46,933	14,007,449,000	42,987	785,615,464	2,411	0	0	500,000,000	1,534
2020	230,514	192	16,442,863,278	50,461	14,007,449,000	42,987	1,435,414,278	4,405	0	0	1,000,000,000	3,069
2030	247,168	192	17,582,633,771	53,959	14,007,449,000	42,987	693,796,193	2,129	2,081,388,578	6,388	800,000,000	2,455
2040	265,025	192	18,904,572,321	58,016	14,007,449,000	42,987	1,124,280,830	3,450	3,372,842,491	10,351	400,000,000	1,228
2050	284,172	192	20,214,981,180	62,037	14,007,449,000	42,987	1,476,883,045	4,532	4,430,649,135	13,597	300,000,000	921
50-Year Cumulative Total			870,068,406,406	2,670,142	703,649,669,406	2,159,422	69,076,645,298	211,988	70,024,981,727	214,899	28,000,000,000	85,929

CITY OF LUBBOCK 50-YEAR WATER PLAN
YEAR 2000 - YEAR 2050

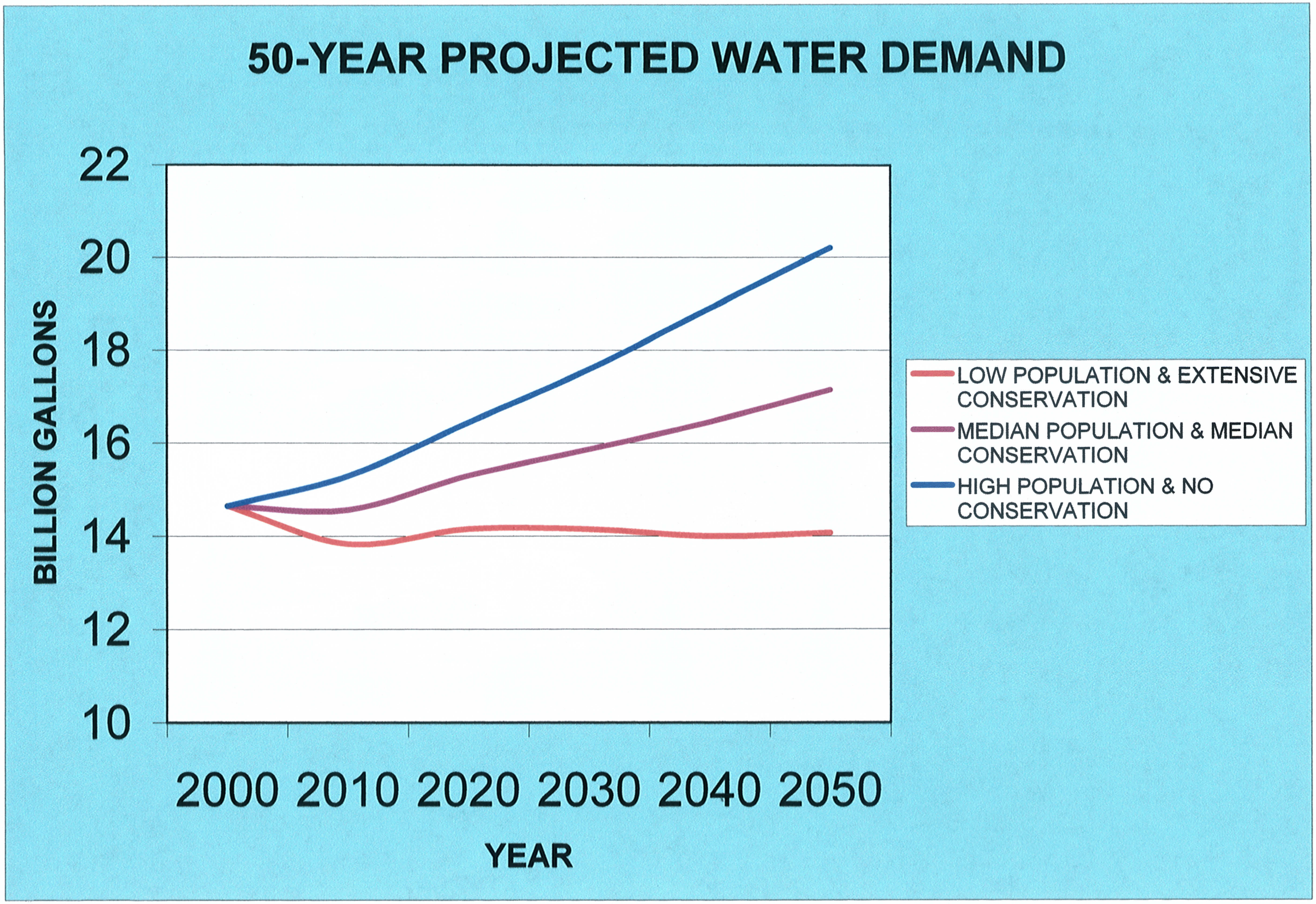
MEDIAN PROJECTIONS

YEAR	LUBBOCK POPULATION PROJECTIONS	GALLONS PER CAPITA PER DAY (GPCD)	PROJECTED WATER DEMAND		SOURCES TO MEET DEMAND							
					CRMWA*		SANDHILLS WELL FIELD		LAKE ALAN HENRY		LOCAL WELL FIELDS	
			GALLONS	ACRE-FEET	GALLONS	ACRE-FEET	GALLONS	ACRE-FEET	GALLONS	ACRE-FEET	GALLONS	ACRE-FEET
2000	199,564	198	14,649,198,476	44,957	12,330,532,500	37,841	2,319,922,476	7,120	0	0	0	0
2010	212,820	185	14,566,976,212	44,704	13,924,168,479	42,732	392,807,732	1,205	0	0	250,000,000	767
2020	224,493	183	15,299,699,313	46,953	14,007,449,000	42,987	792,250,313	2,431	0	0	500,000,000	1,534
2030	234,924	182	15,868,867,691	48,700	14,007,449,000	42,987	420,724,402	1,291	1,040,694,289	3,194	400,000,000	1,228
2040	244,197	180	16,454,439,549	50,497	14,005,877,889	42,982	562,140,415	1,725	1,686,421,245	5,175	200,000,000	614
2050	255,284	180	17,147,321,548	52,623	14,007,449,000	42,987	774,547,980	2,377	2,215,324,567	6,799	150,000,000	460
50-Year Cumulative Total			793,785,050,960	2,436,037	704,798,505,316	2,162,947	40,315,499,793	123,724	35,012,490,864	107,449	14,000,000,000	42,964

CITY OF LUBBOCK 50-YEAR WATER PLAN
YEAR 2000 - YEAR 2050

LOW PROJECTIONS - WITH EXTENSIVE WATER CONSERVATION MEASURES

YEAR	LUBBOCK POPULATION PROJECTIONS	GALLONS PER CAPITA PER DAY (GPCD)	PROJECTED WATER DEMAND		SOURCES TO MEET DEMAND							
					CRMWA*		SANDHILLS WELL FIELD		LAKE ALAN HENRY		LOCAL WELL FIELDS	
			GALLONS	ACRE-FEET	GALLONS	ACRE-FEET	GALLONS	ACRE-FEET	GALLONS	ACRE-FEET	GALLONS	ACRE-FEET
2000	199,564	198	14,653,787,952	44,971	12,438,000,000	38,171	2,215,787,952	6,800	0	0	0	0
2010	210,658	177	13,840,887,959	42,476	13,840,887,959	42,476	0	0	0	0	0	0
2020	218,471	174	14,156,535,347	43,445	14,007,449,000	42,987	149,086,347	458	0	0	0	0
2030	222,680	171	14,155,101,611	43,440	14,007,449,000	42,987	147,652,611	453	0	0	0	0
2040	223,370	168	14,004,306,777	42,978	14,004,306,777	42,978	0	0	0	0	0	0
2050	226,395	167	14,079,661,915	43,209	14,007,449,000	42,987	72,212,915	222	0	0	0	0
50-Year Cumulative Total			717,501,695,514	2,201,932	705,947,341,226	2,166,473	11,554,354,287	35,459	0	0	0	0


50-YEAR PROJECTED WATER DEMAND
BILLION GALLONS
22
20
18
16
14
12
10
2000
2010
2020
2030
2040
2050
YEAR
LOW POPULATION & EXTENSIVE CONSERVATION
MEDIAN POPULATION & MEDIAN CONSERVATION
HIGH POPULATION & NO CONSERVATION

Section 4 – Other Water Supply Models/Studies

f. 1992 Groundwater Management Study

COMPREHENSIVE GROUND WATER MANAGEMENT STUDY FOR THE CITY OF LUBBOCK

April 9, 1992

Geraghty & Miller, Inc. appreciates the opportunity to work for the City of Lubbock on the Comprehensive Ground Water Management Study. This report was prepared in conformance with Geraghty & Miller's strict quality assurance/quality control procedures to ensure that it meets the highest standards in terms of the methods used and the information presented. If you have any questions or comments concerning this report, please contact one of the individuals listed below.

