ENVIRONMENTAL INFORMATION DOCUMENT
FOR JUSTICEBURG RESERVOIR

Garza and Kent Counties, Texas

Prepared to Satisfy Conditions of
Permit Number SWF-86-GARZA-949

May 1990

Prepared by

The City of Lubbock

and

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for

U.S. Army Corps of Engineers
Fort Worth District

Although referred to as Justiceburg Reservoir throughout this report, the proposed reservoir has been renamed Lake Alan Henry by resolution of the Lubbock City Council. The lake is named in honor of former Mayor Henry and his untiring efforts toward the realization of this new source of water supply for his city.

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EXECUTIVE SUMMARY

Increasing population growth and decreasing water supplies have required the City of Lubbock to pursue the development of new sources of water supply. In order to meet future water demand the City proposes to construct a dam and reservoir on the Double Mountain Fork Brazos River near Justiceburg in Garza and Kent Counties. A pump and pipeline would be constructed to divert water from the reservoir to the City of Lubbock. Upon approval of the U.S. Army Corps of Engineers Section 404 Permit, it is estimated that the project will require about two years to construct and three years to fill, under average flow conditions. The estimated construction cost of the project is $39 million. Other capital costs associated with the project include an estimated $4.4 million for land acquisition, an estimated $2.3 million for archeology and an estimated $1 million for fish and wildlife mitigation.

The reservoir conservation pool will have an estimated initial capacity of 115,937 acre-feet and an estimated average yield of 30,200 acre-feet per year. Based on the results of a USGS water quality monitoring program, it is expected that water in Justiceburg Reservoir will be of better quality than Lake Meredith, the City's current primary source.

The proposed project would inundate 2,884 acres at the top of the conservation pool. Unavoidable project impacts include a loss of 2,884 acres of wildlife habitat; a decrease in flood flows below the dam; a loss of ten existing oil wells in the reservoir pool area; a loss of undeveloped sand, gravel, and uranium resources; a loss of 84 acres of prime farmland soils; a loss of active ranchland; a loss of county, school and hospital tax base; a loss of tax revenue from oil wells; and a loss of in-place cultural resources. No residential displacements are required by the project. A mitigation proposal, involving purchase of a 3,038 acre tract in Kent County, has been submitted to the U. S. Army Corps of Engineers to compensate for fish and wildlife impacts. A program for cultural resources investigations has already been implemented as part of the cultural resources mitigation.

In addition to providing a reliable water supply for the City of Lubbock, the reservoir project will have a positive impact on Garza and Kent Counties, primarily due to the recreational potential of the lake. In addition to providing freshwater contact recreational opportunities, the City's proposed development of a 550-acre recreation area will provide camping, picnicking and boating facilities for the South Plains region. It is anticipated that the lake will draw tourism and weekend residents to the area, increasing local sales, demand for local services, and ultimately, increasing the local tax base through the development of weekend homes. Construction of the reservoir project will increase employment through local construction payrolls.

ENVIRONMENTAL INFORMATION DOCUMENT
FOR JUSTICEBURG RESERVOIR
Garza and Kent Counties, Texas

1. PURPOSE AND BASIS OF NEED FOR THE PROPOSED PROJECT

The City of Lubbock currently supplies water to approximately 192,500 citizens within the City corporate limits. In 1989, the City provided an average of 36.6 million gallons per day (mgd) of water. The maximum daily water demand for the year was 70.9 mgd. Over the past 15 years, the population of Lubbock has increased by about 20 percent. Over the same period of time, water use correspondingly increased by 25-30 percent (Table 1.1).

Future population and water demand estimates for the City of Lubbock (Table 1.2) have been projected by the Texas Water Development Board (1989). These projections show a 58 to 74 percent increase in the city population by the year 2040. As a result of population growth, Lubbock's water use in high-use years is expected to increase to 58.4 mgd assuming low population growth. With high population increases, water use in high-use years is expected to increase to 66.1 mgd. These population increases cannot be supported by the City's existing water supply sources.

The City of Lubbock currently obtains water from four sources (Figure 1.1):

1. the Canadian River Municipal Water Authority (CRMWA),
2. the Sand Hills Well Field,

EXISTING SOURCES OF WATER SUPPLY FOR LUBBOCK

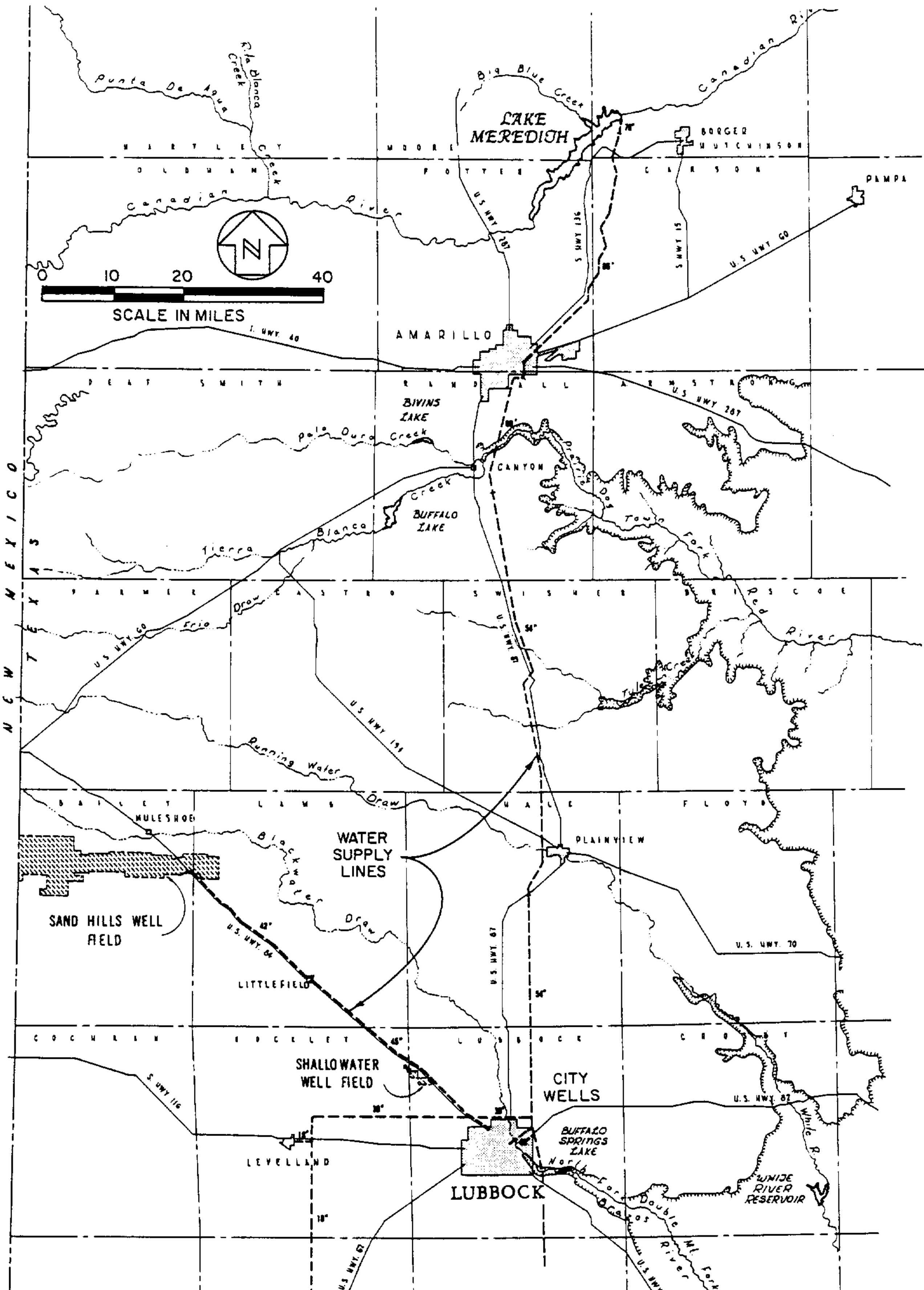


FIGURE 1.1

Table 1.1

Historical Population and Water Demand
City of Lubbock, 1975 - 1989

Year	Population	Average Daily Water Use (mgd)	Maximum Daily Water Use (mgd)
1975	161,050	27.6	56.2
1976	163,550	29.8	57.9
1977	166,100	32.7	68.3
1978	168,700	38.3	78.8
1979	171,300	33.8	60.8
1980	173,979	38.9	76.9
1981	176,700	33.1	68.5
1982	178,282	32.0	58.7
1983	181,500	36.5	66.5
1984	182,103	34.3	60.1
1985	187,629	33.3	67.4
1986	188,282	31.6	69.0
1987	188,694	31.3	59.7
1988	190,017	34.1	61.9
1989	192,500	36.6	70.9

Source: City of Lubbock, 1990

Table 1.2

Projected Population and Water Demand for the City of Lubbock, 1990-2040
TWDB High and Low Series with Conservation Practices

Year	Population	Average Year Water Use (mgd)	High-Use Year Water Use (mgd)
1990	191,008	36.9	42.1
	189,818	36.7	41.8
2000	216,261	39.9	45.4
	214,214	39.4	44.8
2010	241,474	42.5	48.3
	238,549	41.5	47.3
2020	271,128	46.6	52.9
	264,261	44.6	50.7
2030	311,865	53.4	60.4
	290,097	48.7	55.4
2040	334,383	58.4	66.1
	303,827	51.1	58.1

Source: Texas Water Development Board, 1989

3. the Shallowater Well Field, and

4. local wells within the city limits.

The Canadian River supply is piped approximately 150 miles from Lake Meredith to Lubbock. Although the City has a contractual allocation for 34.1 mgd average use and 41.7 mgd maximum daily use, CRMWA has cut back Lubbock's supply in order to meet the projected safe yield limitations of Lake Meredith (HDR, 1987). Lubbock currently receives 80 percent of its contractual allocation (27.3 mgd). Although CRMWA estimates that the allocation should range between 75 and 85 percent (25.6 to 29.0 mgd) over the next few years, the possibility exists for further reductions if upstream water rights from New Mexico's Ute Lake are utilized for consumptive use allocations (personal communication with John Williams, General Manager, Canadian River Municipal Water Authority, 21 May 1990).

The remaining water deficit is supplied from the Sand Hills Well Field located in Bailey and Lamb Counties. The well field supplies from 0 to 41 mgd. During the past few years, the Sand Hills has supplied about 15 to 20 percent of the City's total use. The Sand Hills supply is based on a large volume of water stored in the Ogallala aquifer which is not replenished to any significant degree by recharge. At the present rate of withdrawal (less than 10,000 acre-feet per year or approximately 8.9 mgd average use), the Sand Hills reserve should provide 80 to 100 years of supply. However, full use of the Sand Hills to meet Lubbock's projected needs over and above the amounts available from other existing sources would probably exhaust the field prior to the year 2020.