Respectfully submitted,

GERAGHTY & MILLER, INC.

Hugh B. Robotham, P.E.
Principal Scientist/Project Manager

Philip C. Briggs, P.E.
Senior Project Advisor

Anchor E. Holm, P.E.
Associate/Project Officer

to assist the user in referencing information quickly. Backup of the entire system should be done regularly but not daily.

The WIMS program has been installed by G&M on a computer system at the City's water treatment plant. Data and information for the City's well fields has been entered into the system by City personnel in the water department. Output data consisting of graphs, maps and reports have been generated and furnished to G&M. This data has been analyzed and evaluated and utilized in the present ground water management assessment. The WIMS program is being finalized. The final version will be installed by G&M on the City's computer at the water treatment plant as soon as it is completed. A complete backup of the program should be kept in a secure place to be used if the computer or system crashes.

ANALYSIS AND EVALUATION OF THE CITY OF LUBBOCK'S FUTURE WATER REQUIREMENTS

As stated earlier, the City obtains most of the water that it uses from Lake Meredith through the CRMWA. By contract agreement, the City is entitled to 37.058 percent of the available yield of Lake Meredith. The initial estimate of the yield of the lake is about 103,000 acre-feet per year. However, more recent analysis of the yield of the lake based on rainfall/runoff data has estimated that the safe yield is presently about 82,400 acre-feet per year which is 80 percent of the original estimate. In recent years, allocations to the City from the CRMWA have been based on the 82,400 acre-feet per year yield. The resultant Lubbock allocation has been about 30,535.4 acre-feet (9.95 billion gallons) per year.

At present, the City has a contract with the City of Pampa, Texas for the purchase of 800 million gallons of water annually from its CRMWA allocation as a member city. This contract expires in 1993 but can be renewed annually after that time. Lubbock also has the option to purchase an additional 200 million gallons of water annually from Pampa if enough water is available.

The remainder of the City's water supply is obtained from its existing ground water well fields. The Sandhills well field is the City's main ground water supply. Additional ground water is obtained from the Birdwell ground water lease and wells located within the City of Lubbock. In 1991, the Birdwell lease was renegotiated allowing the City to purchase the Birdwell well field at the end of the lease in 2001. The City had a contract to purchase water from the City Of Muleshoe. This contract expired in 1991. Ground water is used mainly to meet the City's peak water demands during the summer months and to supplement the surface water supply from Lake Meredith during the rest of the year.

Lake Alan Henry is a new multi-purpose reservoir that is being constructed about 56 miles southeast of Lubbock on the Double Mountain Fork of the Brazos River (Figure 6). This reservoir is being built by the Brazos River Authority under contract to the City who will have 100 percent ownership of the lake. The dam construction is planned to be completed by the fall of 1993. Construction of pipeline, water treatment and other facilities are expected to be completed not earlier than 2002. The first delivery of water to Lubbock from the reservoir is expected not earlier than 2002.

The safe yield of Lake Alan Henry has been projected to be about 27,420.5 acre-feet per year. The City of Lubbock has 100 percent allocation from the reservoir.

HISTORICAL WATER DEMANDS

Historical water use data for the City for the period 1985 through 1991 were obtained from the City's water utilities department. This data is summarized in Table 1 where the total use, ground water pumpage and the amount obtained from CRMWA are shown. The actual total water use for the period 1985 through 1991 is shown graphically on Figure 7 along with the projected total water requirements for the City through the year 2040.

Total annual water use over the seven-year period (1985 to 1991) ranged from about 34,056.5 acre-feet (11,097.3 million gallons, MG) in 1987 to about 40,226 acre-feet (13,107.7

MG) in 1989 and averaged 37,049.8 acre-feet (12,072.7 MG). The annual amount of water obtained from CRMWA during the same period ranged from 31,159.0 acre-feet (10,153.2 MG) in 1987 to 33,484.4 acre-feet (10,910.9 MG) in 1985 and averaged 32,135.1 acre-feet (10,471.3 MG). Ground water usage over the seven year period reflects the difference between the total water requirement and the amount obtained from the CRMWA. The annual ground water use ranged from 3,766.6 acre-feet (1,227.3 MG) in 1986 to 8,765.4 acre-feet (2,856.2 MG) in 1990 and averaged 5,833.2 acre-feet (1,900.8 MG). This indicates that the year-to-year ground water use can be somewhat variable depending on the weather conditions and the amount of rainfall experienced within the City. The rainfall in 1986 was well above the average for the Lubbock area and for the High Plains area as a whole. Consequently, the amount of ground water that was needed was quite low. The total ground water use includes the City Of Lubbock and Reese Air Force Base (RAFB).

As stated earlier, most of the ground water used by the City is obtained from the Sandhills well field. Since 1986, a significant amount has been contributed by the Birdwell lease which adjoins the Sandhills well field. With the renegotiation of the Birdwell lease under a lease/purchase agreement, the City essentially owns the water rights to this property. Local wells within the City contribute only a very small amount to the total ground water use. In the past seven years, ground water use has averaged about 5000 acre-feet (1.63 billion gallons) per year.

PROJECTION OF FUTURE WATER REQUIREMENTS

Projections of future water requirements of the City have been made by various entities including HDR Engineering, Inc. (HDR, 1990) and the TWDB. The HDR projections, like many of the others, project water requirements through the year 2020 which is well short of the long range planning that is undertaken in this study. The projections made by the TWDB span the planning horizon of 50 years through the year 2040. Consequently, the TWDB projections are used for planning purposes in this study.

In 1990, the TWDB finalized a report entitled "Water For Texas" which provided a comprehensive assessment of the current and future status of water-related resources within the State of Texas. The objective of the study was to provide workable strategies that will serve as a guide to State policy for development, management, conservation and protection of the State's water resources. As part of this study, the TWDB evaluated the historical water use trends for various regions in the State and made projections of future water requirements for these regions as well as some of the major cities within the regions.

For the TWDB study, the City falls in the High Plains and Trans-Pecos region. The other major population centers in the region are the Cities of Amarillo, Odessa, Midland, Big Spring, Plainview, Pampa, Borger, Hereford and Levelland.

The TWDB population and water requirement projections were developed for two alternative growth scenarios representing high and low series water demand forecasts. The two forecasts were then assessed with and without additional water conservation practices.

Population projections were made using a cohort-survival model that projects births and deaths and net migration into the area or city. The high series forecasts reflects higher than normal levels of migration and population growth experienced during periods of rapid economic expansion. The low series forecast reflects below normal levels of migration.

Municipal water requirements were based on projected population and historical per capita water use. Per capita water use for the high series forecast considers the highest per capita use on record and represents water use demands during periods of below average rainfall conditions. The low series forecast is reflective of per capita water use during average rainfall conditions.

Water use projections with water conservation considered the implementation of water efficient programs and practices such as the use of water-saving plumbing fixtures in the home, and the early detection and repair of leaks in water conveyance systems such as pipelines. According to the TWBD projections, implementation of water conservation programs and practices could reduce the per capita water use by 7-1/2 percent by 2000, 12-1/2 percent by 2010 and 15 percent by the year 2020. In July, 1991 the City Of Lubbock adopted a water conservation and drought contingency plan. The goal of the water conservation plan is to reduce the overall water usage by about 9.5 gallons per capita per day which represents a 5 percent reduction from current consumption levels. This would be accomplished through education and the implementation of water saving practices such as water-saving plumbing fixtures and lawn watering equipment, water-saving landscaping, reduction of leaks and the early detection and repair of leaks in the water distribution system.

Total water use projections made by the TWDB through the year 2040 are presented in Tables 2 and 3. Projections of water use without water conservation practices are given in Table 2. Table 3 contains the water use projections considering water conservation practices as described earlier. This data is presented graphically on Figure 7.

Total annual water requirements for the City of Lubbock are projected to reach about 65,096 acre-feet (21.2 billion gallons) by the year 2040. This assumes the high series forecast of population growth and no water conservation practices. Total water requirement through the year 2040 is estimated to be 2,514,709 acre-feet (819.42 billion gallons).

PROJECTION OF FUTURE GROUND WATER REQUIREMENTS

Future ground water use will be dictated by the available surface water supplies from Lake Meredith and Alan Henry and weather conditions. Year-to-year ground water use can be expected to vary reflecting the amount of rainfall experienced within the City. Ideally, the City should utilize its water resources in a manner that would conserve the ground water resources. This is desirable since the ground water resources are not renewable. Once they are depleted, ground water sources would require many years to be replenished by the limited amount of recharge that occurs in this area. On the other hand, the surface water resources are perennially replenished by rainfall/runoff events on the watershed. Utilizing the ground water resources in a manner that would conserve this resource has always been the goal of the City and is practiced as the water demand allows.

In the utilization of the ground water resources, the most ideal situation would be to withdraw just that amount of water from the aquifer annually which balances the yearly recharge to the aquifer. The amount of ground water withdrawal that balances the recharge to the aquifer can be considered the "safe yield" of the aquifer. In areas where other ground water development is fairly intensive, this is may not be possible unless a coordinated and cooperative effort is made between the various ground water users in the area.

In Bailey County as a whole, annual ground water withdrawal from the aquifer, consisting mostly of water used for irrigation, has historically greatly exceeded the recharge rate. The annual ground water withdrawal from the Sandhills well field and immediate vicinity has historically also exceeded the safe yield of the aquifer. This is reflected by the continuing decline in static water levels in the Sandhills well field and immediately surrounding areas. Water level declines in and immediately adjacent to the Sandhills well field are discussed in greater details later in this report.

Annual recharge to the Ogallala aquifer under the Sandhills well field and Birdwell lease is estimated to be about 3,400 acre-feet (1.11 billion gallons) per year based on a recharge rate of 0.5 inches per year. Recharge is discussed in more detail later under the evaluation of each well field. During the past seven years, ground water production from the Sandhills well field and the Birdwell lease has averaged over 5,000 acre-feet (1.63 billion gallons) per year. This amount is well above the estimated annual recharge to the aquifer under the well fields. In order to preserve the ground water resources and minimize water level declines, G&M recommends that, if possible, future ground water withdrawal from the Sandhills well field (including the Birdwell lease which is being acquired by the City under a lease/purchase agreement) be limited to the amount of estimated annual recharge.

Future ground water requirements will be dictated primarily by the water demand and when the City begins utilization of surface water from Lake Alan Henry. The ground water management plan, discussed later in this report, recommends that utilization of water from Lake Alan Henry commence in the period 2005 to 2010 at which time only about half the safe yield of the reservoir would be utilized. The remaining Lake Alan Henry supply would be utilized beginning in 2025. Based on this scenario and recommendation, annual ground water requirements will reach between 11,685 acre-feet and 13,645 acre-feet depending on the actual year when utilization begins. In the year 2010 the ground water requirement is projected to be about 3,135 acre-feet (1.02 billion gallons). From 2011 through 2040 the annual ground water requirement is projected to range between 2,751 acre-feet (0.89 billion gallons) and 12,068 acre-feet (3.94 billion gallons). The projected ground water requirements through the year 2040 are contained in Table 28. The ground water requirements will be met from the Sandhills well field producing about 3,400 acre-feet (1.11 billion gallons) with the remainder coming from local wells as discussed later. Beyond the 50-year planning horizon (after the year 2040), ground water requirements are expected to increase significantly depending on the water demands and the availability of other surface water supplies.

EVALUATION OF LUBBOCK'S WELL FIELDS

DESCRIPTION OF WELL FIELDS

The City's primary ground water well field is the Sandhills well field located about 60 miles northwest of the City in Bailey and Lamb Counties, Texas (Figure 1). This well field encompasses approximately 81,000 acres (126.5 sections). The water rights under the well field are owned by the City.

The Birdwell ground water lease consists of 664 acres of land located in Sections 25, 40 and 41, Block Z, WD & FW Johnson's Subdivision, Bailey County, Texas. The well field adjoins the Sandhills well field at its northwest boundary (Figure 8). The Birdwell lease was yield of 15 percent was used for the aquifer. The specific yield is the percent, by volume, of water that will drain by gravity from a unit volume of the aquifer. The TDWR uses specific yield values ranging from 12 percent to 20 percent for this area of Bailey and Lamb Counties. A recovery factor of 75 percent was used in the reserves calculations. The recovery factor takes into account the physical and economic limitations in completely dewatering an aquifer. Using the stated values of specific yield and recovery factor for the Ogallala aquifer, the in-place recoverable reserves in the developed part of the Sandhills well field are estimated to be 486,700 acre-feet.

Total in-place recoverable reserves in the undeveloped part of the Sandhills well field are estimated to be about 582,000 acre-feet. This estimate is based on the average gross saturated thicknesses of the Ogallala aquifer in the undeveloped areas of 145 feet in Block A and 90 feet in League 172, 173, 174, 188 and 189. These averages were calculated from available static water level and base of aquifer data for several State observation wells in the area and extrapolation of the gross saturated thicknesses from the developed portions of the well field. The same values of specific yield and recovery factor used for the developed areas were used for the undeveloped areas.

The total in-place recoverable ground water reserves under both the developed and undeveloped portions of the Sandhills well field are estimated to be about 1.07 million acre-feet (348.66 billion gallons).

Productive Life Of Reserves In The Sandhills Well Field

The productive life of the in-place recoverable reserves under the well field will depend on the rate of future ground water withdrawal. This is a direct function of the City's rate of withdrawal but will also be affected by other ground water development in the area, primarily irrigation.

If the amount of ground water withdrawal from the well field is limited to the amount of annual recharge (estimated to be 3,400 acre-feet per year), the only decline in the reserves would be the result of other pumping that is occurring adjacent to the well field. Water level declines within the boundaries of the well field have been in the range of 0.25 feet per year to 0.75 feet per year which is somewhat less than in the surrounding areas. By maintaining the ground water withdrawal rate equal to the recharge rate, the rate of water level decline in the field may decrease. However, enough historical pumpage and water level information are not presently available to determine what the long-term decline rate would be. Assuming that the static water levels within the well field continue to decline at their present rate (0.25 to 0.75 feet per year), the reserves in the well field would be depleted in 160 to 480 years. Any additional overdraft of the reservoir would accelerate the depletion of the ground water reserves.

Ground Water Quality

Ground water quality data for the years 1990 and/or 1991 were entered into the WIMS database program by water department personnel. The available data have been printed in the form of reports. Copies of the available water quality reports for each well are contained in Appendix I. Contour maps of the total dissolved solids, chloride, sulfate, fluoride, nitrate, turbidity and suspended solids are presented in Figures 13 through 19.

The quality of the ground water from the Sandhills well field is excellent with regard to most of the ions and parameters that were tested and reported. In terms of the chloride, sulfate and total dissolved solids, the water quality in all of the wells is below the TDH recommended secondary standards for those parameters. These standards are 300 milligrams per liter (mg/L), 300 mg/L and 1,000 mg/L, respectively.

The TDH secondary standard for fluoride is 2.0 mg/L. The vast majority of wells in the well field meet this standard. However, 24 wells have fluoride levels that exceed the 2.0 mg/L standard. These wells are Nos. 115, 139, 146, 241, 250 through 266, 269, 270 and

TDH, appropriate pipeline and facilities would have to be constructed to accomplish this. With the fluoride ion concentration being the main quality concern with regard to the utilization of Pump Station No. 6, it is recommended that long-term fluoride ion monitoring in the ground water be conducted to determine the need for blending. Furthermore, if blending becomes necessary, engineering feasibility studies should be conducted to determine the optimal location of the needed facilities from both a water supply and cost standpoint.

With the high potential which exists for utilization of local wells to meet part of the City's water demands, it would be prudent for the City to conduct a city-wide baseline study to determine the quality of the ground water in various parts of the City. The first phase of such a study would identify areas of potential quality problems including those resulting from leaking underground storage tanks, industry, surface water recharge and natural occurrences. After the areas of potential quality problems are identified, a more detailed study of each area (or selected areas) would be conducted to determine the exact nature and extent of the problem and how it affects utilization of the ground water for municipal purposes.

SUMMARY OF RECOMMENDATIONS BASED ON EVALUATION OF LUBBOCK'S WELL FIELDS

The following is a summary of the recommendations resulting from evaluation of the various well fields. These recommendations with associated cost estimates, where appropriate, are also summarized in Appendix L.