The Shallowater Well Field and the local wells are not capable of sustained operation for long periods of time. Water from these sources is of poor quality and is used only for emergency and peak hour use. The peak rate provided from the city wells on days of heavy demand is about 10 mgd. The Shallowater Field has been able to furnish about 4 mgd on maximum days, but it is anticipated that this rate will drop to around 3 mgd. Several local city wells have exceeded the state water quality standard for selenium. In response to the exceedences, City officials have closed several of these wells. On an annual basis, the volume of water obtained from the Shallowater and local well sources is essentially negligible; the Canadian River and Sand Hills sources furnish virtually all of the City's supply.

Although the historical population increases have not been as great as the Texas Department of Water Resources (TDWR) 1980 population estimates (which projected a 25 percent increase between 1975 and 1990), increased population and decreasing water supplies have required the City to pursue new sources of supply. Since 1971, the City has been studying the potential development of a water supply reservoir on the Double Mountain Fork Brazos River near Justiceburg in Garza and Kent Counties.

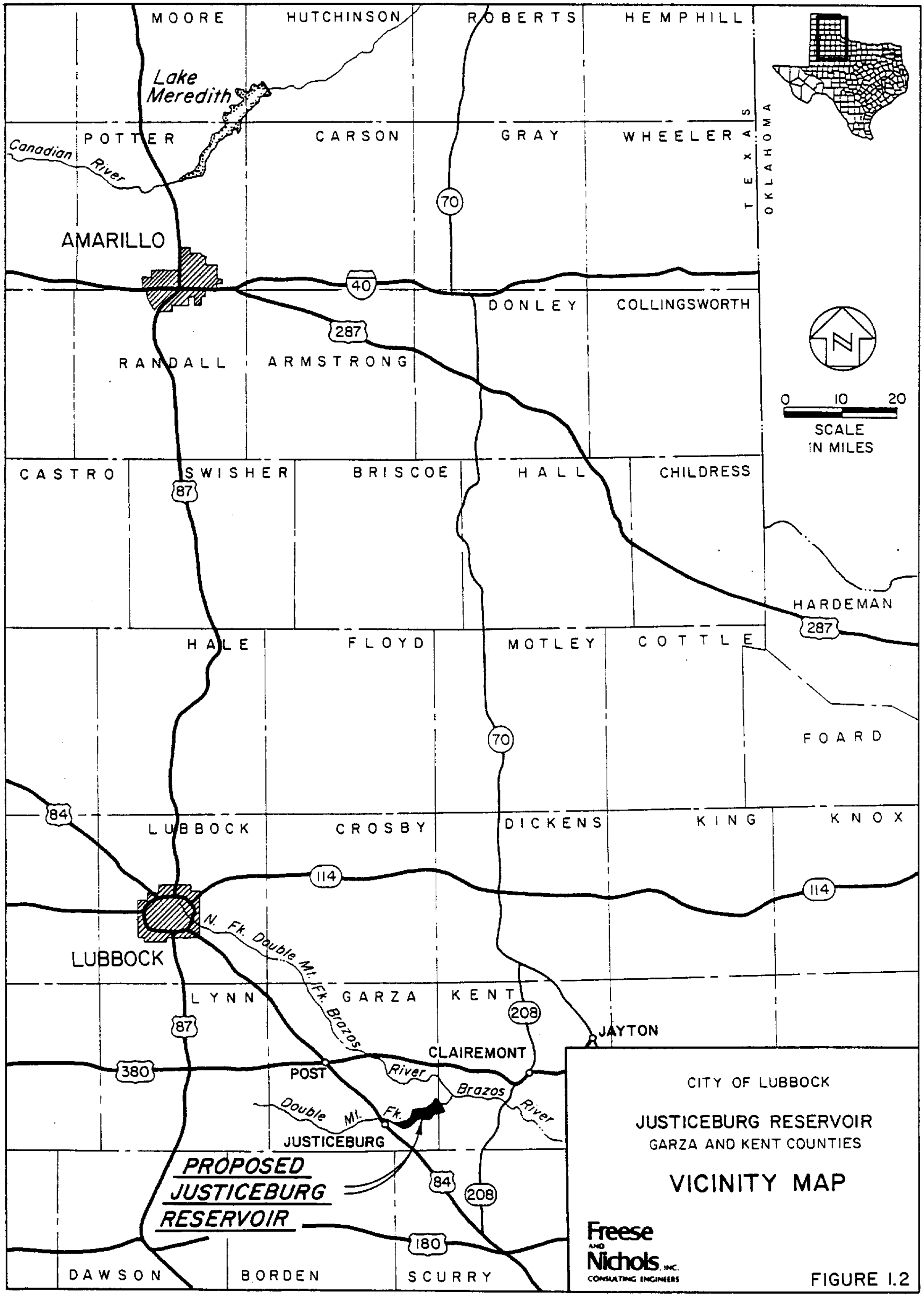
In 1971, the City of Lubbock contracted with Freese and Nichols to prepare a report on the probable long-range water requirements of the City and potential sources of additional future supply. Comparison of several alternative sources led to the recommendation that Lubbock consider development of new surface water supplies, including Justiceburg

Reservoir (Figure 1.2).

In 1975, Freese and Nichols was asked to prepare a supplemental report in which the basic findings of the 1971 study were reviewed and up-dated. The 1975 investigation, like the earlier study, indicated the potential of the Justiceburg source. The report also emphasized the need for field testing of the water quality and for preliminary geotechnical studies, to confirm the basic feasibility of the Justiceburg site.

In August of 1975, Lubbock authorized Freese and Nichols to proceed with additional, more detailed studies relating to the Justiceburg project. At that same time, the City approved a program of field investigations on and near the Justiceburg site by Mason-Johnston and Associates, Inc., a geotechnical consulting firm experienced in dam foundation work. The City also instructed Freese and Nichols to enter into agreement with the U.S. Geological Survey (USGS) for establishment and operation of a chemical quality monitoring station at the U.S. Highway 84 bridge on the Double Mountain Fork at Justiceburg.

The results of the geotechnical and water quality studies were presented in a 1978 report by Freese and Nichols, which included an evaluation of the reservoir yield and a preliminary design analysis of the dam and spillway. Findings of the report estimated that the Justiceburg Reservoir would have a firm yield of 26,100 acre-feet per year when the lake is first constructed and 20,600 acre-feet per year after 50 years of project operation. If the reservoir is operated with a variable rate of demand, an estimated average yield of 30,200 acre-feet



CITY OF LUBBOCK

JUSTICEBURG RESERVOIR
GARZA AND KENT COUNTIES

VICINITY MAP

FIGURE 1.2

per year could be withdrawn initially. After 50 years of project operation, the variable demand yield would decrease to 27,000 acre-feet per year. This would provide the City of Lubbock with a reliable water supply of 23.3 mgd and an average water supply of 26.9 mgd. Assuming a worst case scenario of: a 75 percent allocation from CRMWA (25.6 mgd), an average withdrawal from the Sand Hills field (8.9 mgd), and a firm yield from Justiceburg Reservoir (23.3 mgd), the City would have a reliable supply of 57.8 mgd, which would be sufficient to meet projected normal water demands through about the year 2040. Based on the results of the water quality monitoring program by the USGS and the City of Lubbock and on reservoir quality routing studies by Freese and Nichols (1978), it was concluded that water in Justiceburg Reservoir would be of better quality than water from Lake Meredith.

The City of Lubbock proposes to construct a water supply reservoir at the Justiceburg site. A pump station and pipeline would be constructed to divert water from Justiceburg Reservoir to the City of Lubbock. The project will provide the City with an average of 26.9 mgd of municipal water supply. Upon approval of the U.S. Army Corps of Engineers Section 404 Permit, it is estimated that the project will require two years to construct and three years to fill, based on average runoff conditions. The estimated cost of the project is $46.7 million.

2. DESCRIPTION OF REASONABLE ALTERNATIVES AND SELECTION OF THE PREFERRED ALTERNATIVE

The City of Lubbock has considered a broad range of alternative sources for providing a reliable municipal water supply. These include the development of new reservoir sites; utilization of alternative sources, including groundwater, desalting, long-range importation, and reclamation; water conservation; and the possible combination of more than one site and/or source.

2.1 Alternative Surface Reservoir Sites

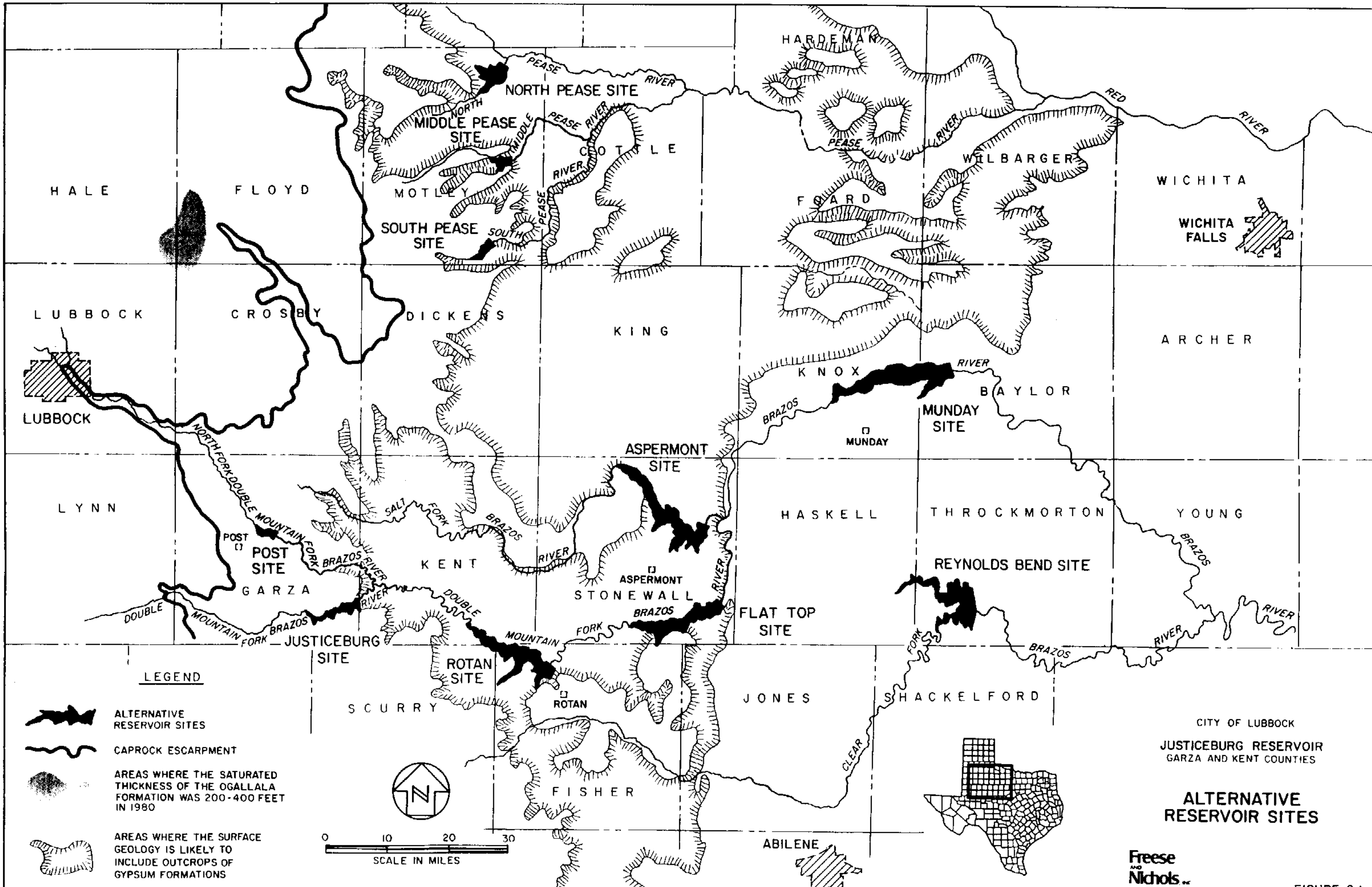
Parts of four major river basins - the Colorado, the Brazos, the Red, and the Canadian - are close enough to Lubbock to be considered for possible surface water sources. Although these four basins occur within feasible pumping distance of Lubbock, there are several factors which tend to narrow the possibilities for additional surface water. Reservoirs capable of producing significant yields must generally be located downstream from the Caprock escarpment and will depend almost entirely on the watershed area east of the High Plains for sustaining runoff.