Sandhills Well Field

1. Implement the data collection procedures and record-keeping methods discussed. These include the use of the following forms for data collection and recording.

- Well, pump and motor data
- Well maintenance records
- Measurement of static water levels
- Pumping level, discharge pressure and flow rate
- Well production data
- Measurement of sand production
- Field testing of pump efficiency

2. Implement the well maintenance activities consisting of well and pump efficiency tests, inspection of wellhead facilities and measurement of sand production. This should be done for all of the active wells.

3. Implement the methods and procedures for ground water sample collection, preservation, analysis and documentation.

4. If possible, restrict the amount of ground water withdrawal from the Sandhills well field (including the Birdwell lease) to the estimated annual recharge rate of about 3,400 acre-feet (1.11 billion gallons).

5. Set up a rotation schedule to utilize the wells with the highest overall pump efficiencies in the Sandhills well field. A rotation schedule among 30 to 60 wells with high overall efficiencies will adequately meet the anticipated ground water requirements from the well field. Installation of a SCADA system would greatly facilitate the implementation of this recommendation. Whenever practical, the wells along the perimeter of the well field and those in the most down-gradient positions should be pumped. Wells with very high sand production such as Nos. 122, 151, 155, 188, 245 and 262 should not be included in the wells that are placed in the rotation schedule.

6. Shut-in wells in the Sandhills well field with overall efficiencies less than 51 percent. The pumping equipment in these wells should be started on a quarterly schedule to maintain the equipment in operating condition.

7. Implement the recommendations for control and removal of sand in the ground water collection system for the Sandhills well field presented in the report on the evaluation of the Bailey County water transmission line.

8. Install a SCADA system for 20 wells now with the remaining wells in the rotation schedule added over the next 10 to 20 years.

9. The engineering report on the evaluation of the Bailey County water transmission line contains recommendations for the ground water collection system, the electrical ground for the East field, the gas chloramine system, the disinfection and control building, the Bailey County water transmission line and appurtenant structures. These are discussed in the engineering report and summarized with cost estimates in Appendix L.

Shallowater Well Field

Use of the Shallowater well field is not recommended for the near term. However, this field could become a viable supply in the future. A detailed evaluation of the wells, pumping equipment, reservoir and pump station is recommended before this well field is reactivated. Appendix L contains cost estimates for recommended work should reactivation of this well field be considered.

With the well field remaining in an inactive state, it is recommended that static water levels be measured on an annual basis. The continuing collection of the water level data will allow for ongoing monitoring of water level decline in the well field and corresponding changes in ground water reserves. The water level data should be documented and record keeping procedures followed as described earlier in this report.

Local Well Field

The following recommendations are made for utilization of the Local well field. These recommendations along with costs estimates are summarized in Appendix L.

1. Utilize the eight water supply wells that feed into Pump Station No. 6 for meeting a portion of the water demands of the City.

2. Consider replacing the pumping equipment in well Nos. 78 and 79 with new or newer equipment. The existing pumping equipment in these two wells have overall efficiencies that are relatively low and are considered unsatisfactory from a performance standpoint.

3. Construct five monitor wells with the intent of encircling the eight wells at Pump Station No. 6. The purpose of these monitor wells is to monitor the possible encroachment of poorer quality ground water from other areas of the City.

4. Refurbish or drill other local water supply wells to meet off-line water demands such as watering of parks and trees. The decision to drill or refurbish wells should be based on the location of the areas to be irrigated within the City.

5. Conduct a city-wide baseline study to identify areas of potential ground water quality problems within the City including those resulting from leaking underground storage tanks, industry, surface water recharge and natural occurrences. A more detailed study of each area or selected areas would be

conducted to determine the exact nature and extent of the problem and how it affects utilization of the ground water for municipal purposes.

6. A SCADA system is not recommended for the local wells at Pump Station No. 6. However, a cost estimate for installation of such a system is provided in Appendix L should the City determine that one would be advantageous.

MANPOWER REQUIREMENTS FOR RECOMMENDED DATA COLLECTION AND RECORD KEEPING

The recommendations made in this report for data collection and record keeping may require additional staffing in the water department to accomplish them. To aid the City in determining its water department staffing needs, an estimate of the number of additional manhours required to accomplish the recommended work was made. A summary of the recommended data collection and recording keeping and the estimated yearly manhour requirements are contained in Appendix M.

EVALUATION OF LUBBOCK'S BAILEY COUNTY GROUND WATER TRANSMISSION LINE

The engineering report for the evaluation of the Bailey County water transmission line is being submitted as a stand-alone report. References to the engineering report have been made throughout this report. A summary of the recommendations made in the engineering report and associated cost estimates can be found in Appendix L.

GENERAL AREAS FOR IMPROVEMENT WITHIN THE EXISTING GROUND WATER PRODUCTION SYSTEM INFRASTRUCTURE

This section identifies and lists the general areas for improvement that have been identified within the current ground water production infrastructure based on the evaluation of the City's well fields and Bailey County water transmission line.

GENERAL AREAS FOR IMPROVEMENT FOR ALL WELL FIELDS

The main areas that are identified in the production, operation and maintenance of the well fields that could be improved are listed below. These have been discussed in detail in earlier sections of the report.

- Data acquisition, documentation and record keeping.
- Data analysis, evaluation and interpretation.
- Sand production from wells especially in the Sandhills well field.
- Well, pump and motor maintenance.
- Inadequate rotation of wells in the Sandhills well field.
- Outdated design of pumping equipment.
- Inadequate supervisory control system especially at the Sandhills well field.

The following areas that could be improved are identified specifically for the Sandhills well field, collection system and Bailey County water transmission line. Many of these items have been discussed in the engineering report for the evaluation of the Bailey County water transmission line.

- Bypass piping arrangement at reservoir.
- Accumulation of sand in transmission line.
- Inadequate supervisory control system.

FUTURE BEYOND 2040

While the planning period ends in the year 2040, the City's water demands will not. Demands for water will continue to grow. Additional water supplies can be developed by reclamation of waste water and reduction of demands through conservation can be used to meet a portion of new demands. The surface water and ground water supplies identified in this planning effort are finite and the model runs indicate that the identified supplies will not be able to accommodate much more demand than has been projected for year 2040. To insure that the City has adequate water supplies to meet its demands beyond 2040, it is imperative that further planning including the evaluation and acquisition of additional water rights (whether ground or surface water) be conducted early in the planning period.

CONCLUSIONS

The Plan that has been produced for the City provides an array of water supplies and water and demand management options to meet the City's projected demands for water. The Plan also provides guidance on the implementation of the Plan elements and evaluations of near term cost of implementing the recommended Plan. The Plan is not intended to be adopted and placed on a shelf as a reference document, but rather to be used as time progresses as a guide to a continuing planning process. The Plan should become a key part of planning and development of City growth and revised as the future unfolds itself.

The planning model used in evaluating the future water supply scenarios to develop the recommended Plan has been designed for easy use and ready understanding. While no one can predict the future with certainty, the planning model allows rapid evaluation and comparison of an array of reasonably likely futures and, hence, provides a tool to assess and plan for the future in the face of this uncertainty. The planning model can be used to update the Plan periodically, say every five years. The planning model is, therefore, a powerful tool for use by the City to analyze the opportunities and cope with the impacts contained within an uncertain future.

Several of the future water supplies relied upon in the recommended Plan are not yet certain in their availability, amount, quality or timing. For example, the actual amount and quality of the water from Lake Alan Henry has been estimated but is not certain. Other water supplies, such as the Local well field, while now available, are not certain over the long term due to water quality concerns. There is a need, therefore, for the City's continuing participation in water supply acquisition to insure that the relied upon supplies are eventually secured as well as to cope with unexpected problems and to take advantage of unforeseen opportunities.

The City should also maintain and increase its involvement in water resources planning and management over time. More reliance on reclaimed water, recharge and recovery, and water conservation than considered in the recommended Plan will reduce the need for additional water supplies and/or provide supplies for a safety factor, for unexpected growth or long-term drought. The City will also have water demands in the future beyond the year 2040 that will require water supplies beyond those identified in the recommended Plan.

A major objective of this study was to develop a ground water management plan that would allow the City to meet a goal of safe yield in it's well fields. As shown by the results of the model runs made for this study, and considering the water supply and management options that are possible, the City could meet this goal in the 1990's.