Not far to the east, however, the surface geology contains outcrops of gypsum (calcium sulfate) formations. Where gypsum occurs, the subsurface strata tend to be porous and relatively soluble in water, making dam construction difficult and costly. Gypsum can also lead to high concentrations of sulfates in natural runoff. Sulfate levels above 300 mg/l give water a detectable and sometimes unpleasant taste, and concentrations exceeding 600 mg/l may produce a laxative effect in people who are not accustomed to drinking such water (Lehr et al., 1980). Sulfates, as well as other dissolved solids, are difficult and expensive to remove from solution, and present water treatment technology does not offer economical methods for lowering the sulfate level if the concentration is too high. For reference, federal and state drinking water standards for sulfate and other chemical constituents are provided in Table 2.1. A more comprehensive discussion of the standards is provided in Section 3.3.1.

For all practical purposes, areas of the Canadian and Colorado River basins that are reasonably close to Lubbock offer no further opportunities for surface water supply since all water rights have been appropriated and all feasible dam sites have been developed. Therefore, only the Brazos and Red River basins are considered for possible reservoir sites. Portions of these basins that lie below the Caprock escarpment and lie upstream from major gypsum deposits may offer feasible opportunities for additional surface water. Ten reservoir sites, occurring on tributaries of the Brazos and Red Rivers (see Figure 2.1), were considered as potential surface water supplies for the City of Lubbock (Freese, Nichols and Endress, 1971). A comparison of the alternative sites is summarized in Table 2.2.

2.1.1 North Pease Site

The North Pease site, located approximately 85 miles northeast of



NORTH PEASE SITE
MIDDLE PEASE SITE
SOUTH PEASE SITE
ASPERMONT SITE
MUNDAY SITE
REYNOLDS BEND SITE
FLAT TOP SITE
ROTAN SITE
POST SITE
JUSTICEBURG SITE
HALE
FLOYD
MOTLEY
COTTLE
HARDEMAN
FOARD
WILBARGER
WICHITA
WICHITA FALLS
LUBBOCK
CROSBY
DICKENS
KING
KNOX
BAYLOR
ARCHER
LYNN
GARZA
KENT
STONEWALL
HASKELL
THROCKMORTON
YOUNG
SCURRY
FISHER
JONES
SHACKELFORD
ABILENE
LUBBOCK
POST
ASPERMONT
MUNDAY
ROTAN
RED RIVER
PEASE RIVER
BRAZOS RIVER
SALT FORK
DOUBLE MOUNTAIN FORK
NORTH FORK DOUBLE MOUNTAIN FORK
CLEAR FORK
LEGEND
ALTERNATIVE RESERVOIR SITES
CAPROCK ESCARPMENT
AREAS WHERE THE SATURATED THICKNESS OF THE OGALLALA FORMATION WAS 200-400 FEET IN 1980
AREAS WHERE THE SURFACE GEOLOGY IS LIKELY TO INCLUDE OUTCROPS OF GYPSUM FORMATIONS
0 10 20 30
SCALE IN MILES
N
CITY OF LUBBOCK
JUSTICEBURG RESERVOIR
GARZA AND KENT COUNTIES
ALTERNATIVE RESERVOIR SITES
Freese and Nichols inc
CONSULTING ENGINEERS

FIGURE 2.1

Table 2.1

National and State Drinking Water Criteria for Selected Chemical Constituents

	National Criteria[1] (mg/l)	State Criteria[2] (mg/l)
Primary Constituents:		
Nitrate-nitrogen	10.0	10.0
Fluoride	4.0	4.0
Recommended Secondary Constituents:		
Chloride	250	300
Sulfate	250	300
Total Dissolved Solids	500	1,000
pH (Standard Units)	6.5-8.5	Greater than 7.0
Fluoride	2.0	2.0

[1] Environmental Protection Agency, 1988; 1989

[2] Texas Department of Health, 1987.

Table 2.2

Comparison of Alternative Reservoir Sites, Stream Segments and Drinking Water Criteria

	Recommended Secondary Constituents (mg/L)		
	Total Dissolved Solids	Chloride	Sulfate
National Drinking Water Criteria[1]	500	250	250
State Drinking Water Criteria[2]	1,000	300	300

Reservoir/ (TWC Segment)	Estimated Annual Firm Yield (ac-ft)	Pumping Distance to Lubbock (miles)	Significant Gypsum Deposits in Watershed	Estimated Average Concentration (mg/L) Total Dissolved Solids[3]	Chloride[3]	Sulfate[3]	Hardness	Other WQ Problems
North Pease (Segment 220)	12,200	85	no	N/A (30,000)	N/A (12,000)	N/A (3,500)	N/A	-
Middle Pease (Segment 221)	4,300	80	no	N/A (2,800)	N/A (870)	N/A (1,400)	N/A	-
South Pease (Segment 227)	7,000	72	no	N/A (1,000)	N/A (270)	N/A (200)	N/A	-
Aspermont (Segment 1238)	N/A	108	yes	9,585 (40,000)	4,860 (23,000)	1,070 (4,000)	N/A	high Mn
Munday (Segment 1208	N/A	145	yes	3,124 (12,000)	1,327 (5,000)	624 (2,000)	734	-
Post (nondesignated)	10,600	46	no	1,300 N/A	279 N/A	240 N/A	364	-
Justiceburg (nondesignated)	26,100	58	no	776 N/A	245 N/A	48 N/A	98	-
Rotan (Segment 1241)	N/A	95	yes	1,406 (5,500)	394 (2,500)	463 (2,400)	505	-
Flat Top (Segment 1241)	N/A	115	yes	1,406 (5,500)	394 (2,500)	463 (2,400)	505	-
Reynolds Bend (Segment 1232)	58,200	153	yes	940 (4,900)	257 (1,250)	301 (2,200)	442	petroleum activity

1 Environmental Protection Agency, 1988; 1989.
2 Texas Department of Health, 1987.
3 Texas Water Commission (1988) surface water quality standards for designated segments are provided in parentheses.

Lubbock, occurs on the North Pease River in the Red River basin. This site is situated in Motley County and has a drainage area of 591 square miles, an initial reservoir capacity of 151,000 acre-feet, and an estimated annual yield of 12,200 acre-feet (Freese, Nichols and Endress, 1971). The size and yield of the reservoir are limited by the relatively small watershed above the dam site and by the occurrance of significant gypsum deposits downstream of the dam site. Since the site is located upstream from most of the gypsum formations, dissolved mineral levels might be within reasonable limits. However, the Texas Water Commission (TWC) surface water quality standards indicate that annual average concentrations of total dissolved solids (TDS), chloride, and sulfate can be expected to be as much as 30,000 mg/l, 12,000 mg/l, and 3,500 mg/l, respectively, in Segment 220, which encompasses the North Pease site (TWC, 1988).

2.1.2 Middle Pease Site

The Middle Pease site occurs on the Middle Fork Pease River in the Red River basin. The site is located in Motley County, approximately 80 miles northeast of Lubbock. With a drainage area of 216 square miles and an initial reservoir capacity of 63,000 acre-feet, this reservoir has an estimated annual yield of 4,300 acre-feet (Freese, Nichols and Endress, 1971). Again, the size and yield of the reservoir are limited by the relatively small watershed above the dam site and by the occurrence of significant gypsum deposits downstream of the dam site. Like the North Pease site, this site might yield suitable dissolved mineral levels due to the downstream location of most of the gypsum outcrops. However, the TWC standards for Segment 221, the Middle Fork Pease River, allow up to 2,800 mg/l TDS, 870 mg/l chloride, and 1,400 mg/l sulfate (TWC, 1988).

2.1.3 South Pease Site

The South Pease site, located approximately 72 miles northeast of Lubbock, occurs on the South Pease River in the Red River basin. The reservoir, situated in Motley County, has a drainage area of 319 square miles, an initial reservoir capacity of 98,000 acre-feet, and an estimated yield of 7,000 acre-feet per year (Freese, Nichols and Endress, 1971). Again, the size and yield of the reservoir are limited by the relatively small watershed above the dam site and by the occurrence of significant gypsum deposits downstream of the dam site. Much of the reservoir's watershed is located upstream of the gypsum outcrop, which would enhance the potential for acceptable dissolved mineral concentrations. The TWC standards for Segment 227 suggest that dissolved mineral levels at the South Pease site would be suitable for municipal supply, with average annual limits of 1,000 mg/l TDS, 270 mg/l chloride, and 200 mg/l sulfate (TWC, 1988). Although no sampling data were published for the segment, the TWC (1986) indicated that there were no known or anticipated water quality problems.

2.1.4 Aspermont Site

The Aspermont site is located on the Salt Fork Brazos River, approximately 108 miles southeast of Lubbock in Stonewall County. The site has a drainage area of 2,088 square miles, much of which contains outcrops of gypsum (Freese, Nichols and Endress, 1971). The flow-weighted average TDS concentration of the Salt Fork Brazos River at U.S. Highway 83 north of Aspermont was 9,585 mg/l, based on daily conductivity measurements made by the U.S. Geological Survey from October 1969 through September 1982. Chloride and sulfate averaged 4,860 mg/l and 1,070 mg/l, respectively, on a flow-weighted basis during the same period. Salt seeps and springs issuing from an underground source of saturated brine in the Croton Creek and Salt Croton Creek drainages are responsible for much of the salinity in the Salt Fork (Rawson, 1967). Consequently, concentrations of sulfates, chlorides, and total dissolved solids far exceed acceptable limits for municipal use.

An inventory of water quality sampling data collected by the USGS since 1980 indicates that dissolved manganese is occasionally elevated at the site, with concentrations ranging from 0.01 mg/l to 0.50 mg/l. Manganese in concentrations greater than 0.15 mg/l to 0.20 mg/l causes black stains to form on plumbing fixtures and laundry, and more than 0.5 mg/l may impart a metallic taste to food and water (USEPA, 1986; Lehr et al., 1980). Sources of manganese include decaying vegetation, geological deposits, and oil field brine. Special treatment is required to reduce the effects of manganese, since conventional water treatment does not remove the mineral.

2.1.5 Munday Site

The Munday site is located on the Brazos River approximately 145 miles east of Lubbock in Knox and Baylor Counties. The Munday site has a contributing drainage area of 3,435 square miles and, like the Aspermont site upstream, water quality is affected significantly by gypsum outcrops in the watershed (Freese, Nichols and Endress, 1971). Flow-weighted levels of dissolved minerals in the Brazos River at Seymour indicate that the Munday site would have somewhat better water quality than the Aspermont site, but the concentrations would still be too high for municipal supply. Based on daily flow and conductivity measurements made by the USGS between October 1974 and September 1987, TDS averaged 3,124 mg/l, chloride averaged 1,327 mg/l, and sulfate averaged 624 mg/l. The water was very hard, with an average hardness of 734 mg/l.

It has been pointed out that nearby Millers Creek Reservoir produces good quality water with TDS ranging from 149 to 147 mg/l, chlorides from 6 to 75 mg/l, and sulfates from 13 to 100 mg/l based on the historic record (USGS, 1977-1984). Although Millers Creek Reservoir is located 12 miles south of the Munday site on a tributary of the Brazos River, it has a relatively small 228 square mile watershed which occurs entirely to the east of the major gypsum deposits, whereas the Munday site has a much larger drainage area with major gypsum outcrops.

2.1.6 Post Site

The proposed Post Reservoir is under consideration for development by the White River Municipal Water District (WRMWD), which is authorized by the Texas Water Commission to withdraw 10,600 acre-feet of water per year from the site.

The Post site, located in Garza County approximately 46 miles southeast of Lubbock, is on the North Fork Double Mountain Fork Brazos River. At the conservation pool elevation of 2,434 feet msl, the reservoir would inundate 2,200 acres. Approximately 82 percent of the pool area consists of mesquite shrublands and grasslands; the remaining 18 percent is salt cedar - willow brush along the river corridor. Post Reservoir would have a drainage area of 190 square miles, an initial reservoir capacity of 57,856 acre-feet, and an estimated annual yield of 10,600 acre-feet (Freese, Nichols and Endress, 1971). Water quality measurements by the USGS between November 1983 and September 1987 indicated that dissolved mineral levels in the reservoir might be relatively high, with concentrations of TDS, chloride, and sulfate averaging 991 mg/l, 279 mg/l, and 240 mg/l, respectively, on a flow-weighted basis. The average hardness at the site was 364 mg/l, indicating that water from Post Reservoir would also be relatively hard.

Projections of total dissolved solids concentrations in the reservoir were made based on simulated reservoir operation using 1940 through 1981 hydrologic conditions and USGS water sampling (Freese and Nichols, 1988). The results indicated that TDS levels would be more than 1,300 mg/l, the observed upper limit of acceptability for water users in Lubbock, approximately 64 percent of the time. However, additional analyses indicated that the Post Reservoir could be operated in conjunction with Justiceburg Reservoir to provide water with TDS levels at 1,300 mg/l or less 100 percent of the time. The yield from the two-reservoir system would range from 25,255 acre-feet per year to 45,600 acre-feet per year, with an average of approximately 39,960 acre-feet of water per year, based on the 42-year operation study.

It should be noted that the projections of chemical quality in Post Reservoir assume that current (i.e., November 1983 through March 1988) watershed conditions will be applicable in the future. However, if a significant change in the dissolved solids contribution upstream of the Post site occurs, as would happen if the City of Lubbock implemented direct discharge of treated wastewater effluent into the North Fork Double Mountain Fork Brazos River, then the results of water quality projections under the current study would be invalidated. With upstream discharges, it will be more difficult to achieve suitable quality of blended water from the two reservoirs.

2.1.7 Justiceburg Site

The Justiceburg site is located on the Double Mountain Fork Brazos River approximately 58 miles southeast of Lubbock. The site is situated in Garza and Kent Counties near the town of Justiceburg. The reservoir site has a contributing drainage area of 394 square miles and would have an initial capacity of 115,937 acre-feet. The estimated firm annual yield is 26,100 acre-feet per year, although the average yield could be increased to approximately 30,200 acre-feet per year by using a variable-demand overdraft operation.

Water quality sampling by the USGS in the mid 1960s and from 1975 to present indicates that the natural runoff on the upper reaches of the

Double Mountain Fork is of acceptable chemical quality for municipal supply. The water is moderately hard and contains average levels of 520 mg/l TDS, 245 mg/l chloride, and 48 mg/l sulfate on a flow-weighted basis. Concentrations of TDS in the reservoir are projected to range from 546 mg/l to 1,210 mg/l, with a median of 776 mg/l, based on simulated reservoir performance using 1940 through 1981 hydrologic conditions and the USGS water quality sampling results (in the mid 1960s and from 1975 to present).

2.1.8 Rotan Site

The Rotan site is located on the Double Mountain Fork Brazos River in Kent and Fisher Counties, approximately 95 miles southeast of Lubbock and has a drainage area of 1,031 square miles (Freese, Nichols and Endress, 1971). A significant portion of the watershed above the site contains gypsum outcrops which contribute to elevated dissolved mineral conditions. The USGS made continuous measurements of conductivity from 1974 through 1987 at the U.S. Highway 83 bridge south of Aspermont, Texas, about 34 river miles downstream of the dam site. The measurements indicate that the water has average concentrations of 1,406 mg/l TDS, 394 mg/l chloride, and 463 mg/l sulfate on a flow-weighted basis. Total hardness averaged 505 mg/l, indicating that the water is very hard. Although dissolved mineral concentrations in this reach of the Double Mountain Fork are not as extreme as on the Salt Fork, they would render the water undesirable for municipal supply.

An inventory of USGS samples collected periodically between 1980 and the present showed that manganese levels were occasionally elevated in the stream, with concentrations of 26 samples ranging from 0.001 mg/l to 0.320 mg/l. The TWC indicated that potential water quality problems in Segment 1241, which encompasses the Rotan site, may occur from periodic elevations of fecal coliform bacteria and total phosphorus (TWC, 1986).

2.1.9 Flat Top Site

The Flat Top site, situated in Stonewall County, is approximately 115 miles southeast of Lubbock. The site is located on the Double Mountain Fork Brazos River and has a drainage area of 1,405 square miles (Freese, Nichols and Endress, 1971). The water quality discussion for the Rotan site applies to this site as well, since the USGS sampling point is located within the area which would be inundated by Flat Top Reservoir. Like the Rotan site, the dissolved mineral concentrations at the Flat Top site are not as extreme as on the Salt Fork, but are nevertheless high enough to render the water unsuitable for municipal use.

2.1.10 Reynolds Bend Site

The Reynolds Bend site, in Haskell and Throckmorton Counties, is located on the Clear Fork Brazos River. The site is approximately 153 miles southeast of Lubbock and has a drainage area of 2,618 square miles. The initial reservoir capacity would be 651,000 acre-feet with an estimated yield of 58,200 acre-feet per year (Freese, Nichols and Endress, 1971).

Water quality at the Reynolds Bend site is influenced significantly by an area of gypsum-bearing formations covering approximately 416 square miles (16 percent) of the upper Clear Fork basin, and petroleum extraction activities scattered throughout the watershed may have contributed dissolved minerals to the Clear Fork and its tributaries in the past (Freese and Nichols, 1985; TWC, 1986). The TWC indicated that Segment 1232, the Clear Fork Brazos River, has known water quality problems which include elevated dissolved minerals (TWC, 1986). Based on flow-weighted concentrations reported by the USGS between 1973 and 1984, TDS at the site averages 940 mg/l, chloride averages 257 mg/l, sulfate averages 301 mg/l, and the water has an average hardness of 442 mg/l. These concentrations suggest that dissolved minerals would be near the upper limits of acceptability, and they tend to confirm previous projections of water quality in the Reynolds Bend Reservoir, which indicated that TDS levels would frequently exceed 1,000 mg/l and would range as high as 3,900 mg/l (Freese, Nichols and Endress, 1971). Such levels would limit the desirability of the water for municipal use.

2.2 Alternative Groundwater Sources

The Ogallala Formation is the primary groundwater bearing unit in the High Plains region. The relatively high level of agricultural usage for irrigation has a substantial influence on the availability and cost of pumping the Ogallala water. Water levels in the Ogallala Aquifer in Texas have declined significantly since World War II due to demands which have exceeded annual recharge (High Plains Associates, 1982). It should be noted that since 1985 and the implementation of House Bill 2 of the 69th Legislature, it has been a policy of the State of Texas not to mine aquifers that have been overdrafted. It is further policy to encourage the conversion from the use of groundwater to the use of surface water in areas where continued reliance upon groundwater is causing, or will cause, undesirable environmental and social problems.

In cases where there is no reasonable alternative, it is apparent that purchase of irrigable lands may be an option for securing additional municipal supplies. However, for reasons of economy and general policy, the direct purchase of irrigable lands would not be as satisfactory as other options. Since the region's agricultural productivity and economic base are closely tied to irrigation, it is best to minimize municipal use of water which would otherwise be used for agricultural purposes. In addition, water obtained from non-farming areas is expected to be less expensive. Therefore, only groundwater sources which would not interfere with irrigation, or would do so only to a minor degree, would be valid alternatives for consideration as supplemental supply sources for the City of Lubbock.

Three areas of potential groundwater supply in the region surrounding Lubbock were evaluated (Freese, Nichols and Endress, 1971). These included the Ogallala Formation in the southern High Plains, the Ogallala in the northern High Plains, and the Santa Rosa Formation. A comparison of the alternative groundwater sources is summarized in Table 2.3. Water quality in the Ogallala is generally suitable for municipal supply, with

Table 2.3

Comparison of Alternative Groundwater Sources

	Approximate Pumping Distance to Lubbock (miles)	Estimated Recoverable Volume In 1980 (acre-feet)	Estimated Total Dissolved Solids (mg/L)	Other Known Problems
Ogallala Formation in the Southern High Plains	30	6,000,000	<1,000	occasional elevated fluoride & nitrate
Ogallala Formation in the Northern High Plains:				
• Hartley County	164	4,800,000	<1,000	occasional elevated fluoride & nitrate
• Ochiltree County	190	3,700,000	<1,000	occasional elevated fluoride & nitrate
Santa Rosa Formation:				
• Scurry, Mitchell & Nolan Counties	60-110	N/A	<1,000	occasional elevated fluoride & nitrate
• Gaines, Andrews, Winkler, Ector, Ward, Crane and Upton Counties	40-160	N/A	1,000-10,000	---

Source: Texas Water Development Board, 1986

TDS levels ranging below 1,000 mg/l. However, elevated levels of fluoride and nitrate are found occasionally (TWC, 1986). The Santa Rosa Formation contains TDS levels varying from less than 1,000 mg/l in outcrop areas up to 10,000 mg/l in the downdip areas where it underlies the Ogallala Formation (TWC, 1986). Comparative economic investigations for the City of Lubbock (Freese and Nichols, 1971) showed groundwater to be one-third more expensive than the development of surface water sources, including the Justiceburg project. Although the study was prepared in 1971, the relative costs remain the same in 1990 for development of groundwater versus surface water.