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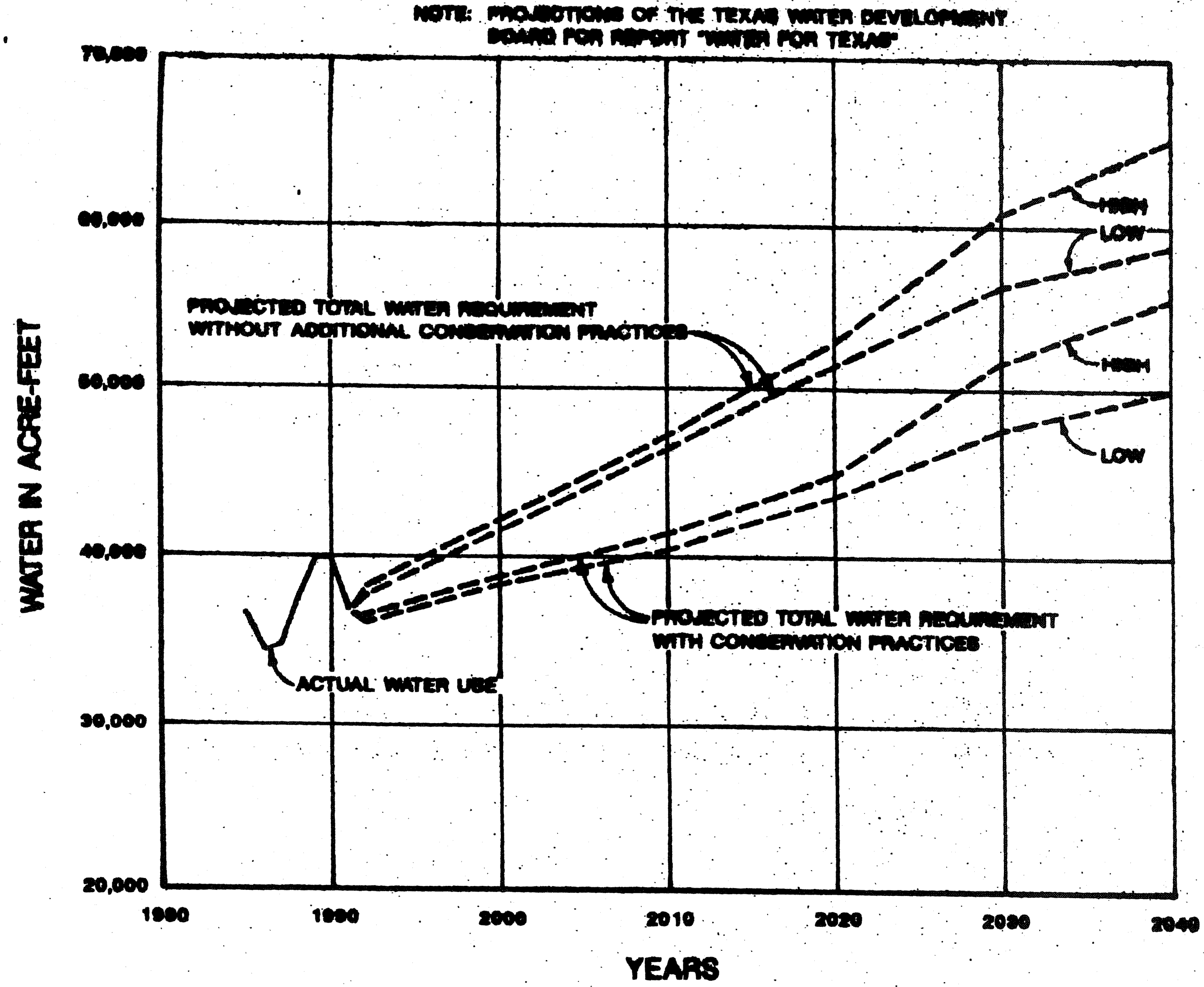

GERAGHTY & MILLER, INC.
Environmental Services

CITY OF LUBBOCK
COMPREHENSIVE GROUND WATER
MANAGEMENT STUDY
ACTUAL AND PROJECTED TOTAL WATER REQUIREMENT
Lubbock County, Texas

FIGURE
7

Section 4 – Other Water Supply Models/Studies

g. 1975 Plan for Additional Water Supply

LUBBOCK, TEXAS

RECOMMENDED PLAN OF ACTION FOR
DEVELOPMENT OF ADDITIONAL SURFACE WATER SUPPLY

MAY 1975

Table 2.1

Projection of Future Lubbock Water Requirements
For Long-Range Planning

	Population	Normal Year Conditions				Dry Year Conditions				Potential Peak Day MGD
		Avg. GPDPC	Avg. MGD	Billion Gal/Yr.	Acre-Feet Per Year	Avg. GPDPC	Avg. MGD	Billion Gal/Yr.	Acre-Feet Per Year	
1975	165,000	178	29.4	10.72	32,900	194	32.0	11.68	35,800	76.8
1980	185,000	187	34.6	12.66	38,900	203	37.6	13.75	42,200	90.1
1985	207,000	196	40.6	14.81	45,500	212	43.9	16.02	49,200	105.3
1990	230,000	205	47.2	17.21	52,800	221	50.8	18.55	56,900	122.0
1995	256,000	214	54.8	20.00	61,400	230	58.9	21.49	66,000	141.3
2000	285,000	223	63.6	23.26	71,400	239	68.1	24.93	76,500	163.5
2005	315,000	232	73.1	26.67	81,900	248	78.1	28.51	87,500	187.5
2010	347,000	241	83.6	30.53	93,700	257	89.2	32.55	99,900	214.0
2015	380,000	250	95.0	34.68	106,400	266	101.1	36.89	113,200	242.6
2020	415,000	259	107.5	39.34	120,700	275	114.1	41.77	128,200	273.9

7. RECOMMENDED PLAN OF ACTION

Set forth in the following pages of this section is an outline of the main activities which are expected to be involved in development of the proposed new surface water sources, with suggested target dates assigned to the various items. The key factors in the next few years probably will be (a) the time required to collect adequate information regarding water quality on the South Fork of the Double Mountain Fork and (b) the target date of having surface water available from the Post project by the summer of 1984.

Because of the interdependence of the Post and Justiceburg sources in the over-all plan, the timing of the application for water rights at the Justiceburg site is governed by the need to be sure of having the Justiceburg permit before going ahead with preparation of plans and specifications relating to the raw water delivery system. The proposed submittal of an application for the Justiceburg water rights is thus scheduled several years before the anticipated beginning of construction of Justiceburg Dam, with a view to receiving a determination of the water rights issue by about September of 1978. Land acquisition and definitive design for the first stage of the plan are indicated to begin in late 1978, after receiving a decision from the Texas Water Rights Commission regarding the Justiceburg application. It is anticipated that the fact that the two reservoirs would be so clearly inter-related, together with the proposed purchase of some land at the Justiceburg Dam site before September 1980, would either satisfy the Commission's requirement for commencing the Justiceburg project within two years after issuance of the permit or else would be considered sufficient grounds for subsequent extensions of time.

It is also suggested that Lubbock should plan to have its representatives go to Austin and discuss the contemplated plan of development with the members and staff of the Commission later this year, and again in about January of 1978 before filing the Justiceburg water rights application. Although the Commission would not be able to make any firm decisions or commitments on the basis of such meetings, and final determinations would obviously depend on the outcome of a formal water rights hearing, it will be desirable to advise the Commission of the intended approach and to have the benefit of any suggestions that might be offered by the Commissioners or their staff before actually filing the application. The initial visit to the Commission should, if possible, be a joint visit with representatives of the White River Municipal Water District.

The date of construction of Lake 8 has been indicated only approximately in the timetable as being some time after 1995. It is apparent that the terminal storage function of Lake 8 would not be required for several years after completion of the Justiceburg project. However, as the largest of the Canyon Lakes, it may be desired to build Lake 8 for recreation use sooner than it would be required for terminal storage. The date given herein for Lake 8 is intended merely to show its relative position in the sequence of development of the surface water supply and does not reflect on the possibility that it may be constructed sooner for recreation purposes.