2.2.1 Ogallala Formation in the Southern High Plains

The most economical sources of Ogallala water, and therefore the most desirable sources, were judged to be in areas where the saturated thickness of the aquifer was 200 feet or more (Freese, Nichols and Endress, 1971). At the time of the 1971 study, the area of interest in the southern High Plains (i.e., the portion of the High Plains south of the Canadian River) covered a total of approximately 794,300 acres of land and contained at least 19.5 million acre-feet of recoverable water. The majority was in Castro and Parmer Counties, with smaller areas contained in Deaf Smith, Bailey, Lamb, Hall, and Floyd Counties. A subsequent study showed that the area where the saturated thickness was at least 200 feet had diminished to approximately 202,000 acres by 1980

(High Plains Associates, 1982). The total volume of recoverable water in the 200-foot (or more) saturated thickness zone in 1980 is estimated to have decreased to approximately 6 million acre-feet, assuming a specific yield of 15 percent.

The water table is expected to continue to fall because intensive irrigation occurs in nearly all of these areas. For example, the water level in an irrigation well in west-central Floyd County declined steadily at a rate of approximately 5 feet per year between 1940 and 1978, and the saturated thickness in the vicinity of the well decreased from 300 feet to about 105 feet (High Plains Associates, 1982). In Deaf Smith County, approximately 75 percent of the saturated area is projected to have a maximum thickness of only 25 feet in the year 2020, with a maximum thickness of 125 feet (Wyatt et al., 1977). In 1974, by comparison, approximately 86 percent of the saturated area had a thickness greater than 25 feet, with five percent of the area having a saturated thickness of 200 to 275 feet.

2.2.2 Ogallala Formation in the Northern High Plains

The Ogallala Aquifer in the northern High Plains (i.e., north of the Canadian River) was also surveyed previously for areas that might be developed for water supply (Freese, Nichols and Endress, 1971). At that time, there were areas of untapped Ogallala water in both Hartley and Ochiltree Counties with at least 200 feet of saturated thickness. The distance from the Hartley County area to Lubbock is approximately 164 miles, while the distance from the area to the City's Bailey County pump station at the Sand Hills Well Field is approximately 120 miles. The Ochiltree County area is about 190 miles north of Lubbock.

In Hartley County, the undeveloped portion of the aquifer with a saturated thickness of at least 200 feet in the late 1960s was estimated to contain 6 million acre-feet of water under 283,000 acres of land (Freese, Nichols and Endress, 1971). In 1980, there were approximately 158,720 acres in the county where the saturated thickness of the aquifer was at least 200 feet (High Plains Associates, 1982). This area would represent an estimated 4.8 million acre-feet of recoverable groundwater. On a county-wide basis, the total recoverable volume in Hartley County is expected to decrease by approximately 52 percent between 1974 and 2020 (Bell and Morrison, 1981). The southeast quarter of Ochiltree County was also cited previously as a potential source of water (Freese, Nichols and Endress, 1971). It was estimated that approximately 7.4 million acre-feet of water were economically recoverable under 185,000 acres of land in the early 1970s. As in most other parts of the Ogallala, the water table in Ochiltree County is declining. In 1980, the area in southeast Ochiltree County with a saturated thickness of at least 200 feet had decreased to 125,440 acres (High Plains Associates, 1982), with an estimated volume of 3.7 million acre-feet of available water. The total volume of recoverable Ogallala water in storage in Ochiltree County is projected to decline by about 44 percent between 1974 and 2020 (Bell and Morrison, 1980).

2.2.3 Santa Rosa Formation

The Santa Rosa Formation is classified as one of the state's minor aquifers. The Formation outcrops primarily to the southeast of Lubbock in Scurry, Mitchell and Nolan Counties and to the northwest in Oldham and Potter Counties. The Texas Water Commission (1986) mapped the aquifer under outcrop conditions in Scurry, Mitchell and Nolan Counties, and under downdip conditions beneath the Ogallala Aquifer across a large portion of the Southern High Plains in Gaines, Andrews, Winkler, Ector, Ward, Crane and Upton Counties. For many years, the Santa Rosa Formation supplied all of the municipal water for the City of Canyon, and it is the principal source of domestic and stock water along the Canadian River where the Ogallala is absent.

The Santa Rosa occurs under water table conditions in the outcrop area, and as the formation dips southeastward the overlying Chinle shales act as a barrier to upward movement, resulting in artesian conditions away from the Canadian River. In the outcrop area of Scurry, Mitchell and Nolan Counties, and for relatively short distances down-dip (southeastward) the quality of Santa Rosa water is acceptable for municipal purposes. However, over most of the Southern High Plains the water is brackish to salty (Freese, Nichols and Endress, 1971).

Although the aquifer has a thickness ranging up to 400 feet (TWC, 1986), permeability and storage coefficients are low. Therefore, large land areas would be required to support a reasonably large demand. These factors, combined with the erratic and frequently unsatisfactory water quality in the Santa Rosa, led to the conclusion that the aquifer would be an unlikely source of water for the City of Lubbock (Freese, Nichols and Endress, 1971).

2.3 Other Alternatives

Besides surface water and groundwater development options, four other alternatives for augmenting Lubbock's water supply were considered: (a) desalting of mineralized water, (b) importation of water, (c) reclamation of municipal wastewater, and (d) water conservation. Some of these alternatives are expected to be more expensive than development of conventional supplies (i.e., surface water or groundwater). In addition to cost, there are other problems inherent in each of the alternatives which will not be easily resolved. Nevertheless, they were examined as potential options for satisfying a portion of Lubbock's water needs.

2.3.1 Desalting of Mineralized Water

In the Lubbock vicinity, there are significant amounts of brackish surface water and groundwater that could be used for municipal purposes if economical methods were available for removing excessive chemical impurities. The cost of desalting was analyzed for several areas in Texas in 1967 by the U.S. Department of Interior Office of Saline Water. The estimated cost of the product water varied widely depending on the dissolved mineral levels in the raw water, the amount of water treated, and other factors specific to each case (Freese, Nichols and Endress, 1971).

A more recent study of desalination processes to treat brackish water was conducted for the City of Abilene, Texas (Freese and Nichols, 1984). The study noted that worldwide there are demineralization plants with a capacity for producing approximately 2 billion gallons of water per day. Most of the plants are located in the Middle East and in North Africa. The three main processes used to demineralize water include distillation, reverse osmosis, and electrodialysis. Costs to be considered for demineralization plants include captial expenses for the treatment units, pump stations and pipelines, brine disposal facilities, standard treatment works for reverse osmosis and electrodialysis, and operation and maintenance costs.

Distillation was found to be the most common, with 68 percent of the plants using this technique. Approximately nine ounces of fuel oil were required to distill one gallon of water in 1984, although advances in technology may have reduced this requirement slightly by 1989. The energy costs for application of the distillation process in the United States were estimated to be at least $15 per 1,000 gallons of water.

The reverse osmosis process was used at about 25 percent of the demineralization plants worldwide in 1984. The process involves forcing water under pressure through a semi-permeable membrane so that the contaminant molecules which are larger than water molecules are effectively filtered. Reverse osmosis is also effective in reducing other water-born pollutants such as bacteria and viruses. Surface water must be filtered, then chemically treated, and finally ultra-filtered to control clogging of the membrane during the treatment process. The raw water also may require softening to avoid formation of scale on the membrane. The Orange County Water District in California uses reverse osmosis to demineralize wastewater treatment plant effluent before it is injected into an aquifer (Argo and Moutes, 1979). The District reported that capital cost for the treatment process was $1 per gallon of capacity and the operating cost was $1 per 1,000 gallons (Freese and Nichols, 1984); however, these costs do not include brine disposal because the concentrate from the plant is discharged to the Orange County Sanitation District's wastewater treatment plant outfall into the Pacific Ocean. A 1984 estimate for using reverse osmosis to produce from one to ten mgd in Texas, from a source having 5,000 mg/l TDS or less, indicated that costs would range from $1 to $2.50 per 1,000 gallons, excluding the costs for well field or intake structure, transmission lines, land, brine disposal, and taxes (Beffort, 1984).

Electrodialysis was the process used at approximately 6 percent of the demineralization plants worldwide in 1984. The process uses an electric field to separate dissolved inorganic solids from water and produces a stream of fresh product water and a smaller stream of concentrated wastewater. The City of Granbury, Texas, recently constructed an electrodialysis plant with polarity reversal capabilities, which reduce maintenance requirements. The plant was designed to treat 0.50 mgd, with TDS levels of 1,400 mg/l. Based on actual operating experience of the Granbury plant, it will cost over $3 per 1,000 gallons even at full output. Recent cost estimates by Freese and Nichols for using electrodialysis as a means of augmenting water supply in two other Texas cities also were in the range of $3 per 1,000 gallons.

2.3.2 Importation of Water

Due to the gradual depletion of groundwater reserves on the High Plains, attention has been given to concepts involving importation of water from other areas within Texas or from outside the state. To be feasible, any such plan would have to utilize water that is surplus to the foreseeable needs of the area from which it is taken, and the volumes of water brought into the High Plains would have to be quite large.

A water conveyance system known as the Trans-Texas Canal was proposed by the Texas Water Development Board in 1968. The canal system was part of the first Texas Water Plan. The Water Plan is a periodically updated comprehensive plan, mandated by Section 16.051 of the Texas Water Code and designed to satisfy the current and future water needs of Texas. According to the original Texas Water Plan adopted in 1969, the Trans-Texas Canal would move water from east to west across the northern part of the State and deliver several million acre-feet of raw water per year into the High Plains area (Texas Water Development Board, 1968). The basic supply for this transfer was to be derived from the Sulphur, Cypress, and Sabine River basins of East Texas and also presumably from the lower reaches of the Mississippi River below New Orleans (Texas Water Development Board, 1969).

The Trans-Texas Canal was omitted from the 1984 Texas Water Plan

(Texas Department of Water Resources, 1984). Instead, the revised plan indicates that no surplus water exists for such large-scale transfer within the State of Texas. It concludes that future water supply planning efforts for the West Texas area must include the investigation of alternatives such as importation of surplus water from other states and water conservation measures. However, two major planning studies have shown that importation from outside the state is not economically feasible at this time (TDWR, 1984).

2.3.3 Reclamation of Municipal Wastewater

Lubbock is already reclaiming and reusing all of its treated municipal wastewater for secondary applications. The sewage treatment plant effluent has been used for irrigation for a number of years and effluent from the southeast activated sludge facility is currently being used as cooling water for the Southwestern Public Service Company's generating plant. Groundwater from beneath fields irrigated with wastewater plant effluent is recovered by pumping and used as makeup water in a series of recreational reservoirs (the Canyon Lakes) along Yellowhouse Draw in the City of Lubbock. Historically, recovered water has mounted to a yearly average of 1.6 mgd. With the recently approved remediation plan, the yearly average of recovered water will increase to 2.3 mgd (personal communication with Dan Hawkins, Director of Public Utilities, City of Lubbock, 21 May 1990).

2.3.4 Water Conservation

As mentioned previously, the City of Lubbock utilizes its secondary wastewater effluent for irrigation, industrial cooling water and, indirectly, for makeup water in the City's Canyon Lakes. In addition, the City uses water from local wells (which is unsuitable for drinking due to high mineral concentrations) for watering parks and campuses in Lubbock. These measures may qualify the City of Lubbock as one of the most water-conserving cities in the state.

The City of Lubbock plans to prepare a water conservation plan as part of an application for a Texas Water Development Board State Revolving Fund loan (pers. com., Sam Wahl, 1989). One goal of the plan will be to identify additional water conservation measures which, if implemented, could extend the useful life of the City's existing water supply. However, in comparison to the conservation measures currently employed, it is doubtful that any additional measures will be identified that will significantly decrease demands on existing supplies. Recent experience of the City of Abilene indicates that water conservation can reduce per capita use by about ten percent (Freese and Nichols, 1989).

2.4 Selection of the Preferred Alternative

The description of alternatives for meeting Lubbock's water supply needs provides a basis for comparison and selection of the alternative which would be the most acceptable from an environmental and economic standpoint. A summary of the alternatives and evaluations is provided in Table 2.4.

Table 2.4

Water Supply Alternatives Considered by the City of Lubbock

Alternatives	Evaluations
The Ogallala Aquifer in the Southern High Plains	Only small amounts of undeveloped water available; state policy discourages use
The Ogallala Aquifer in the Northern High Plains	Significant amounts available in Hartley and Ochiltree Counties; 164-190 mile pipeline distances; state policy discourages use
The Santa Rosa Formation	Unfavorable aquifer characteristics and water quality; state policy discourages use
The South Canadian River	Already fully developed
The North Canadian River	Yields less than Lubbock will need; 190 miles away
The Colorado River	Already fully developed
North Pease Reservoir site	Moderate yield; uncertain water quality
Middle Pease Reservoir site	Small yield; uncertain water quality
South Pease Reservoir site	Small yield; uncertain water quality
Aspermont Reservoir site on the Salt Fork Brazos River	Unsuitable water quality
Munday Reservoir site on the Salt Fork Brazos River	Unsuitable water quality
Post Reservoir site on the North Fork Double Mountain Fork Brazos River	Moderate yield; could be operated in coordination with Justiceburg site
Justiceburg Reservoir site on the Double Mountain Fork Brazos River	Significant yield; acceptable water quality; most economical alternative
Rotan Reservoir site on the Double Mountain Fork Brazos River	Unsuitable water quality
Flat Top Reservoir site on the Double Mountain Fork Brazos River	Unsuitable water quality
Reynolds Bend Reservoir site on the Clear Fork Brazos River	Significant yield; unsatisfactory water quality
Demineralization of saline waters	High costs
Importation under Texas Water Plan	Uncertain of realization
Reclamation of municipal wastewater	Wastewater already largely committed; not desirable at this time if other alternatives available
Water Conservation	Significant conservation measures already in effect

The use of conservation measures to extend the use of existing supplies would not be adequate to meet projected future needs. Since Lubbock already has facilities for reclaiming its municipal wastewater for irrigation and industrial cooling water, and since wastewater reuse for drinking water is not likely to receive widespread public approval, recycling for drinking water is not considered a feasible alternative. Although the City of El Paso injects treated wastewater into the City's primary drinking water aquifer, this type of recycling by aquifer filtration is very expensive and is still considered experimental. Water injected into El Paso's recharge wells has not yet been demonstrated to have reached any of the water supply wells and therefore the City is not actually using recycled water at this point in time. Importation of water into the High Plains region via the Trans-Texas Canal system is infeasible at this time since no adequate supply of surplus water exists within Texas and no economical source outside the state has been identified. Although desalting has proven to be economically competitive in some areas, it is more costly than the construction of a nearby reservoir and undesirable environmentally and economically due to the brackish wastewater disposal problem created.

Due to intensive agricultural use of groundwater resources in the High Plains region, there are very few economically developable groundwater reserves available to the City of Lubbock. Groundwater in the Ogallala Aquifer is being pumped at rates faster than natural recharge is occurring. The aquifer is therefore considered a nonrenewable resource that would become depleted, leaving Lubbock in the position of having to replace a water supply as well as needing to develop additional sources to meet the needs of the future population. In addition, it is state policy to discourage mining of aquifers which have been overdrafted, especially when surface water alternatives are available.

Investigation of new reservoir sites in the Canadian, Red, Brazos, and Colorado River basins resulted in few viable options. Due to the lack of appropriate sites and to the prevalence of gypsum in the region, many sites had both limited yield and poor water quality. Of the potential sites investigated, the Aspermont, Munday, Rotan and Flat Top sites were considered infeasible due to unsatisfactory water quality. Of the remaining sites (North Pease, Middle Pease, South Pease, Post, Justiceburg, and Reynolds Bend), Justiceburg Reservoir optimizes the characteristics of water quality, yield, and distance to Lubbock. The Reynolds Bend site would produce a greater yield but would be more costly in terms of capital and operating expenses because of its larger size and pumping distance. Post Reservoir would be about 12 miles closer to Lubbock, but it would provide only about 40 percent of the firm yield of the Justiceburg site. The City selected Justiceburg Reservoir as the preferred alternative because it provided the best balance of acceptable water quality, sufficient yield, pumping distance, and economy.

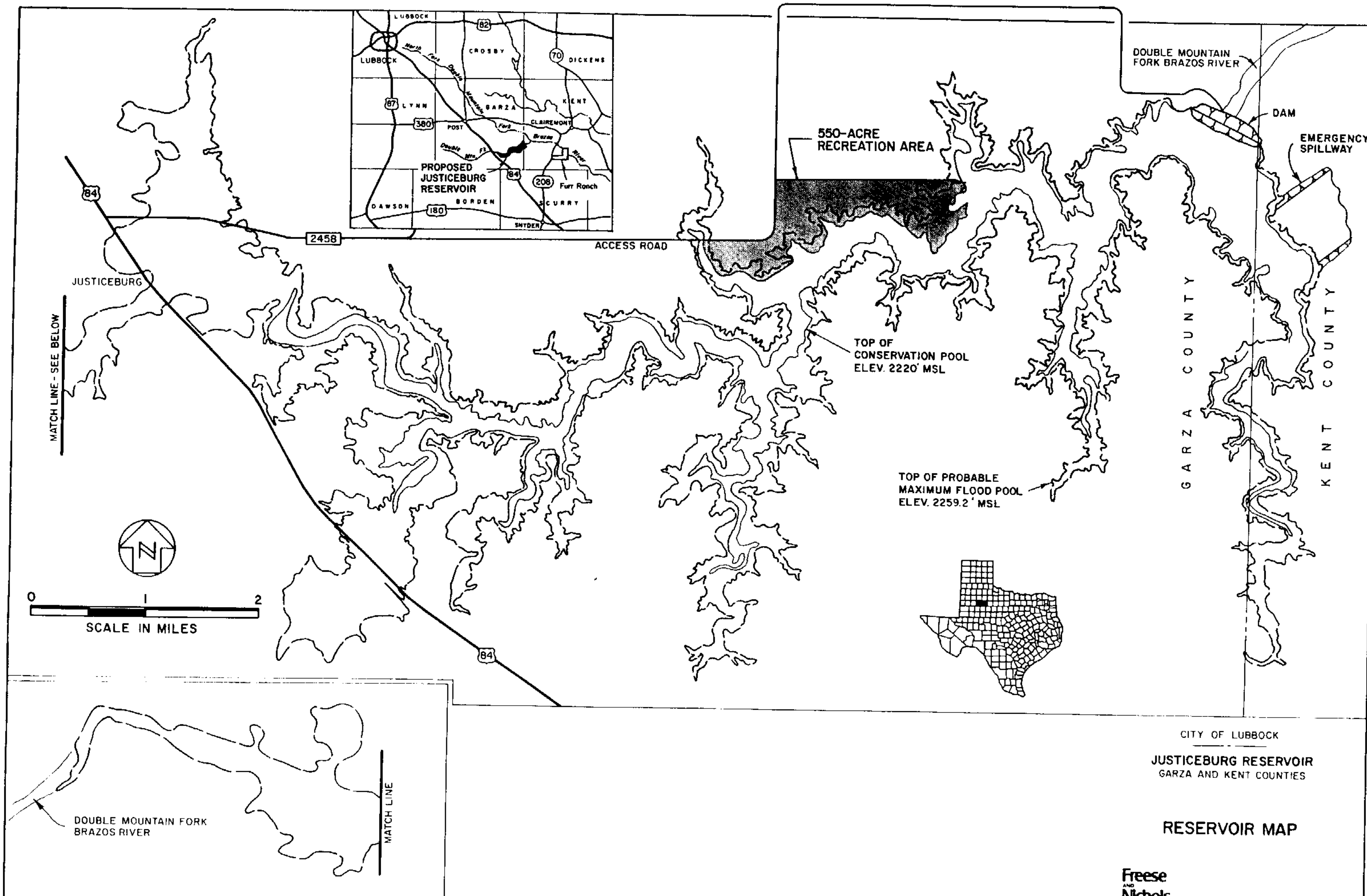
3. DESCRIPTION OF THE PROPOSED ALTERNATIVE AND ENVIRONMENTAL SETTING

3.1 Justiceburg Reservoir

The proposed Justiceburg dam site is located at river mile 126.9 on the Double Mountain Fork Brazos River, approximately 1050.1 river miles upstream from the Gulf of Mexico (Figure 3.1). At this location, the reservoir has a contributing drainage area of 394 square miles. The reservoir conservation pool will extend 14.6 miles upstream and will inundate 2,884 surface acres at elevation 2,220 ft msl. The probable maximum flood pool will extend an additional 6.7 miles upstream and will inundate a total of about 9,226 surface acres at elevation 2,259.2 ft msl.

The yield of Justiceburg Reservoir was estimated based on simulated operation of the reservoir under hydrologic conditions from 1940 through 1981 (Appendix A). The simulated reservoir operation included a variable rate of demand which was dependent on reservoir contents (Freese and Nichols, 1978). The average yield available initially under the proposed operation is estimated to be 30,200 acre-feet per year. At conservation storage, the reservoir will contain 115,937 acre-feet. The mean depth at conservation storage will be approximately 40 feet; maximum depth will be approximately 100 feet near the dam.