The recommended plan of action is as follows:

June 1975	Initiate conferences with representatives of the White River Municipal Water District regarding possible cooperative development of the Post Reservoir project.
July 1975	Preliminary discussion with the Texas Water Rights Commission, by representatives of the City and the White River District.
July 1975	Initiate discussions with the Texas Water Development Board regarding possible financing assistance.
July 1975	Contact representatives of the Brazos River Authority, and initiate discussions toward obtaining the Authority's support for the project.
1975 - 1976	Investigation of geology and foundation conditions at the Justiceburg Reservoir site: a. Preliminary field reconnaissance and limited core borings to confirm basic site suitability. b. Detailed core boring investigation once general suitability of site is established.
1975-1977	Water quality observations on a daily basis at the U. S. Geological Survey gaging station on the South Fork of the Double Mountain Fork at Justiceburg (U. S. Highway 84 Bridge).
1976	Basic design studies and preparation of preliminary design report for the over-all project.
By September 1977	Definitive agreement between the City of Lubbock and the White River Municipal Water District regarding development of the Post Reservoir.
January 1978	General discussion with the Texas Water Rights Commission concerning the Justiceburg application.
February - March 1978	Preparation of water rights application for the Justiceburg Reservoir.

April 1978	Submittal of application to Texas Water Rights Commission for the Justiceburg Reservoir.
November 1978	Water rights hearing on the Justiceburg Reservoir.
1978 - 1979	Purchase of land for the Post Reservoir.
January - May 1979	Preparation of construction plans and specifications for the Post Dam and associated pump station intake structure.
July 1979 - June 1981	Construction of Post Dam and associated pump station intake structure.
By September 1980	Purchase of land in the immediate area of the Justiceburg Dam site.
July 1981	Begin impoundment of water in Post Reservoir.
July 1981 - March 1982	Purchase of right-of-way for pipeline from Post Reservoir to the new filter plant.
July 1981 - March 1982	Preparation of construction plans and specifications for the initial raw water delivery system from Post Reservoir to the filter plant.
July 1981 - March 1982	Preparation of construction plans and specifications for the new filter plant.
May 1982 - April 1984	Construction of the initial raw water delivery system from Post Reservoir to the filter plant.
May 1982 - April 1984	Construction of the new filter plant.
May 1984	Begin using water from the Post Reservoir.
1986 - 1987	Preparation of construction plans and specifications for the Justiceburg Dam and associated pump station intake structure.
1986 - 1987	Purchase of the balance of the land for the Justiceburg Reservoir.
1987 - 1989	Construction of the Justiceburg Dam and associated pump station intake structure.

1989	Begin impounding water in the Justiceburg Reservoir.
1989 - 1990	Preparation of construction plans and specifications for the additional raw water transmission facilities to bring water from the Justiceburg Reservoir.
1990 - 1992	Construction of the additional raw water transmission facilities to bring water from the Justiceburg Reservoir.
1992	Begin using water from the Justiceburg Reservoir.
After 1995	Addition of Lake 8 to the system for use as regulating storage during periods of maximum demand.

Section 4 – Other Water Supply Models/Studies

h. 1971 Report on Water Supply

Table 2.3

Projected Future Lubbock Population

	Water Development Board Projection	Projection Used For This Report
1975	185,700	165,000
1980	203,078	185,000
1990	242,865	230,000
2000	290,447	285,000
2020	415,405	415,000

In Table 2.4 are listed the average and peak daily water requirements of Lubbock during each year since 1940. Per capita demands for this period are also plotted in Figure 2.4. The records show a rising trend in average daily per capita use, which has been increasing at an overall rate of about 1.8 gallons per year since 1945. In some years, when the weather has been unusually dry, the average per capita daily usage has been as much as 16 gallons above the level indicated for normal years. The annual ratio of peak day to average day has ranged from as low as 1.89 (in 1946) to a maximum of 2.70 (in 1944) and generally tends to be 2.4 or less in the more critical years.

Table 2.5 is a projection of the normal year, dry year and potential peak day requirements for planning purposes through the year 2020, based on the population projection of Table 2.3 and assuming continuation of the per capita water demand trends observed over the past 20 to 30 years. Specifically, it is assumed that:

a. Population will rise as predicted in Table 2.3.

Table 2.4

Lubbock Records of Historical Water Use: 1940-1970

	Population	Average Requirements MGD	Average Requirements Gal/Day Per Capita	Peak Day Usage MGD	Peak Day Usage Gal Per Capita	Ratio Of Peak Day To Yearly Average
1940	31,853	3.63	114	8.59	270	2.37
1941	35,900	2.94	82	6.68	186	2.27
1942	39,600	3.79	96	8.95	226	2.36
1943	40,900	4.32	106	10.01	245	2.32
1944	42,500	3.97	93	10.71	252	2.70
1945	44,000	5.36	122	11.48	261	2.14
1946	49,400	6.11	124	11.56	234	1.89
1947	54,200	6.76	125	13.44	248	1.99
1948	57,900	8.33	144	18.99	328	2.28
1949	62,700	7.52	120	19.17	306	2.55
1950	71,747	9.27	129	21.15	295	2.28
1951	80,900	11.62	144	29.38	363	2.53
1952	88,900	11.21	126	25.83	291	2.30
1953	95,000	13.75	145	31.52	332	2.29
1954	99,200	13.85	140	33.21	335	2.40
1955	105,400	14.45	137	35.82	340	2.48
1956	110,500	16.66	151	34.30	310	2.06
1957	113,100	14.61	129	38.18	338	2.61
1958	116,100	15.28	132	40.69	350	2.66
1959	123,800	17.54	142	43.79	354	2.50
1960	128,691	18.29	142	41.18	320	2.25
1961	132,800	17.90	135	41.30	311	2.31
1962	136,900	20.49	150	48.90	357	2.39
1963	140,700	22.98	163	55.55	395	2.42
1964	142,900	24.62	172	55.95	392	2.27
1965	145,900	25.47	175	60.58	415	2.38
1966	148,600	24.32	164	58.38	393	2.40
1967	149,100	23.99	161	49.04	329	2.04
1968	149,200	21.72	146	46.00	308	2.12
1969	148,900	25.18	169	60.58	407	2.41
1970	149,101	27.20	182	59.96	402	2.20