Restrictive Flood Easement. The City of Lubbock will contract for a restrictive flood easement on perimeter lands between elevation 2,220 and 2,245 ft msl, or a horizontal distance of 300 feet from elevation



CITY OF LUBBOCK

JUSTICEBURG RESERVOIR
GARZA AND KENT COUNTIES

RESERVOIR MAP

Freese and Nichols Inc.
Consulting Engineers

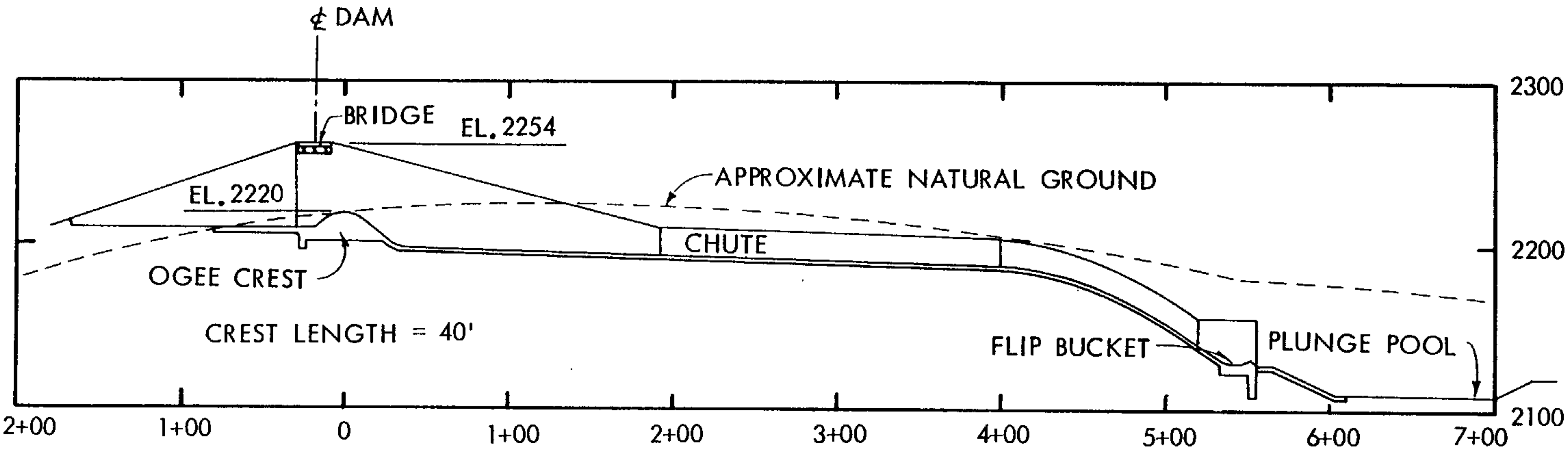
FIGURE 3.1

2,220, whichever is greater. The City will limit the use of the perimeter areas by prohibiting residential structures, barns, sheds, water wells, septic systems, cesspools or boat docks. The easement will allow the City maintenance access and permission to flood these areas. Landowners will be allowed to have fences, gates, cattle guards, and pens within the easement; there are no limitations on normal ranching operations. Each landowner will also be allowed to construct two boat ramps so long as they are in compliance with any regulations imposed by the U.S. Army Corps of Engineers for Justiceburg Reservoir. Landowners have expressed a desire for a minimum amount of public access to or from their properties.

Spillway Design and Flood Routing. A dual spillway system is proposed for the Justiceburg project, consisting of a concrete service spillway structure with crest at elevation 2,220.0 ft msl and a larger emergency spillway at elevation 2,240.0 ft msl. This combination of primary and secondary spillways is typical of dams in West Texas. The service spillway will handle all but very large flood flows and is sized to pass the 100-year flood without incurring unduly high water levels in the lake, giving particular attention in this instance to avoidance of flooding at U.S. Highway 84. Because the service spillway will be a reinforced concrete structure and relatively costly to construct, it is intentionally not designed large enough to pass the full discharge resulting from the probable maximum flood. The emergency spillway is provided to give extra outflow capacity that will be needed under such conditions.

The service spillway at the Justiceburg project is proposed to be an uncontrolled (i.e., without gates) overflow structure, 40 feet wide, with typical ogee crest, concrete chute and flip bucket energy dissipator. A sectional drawing of the structure is shown in Figure 3.2. This spillway would hold the maximum lake level to elevation 2,239.0 during the 100-year flood. The low steel on the U.S. 84 bridge over the Double Mountain Fork at Justiceburg is at elevation 2,241.3. The Santa Fe Railroad bridge near Justiceburg and the community of Justiceburg itself are at higher elevations than the U.S. 84 bridge and would also be above the 100-year flood level.

The emergency spillway is proposed to be an earthen channel, 1,900.0 feet wide, excavated through the south abutment at elevation 2,240.0. It would not operate during floods of 100-year magnitude or smaller and would therefore seldom be called upon to handle flood discharges. Because the emergency spillway will be of natural material, without special protective treatment, it will be subject to erosion damage when it does operate, and some re-grading of the channel will probably be necessary after discharges. Water will pass through this channel so seldom, however, that the expense of occasional maintenance is much less than the cost to provide erosion protection during initial construction. Much of the material removed from the emergency spillway can be used in the dam embankment. The emergency channel will yield approximately 4.3 million cubic yards of excavation, which will be enough to meet the



JUSTICEBURG DAM
SERVICE SPILLWAY SECTION

FREESE AND NICHOLS, INC

FIGURE 3.2

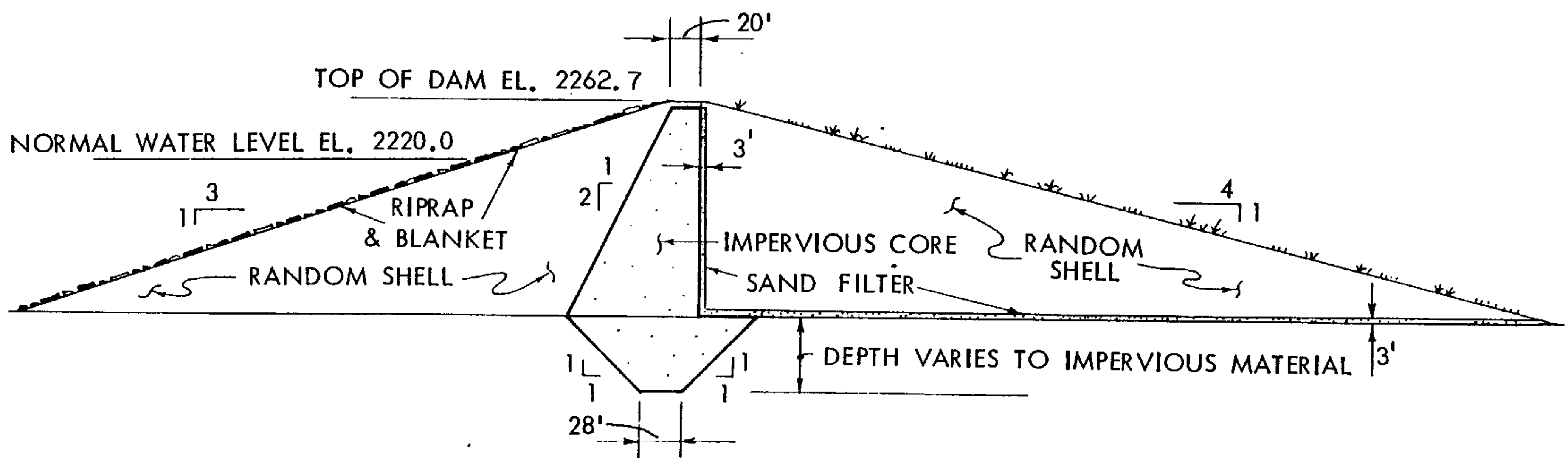
majority of the embankment requirements for materials of this type.

The maximum rise of the design flood, assuming the reservoir to be full to elevation 2,220.0 at the beginning of the probable maximum storm, would be to elevation 2,259.2. Allowing adequate freeboard for wave action during the time of high water requires that the top of the embankment be set at elevation 2,262.7.

Embankment Design. Preliminary recommendations for an embankment design provide for a 20-foot top width, with the upstream face sloping at three horizontal to one vertical (3:1) and the downstream face at 4:1. Most of the embankment section consists of compacted random material, and there is a central core of select, impervious material. A vertical and horizontal filter-drain system is included to drain the downstream random shell and to protect the core against seepage piping. A cutoff extending down to impervious foundation materials will be required, to minimize seepage. A typical embankment section is shown in Figure 3.3.

The upstream slope will need to be protected against wave action and erosion. It is planned to use a three-foot layer of riprap, consisting of hard native sandstone, with a gravel filter blanket underneath. An alternate proposal of soil cement slope protection will also be acceptable.

Grass will be grown on the downstream slope to control erosion on that face of the dam. An irrigation system is planned to maintain the grass. A stabilized-base service roadway will be included along the top of the dam, and a vehicular bridge will be built across the service



JUSTICEBURG DAM
TYPICAL EMBANKMENT SECTION

FREESE AND NICHOLS, INC.

FIGURE 3.3

spillway to allow access from either abutment.

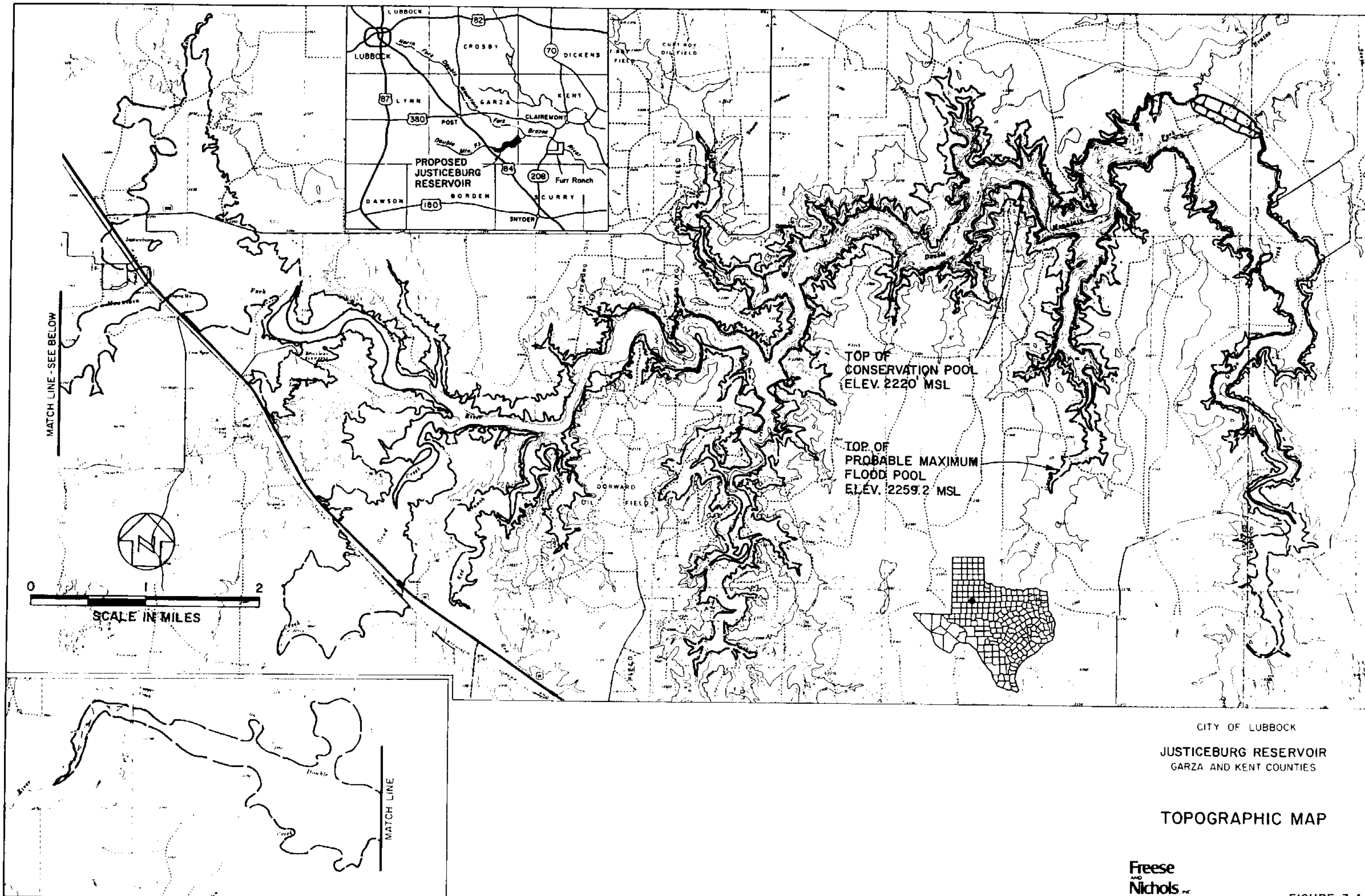
Service Outlet. A service outlet, 48 inches in diameter, is included in the preliminary design. The Texas Water Commission generally requires that a low-level outlet structure be provided, to allow releases of water through the dam if required when the lake is below spillway level. A control tower and double valving system will also be provided.