LUBBOCK PER CAPITA WATER REQUIREMENTS

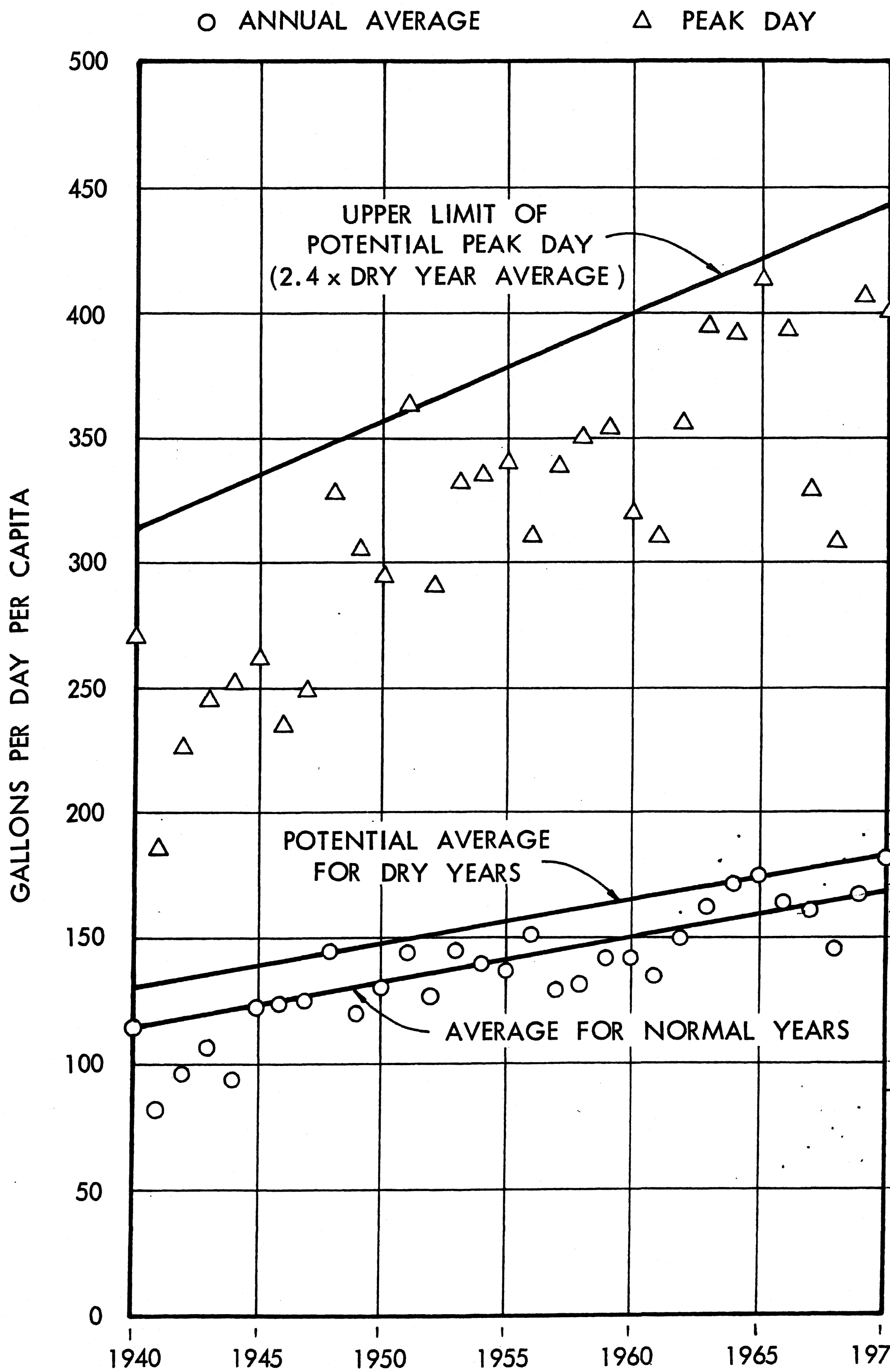

FIGURE 2.4

Table 2.5

Projection of Future Lubbock Water Requirements For Long-Range Planning

	Population	Normal Year Conditions				Dry Year Conditions				Potential Peak Day MGD
		Avg. GPDPC	Avg. MGD	Billion Gal/Yr.	Acre-Feet Per Year	Avg. GPDPC	Avg. MGD	Billion Gal/Yr.	Acre-Feet Per Year	
1975	165,000	178	29.4	10.72	32,900	194	32.0	11.68	35,800	76.8
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1983	198,000									
1985	207,000	196	40.6	14.81	45,500	212	43.9	16.02	49,200	105.3
1990	230,000	205	47.2	17.21	52,800	221	50.8	18.55	56,900	122.0
1995	256,000	214	54.8	20.00	61,400	230	58.9	21.49	66,000	141.3
2000	285,000	223	63.6	23.26	71,400	239	68.1	24.93	76,500	163.5
2005	315,000	232	73.1	26.67	81,900	248	78.1	28.51	87,500	187.5
2010	347,000	241	83.6	30.53	93,700	257	89.2	32.55	99,900	214.0
2015	380,000	250	95.0	34.68	106,400	266	101.1	36.89	113,200	242.6
2020	415,000	259	107.5	39.34	120,700	275	114.1	41.77	128,200	273.9

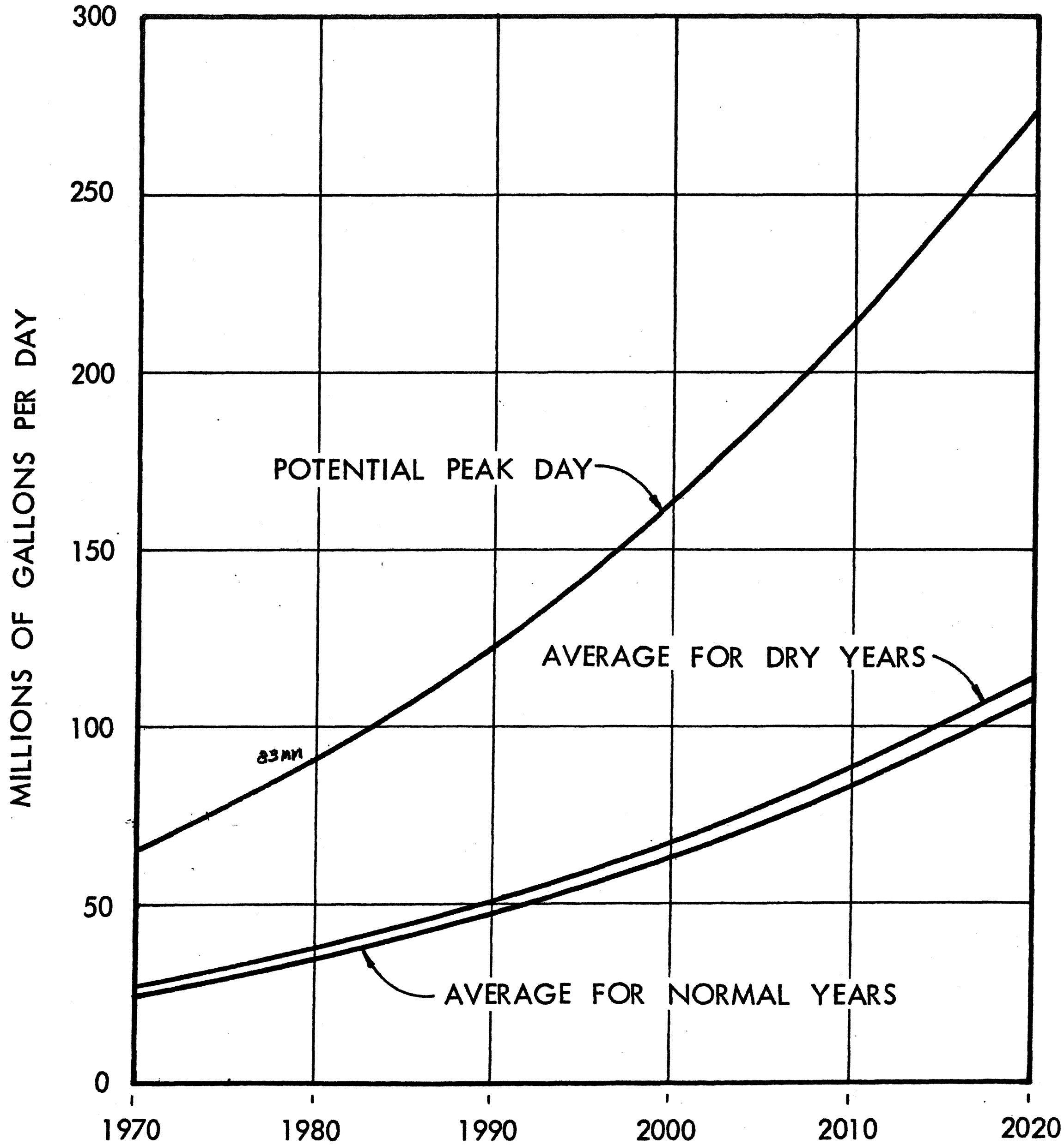
b. Average per capita daily requirements for normal conditions will continue to increase at about 1.8 gallons per year.

c. The potential upper limit of average daily per capita requirements in dry years will be 16 gallons more than in normal years.

d. The potential peak day demand will be 2.4 times the potential upper limit of average daily demand.

The resulting projections are also shown graphically in Figure 2.5. In order to give adequate municipal water service under all conditions, the basic supply should be enough to provide the potential dry year requirements, and the delivery and purification facilities should be able to handle the potential peak day demands in any given year.

PROJECTION OF LUBBOCK WATER REQUIREMENTS FOR LONG-RANGE WATER SUPPLY PLANNING



FREESE, NICHOLS AND ENDRESS

FIGURE 2.5

capabilities of the present sources, if fully developed, with the projected long-range requirements. The peak daily demand in 2020 is expected to be approximately twice the rate that can be obtained from optimum expansion of present facilities. In terms of the total volume of water, the predicted cumulative demand between now and 2020 exceeds the amount which can be provided from the Canadian River system and the Sand Hills Well Field by about 34%, or some 277 billion gallons.

Table 7.3 presumes continued operation of the Sand Hills Field with a peak supply rate of 60 MGD until 2020 or after. Since the reserves

Table 7.3

Comparison of Capabilities of Existing Sources Vs. Projected Requirements Through the Year 2020

Peak Daily Capability (Millions of Gallons)	
Projected peak day as of the year 2020	273.9
Potential development of present sources	137.3*
Additional requirement by 2020	136.6
Cumulative Volume of Water (Billions of Gallons)	
Projected total requirements: 1971-2020	1,088
Projected availability from the Canadian River: 1971-2020	594
Projected availability from the Sand Hills Well Field	217*
Additional requirement by 2020	277

*Note: The values indicated for availability from present sources assume that the Sand Hills Field will still have a peak capability of 60 MGD. Thus, the cumulative volume shown as available from the Sand Hills is limited to the approximate amount that can be removed without reducing the field's output below 60 MGD.

remaining at the Sand Hills are substantially less than the City will probably consume in the next 50 years, even after allowance for the water that will be received from the Canadian River, the Sand Hills contribution on peak days can only be protected if other sources are obtained in time to avoid having to draw too heavily on the field. It will be desirable to plan future water supply expansion so as to keep the Sand Hills in operation as long as reasonably possible. The cumulative amount shown as available from the Sand Hills Field through 2020 (217 billion gallons) is the estimated volume which can be pumped without decreasing the field's output below 60 MGD.

In essence, the outlook for future requirements can be summarized as follows:

a. Present sources, if enlarged and improved in a timely manner, should be adequate to meet maximum daily requirements until some time after 1990.

b. By the year 2020, the potential peak daily demand is projected to be roughly twice as much as present sources can provide when fully developed.

c. With proper planning, most of the existing supply can be kept in service until 2020 and after. To keep the Sand Hills Well Field operative through 2020, it will be necessary to obtain at least 277 billion gallons (850,000 acre-feet) of cumulative supply from new sources other than those now in operation.

d. In round numbers, the new supply that will need to be developed between now and 2020 should be adequate to furnish at least 40,000 acre-feet per year (and preferably around 60,000 acre-feet per year), with peak daily supply rates of approximately 140 MGD.

Section 4 – Other Water Supply Models/Studies

i. 1968 Interim Report on Water Supply

Roy

SEED COPY

LUBBOCK, TEXAS

INTERIM REPORT ON WATER SUPPLY

1968

FREESE, NICHOLS AND ENDRESS
CONSULTING ENGINEERS

LUBBOCK, TEXAS

INTERIM REPORT ON WATER SUPPLY

1968

1. INTRODUCTION

In February of 1968, the City of Lubbock authorized Freese, Nichols and Endress to undertake a comprehensive study of the City's future water requirements and potential sources of supply. This interim report covers the first phase of the study, relating specifically to the three following considerations:

a. Projections of estimated annual water usage and possible maximum daily demands through the year 2020.

b. Determination of the average annual yield and peak daily supply that can be made available by complete utilization of Lubbock's present sources, with emphasis on meeting probable demands through 1980.

c. Estimates of cost and economic analyses directed to optimum development of the Sand Hills ground water supply.

For the immediate present, Lubbock has more than enough water to meet its needs. Introduction of the new supply from Lake Meredith on the Canadian River has eased the load on the Sand Hills Well Field, and the facilities now in operation can provide more than the maximum daily requirement. However, this condition is relatively temporary, and further expansion will be needed within a few years.

As will be outlined more fully in later pages, indications are that new wells will be required at the Sand Hills Field in 1970 or before, and that the full delivery capacity of the existing Sand Hills pipe line may again be used during peak days by about 1975. If booster pump stations are then constructed on the Sand Hills line, the delivery rate could be increased sufficiently to gain another four or five years before the maximum summertime demand rate would once more approach the limit of availability from the over-all system.

Another possibility that would result in a comparable amount of added capacity will be for Lubbock to build its own terminal storage reservoir for Canadian River water near the filter plant. By setting aside a moderate volume of surface water in such storage prior to periods of highest demand, the filter plant could be enabled to operate at full design output instead of being limited by the delivery rate of the Canadian River aqueduct. This, too, would extend the City's total capability to cover about five years of growth.

Thus, if Lubbock continues to expand as anticipated, it will become necessary in the not-too-distant future to make significant additions to the basic water supply. By 1975, major new facilities will probably be called for either at the Sand Hills or elsewhere. In many respects, the foremost consideration in planning for this situation will be the expected performance of the Sand Hills Field, based on what is now known of the aquifer and past operation of existing wells. The expected useful life of the field and especially the projected rate of decline in peak pumping capacity at various stages of development will be very important in relation to timing and extent of future improvements.

Therefore, this first report is devoted in large part to analysis of the Sand Hills supply. The information presented herein will subsequently be combined with results of investigations of other alternative sources, to serve as a basis for conclusions and recommendations of the final report, which is due in 1969.

Table 2.6

Projection of Future Lubbock Water Requirements For Long-Range Planning

Year	Population	Normal Year Conditions				Dry Year Conditions				Potential Peak Day MGD
		Avg. GPDPC	Avg. MGD	Billion Gal/Yr	Acre-Feet per Year	Avg. GPDPC	Avg. MGD	Billion Gal/Yr.	Acre-Feet per Year	
1970	194,000	154	29.9	10.90	33,500	168	32.6	11.90	36,500	78.2
1975	235,000	157	36.9	13.47	41,300	171	40.2	14.67	45,000	96.4
1980	280,000	161	45.1	16.50	50,600	175	49.0	17.93	55,000	117.6
1985	332,000	164	54.4	19.87	61,000	178	59.1	21.57	66,200	141.8
1990	390,000	167	65.1	23.77	73,000	181	70.6	25.77	79,100	169.4
1995	452,000	171	77.3	28.21	86,600	185	83.6	30.52	93,700	200.7
2000	520,000	174	90.5	33.12	101,600	188	97.8	35.78	109,800	234.6
2005	602,000	177	106.6	38.89	119,300	191	115.0	41.97	128,800	276.0
2010	670,000	181	121.3	44.26	135,800	195	130.7	47.69	146,300	313.6
2015	752,000	184	138.4	50.50	155,000	198	148.9	54.35	166,800	357.4
2020	840,000	187	157.1	57.49	176,400	201	168.8	61.80	189,600	405.2

9. CONCLUSIONS AND RECOMMENDATIONS

Lubbock's existing water supply sources are expected to satisfy peak daily needs through the year 1975, assuming expansion of the Sand Hills Well Field up to the 41 MGD limit of the present delivery system. Before 1976, it will probably be necessary to augment the basic supply with major improvements at one point or another.

The limiting delivery rate from the Sand Hills can be raised to 60 MGD by adding booster pumps on the pipe line. A second line, parallel to the first one, could also be placed in service at a later date, increasing the maximum rate to 120 MGD. The enlargement from 60 to 120 MGD, however, would involve capital expenditures of approximately $12 million and would have a useful operating life of only about 16 years; it is not considered to be economically justifiable.

About 1970, initial work will be needed on a new gathering system, which will eventually serve the entire western portion of the Sand Hills Field. The primary pipe line along the backbone of this gathering network should be sized to match the intended ultimate production rate - 41 MGD or 60 MGD.

It will be possible to increase the peak operating rate of the filter plant by some 22.66 MGD if a terminal storage reservoir for raw water is constructed nearby. Although the design capacity of the existing plant is 75 MGD, only 52.34 MGD can be obtained directly from the Canadian River aqueduct. The full 75 MGD rate could be utilized if supplemental water were available from storage during periods of peak loading and if some additional pipe line capacity were provided between the filter plant and the distribution system. The terminal storage reservoir and associated improvements, as described in Section 7 of this report, will be the most economical next step in providing additional water supply capability to keep up with the City's growth. It is therefore recommended:

a. That a 100-acre site for the terminal storage reservoir be acquired in the near future. The tract of land should be square and located conveniently close to the filter plant. It is also desirable that additional adjacent land be available for future expansion of the terminal storage capacity.

b. That the City plan to build the terminal reservoir for untreated surface water, with a normal storage capacity of 1,204 acre-feet, around 1975.

c. That additional pipe line capacity linking the filter plant to the distribution system be provided as needed, with the expectation that the full 75 MGD capacity of the plant (64.35 MGD for Lubbock and 10.65 MGD for other neighboring communities) could be needed by 1980.

d. That the Sand Hills Well Field be scheduled for additional wells beginning in 1970, with development to a maximum well capacity of 45.1 MGD (110% of the existing 41 MGD supply line capacity) by 1976 and continuing at that level through 1980.

It is also recommended:

e. That future wells in the Sand Hills Field be spaced 2,500 feet apart in an equilateral triangular pattern.

f. That initial pump installations be sized for 50% of the maximum capacity of new wells, so that there will be steady production at or near full pump output until approximately 30% of the water has been removed.

g. That the western gathering line system at the Sand Hills be laid out in a herringbone configuration, conforming generally to the pattern shown by Figure 6.2, with the backbone pipe sized for the intended ultimate capacity of the field.

At this point, it is desirable to withhold judgment regarding installation of the Sand Hills booster pump stations in the year 1980, and therefore also about the size of the new primary western gathering line. Although it does appear now that the booster stations will be needed, and their eventual construction was assumed where applicable in the cost estimates, the matter will depend in large part on the relative availability and estimated costs of other sources of supply. Such considerations will be covered in the final report, to be presented in 1969, and recommendations for the ultimate level of Sand Hills Development (41 MGD or 60 MGD) should be deferred until that time.