3.2 Geological Resources

3.2.1 Surface and Subsurface Geology

The project area topography is composed of hilly plains intersected by the flat-bottomed riverbed of the Double Mountain Fork Brazos River. Local relief within the reservoir maximum flood pool is approximately 140 feet. Rough breaks occur along the steep banks of the river and in intermittent drainages where erosional processes have cut into the sedimentary formations. These areas are characterized by steep slopes of about 40 percent and distinctive V-shaped gullies from 20 to 150 feet in depth. Slope faces typically have hard alabaster gyprock or sandstone ledges (SCS, 1973). A topographic map is provided in Figure 3.4.

Surface geology within the reservoir area (Figure 3.5) consists primarily of the Triassic age Dockum Group formation of sandstones, clays, shales, and conglomerates (Bureau of Economic Geology, 1967). The older Permian age Quartermaster Formation occurs at the east end of the reservoir and forms the erosional redbed areas near the proposed dam site. The formation consists of shales, sandstones, gypsum, and



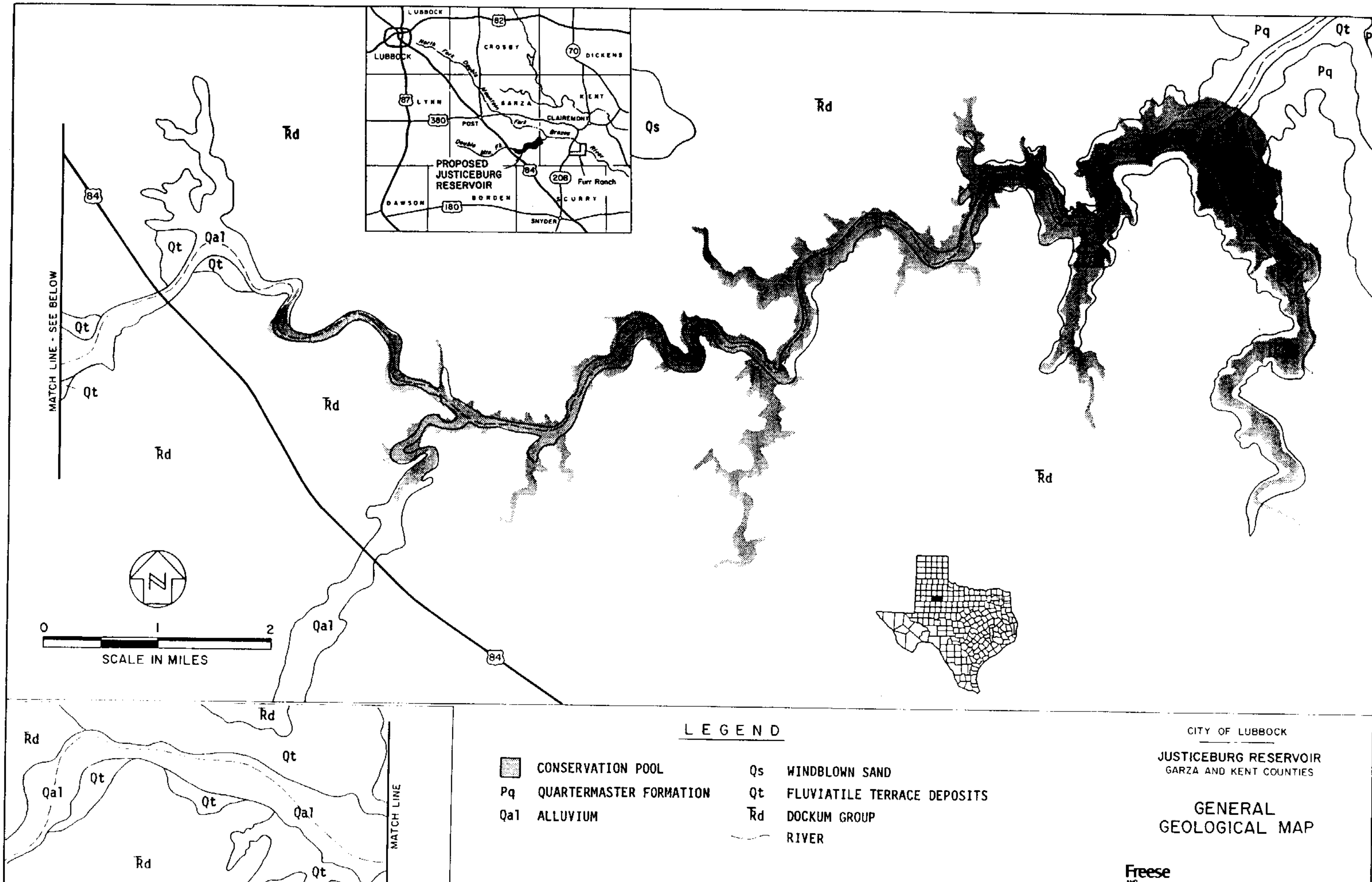
CITY OF LUBBOCK

JUSTICEBURG RESERVOIR
GARZA AND KENT COUNTIES

TOPOGRAPHIC MAP

Freese and Nichols Inc.
CONSULTING ENGINEERS

FIGURE 3.4


MATCH LINE - SEE BELOW
MATCH LINE
LUBBOCK
CROSBY
DICKENS
LYNN
GARZA
KENT
POST
CLAIREMONT
PROPOSED JUSTICEBURG RESERVOIR
Furr Ranch
DAWSON
BORDEN
SCURRY
SNYDER
84
82
70
87
380
208
180
Qt
Qal
Qs
Pq
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0
1
2
SCALE IN MILES
LEGEND
CONSERVATION POOL
Pq QUARTERMASTER FORMATION
Qal ALLUVIUM
Qs WINDBLOWN SAND
Qt FLUVIATILE TERRACE DEPOSITS
Ŧd DOCKUM GROUP
RIVER
CITY OF LUBBOCK
JUSTICEBURG RESERVOIR
GARZA AND KENT COUNTIES
GENERAL GEOLOGICAL MAP
Freese and Nichols Inc.
CONSULTING ENGINEERS

FIGURE 3.5

interbedded dolomite (Bureau of Economic Geology, 1967). Quaternary alluvium and fluviatile terrace deposits occur in the floodplains of the Double Mountain Fork Brazos River and the larger tributary creeks. These deposits consist of gravel, sand, and silt (Bureau of Economic Geology, 1967).

Subsurface geology includes the underlying Permian age Quartermaster Formation, Whitehorse Sandstone and Cloud Chief Gypsum Formation, and Blaine Formation. These formations contain oil reserves which are of economic importance in the project area. The Quartermaster Formation is the youngest of the Permian formations and is approximately 250 to 350 feet thick. The Whitehorse Sandstone and Cloud Chief Gypsum Formation, approximately 650 feet thick, consists of a layer of Claytonville dolomite (youngest), a layer of Eskota gypsum, and a layer of Childress dolomite (oldest). The Blaine Formation, approximately 650 to 700 feet thick, consists of a layer of Aspermont dolomite (youngest), Guthrie dolomite, Acme dolomite, Mangum dolomite (oldest), and unnamed dolomites at various levels (Bureau of Economic Geology, 1967).

3.2.2 Soils

Soil nomenclature varies slightly between the two counties because the county soils maps were prepared at different times by various soil scientists. Since the Garza County soil survey was issued more recently, its nomenclature was used in this evaluation. Nomenclature for Kent County is included in parentheses.

Soils within the reservoir pool are primarily of the Vernon-Rough

Broken Land Association (Vernon-Wichita). Soil associations include groups of soil series that have similar characteristics and occur at regular predictable positions within the landscape of the region (SCS, 1973; 1975). The Vernon-Rough Broken Land Association consists of gently sloping to steep, moderately deep clay loams, and rough broken land. This soil association occurs in areas along the major streams in Garza and Kent Counties. Some of the areas are deeply dissected by geological erosion. Due to the steep slopes and broken topography, these soils are primarily used for rangeland, and are only occasionally cultivated (SCS, 1973; 1975). The primary soil series in this association are Vernon soils and Rough Broken Land soils. However, lesser amounts of Berda, Frio, Lincoln-Yahola, Mobeetie, Spade, and Spur soils also occur in the association (SCS, 1973; 1975). A description of specific soils occurring within the reservoir conservation pool is discussed below.

Soils of the Vernon series are moderately deep, very slowly permeable upland soils. These soils are well-drained and are highly susceptible to water and geological erosion. They occur along ridges, hillsides, and major drainageways. Both the Vernon complex, hilly, and the Vernon soils, 3 to 5 percent slopes, are mapped within the reservoir conservation pool in Garza County. The equivalent Vernon soils, sloping, are mapped in Kent County. These soils are best suited for use as native rangeland, but some are cultivated (SCS, 1973; 1975).

Areas classified as Rough Broken Land are sloping to steep and occur in areas along escarpments. Local relief ranges from 50 to 200 feet.

This type of topography is the result of active geological erosion due to rapid runoff. The rough topography is difficult to utilize for either cropland and cattle grazing (SCS, 1973; 1975).

The Berda series consists of deep, moderately permeable, calcareous, upland soils on foot slopes below the caprock escarpment. They are well-drained and moderately susceptible to water erosion. The Berda loam, 3 to 5 percent slopes, occurs within the conservation pool in Garza County. The Berda fine sandy loam, 1 to 3 percent slopes, and 3 to 5 percent slopes, are mapped within the conservation pool in Kent County. Berda soils are primarily used for native rangeland (SCS, 1973; 1975).

Soils of the Frio series are deep, nearly level, bottomland soils. They occur in the flood plains of rivers and major creeks and are subject to occasional flooding. However, these floods are short-lived and do not severely damage crops (SCS, 1973). In their native state, Frio clay loam soils are classified as prime farmland soils (SCS, 1982). Although, they are suited for cultivation, most are used for native rangeland (SCS, 1973).

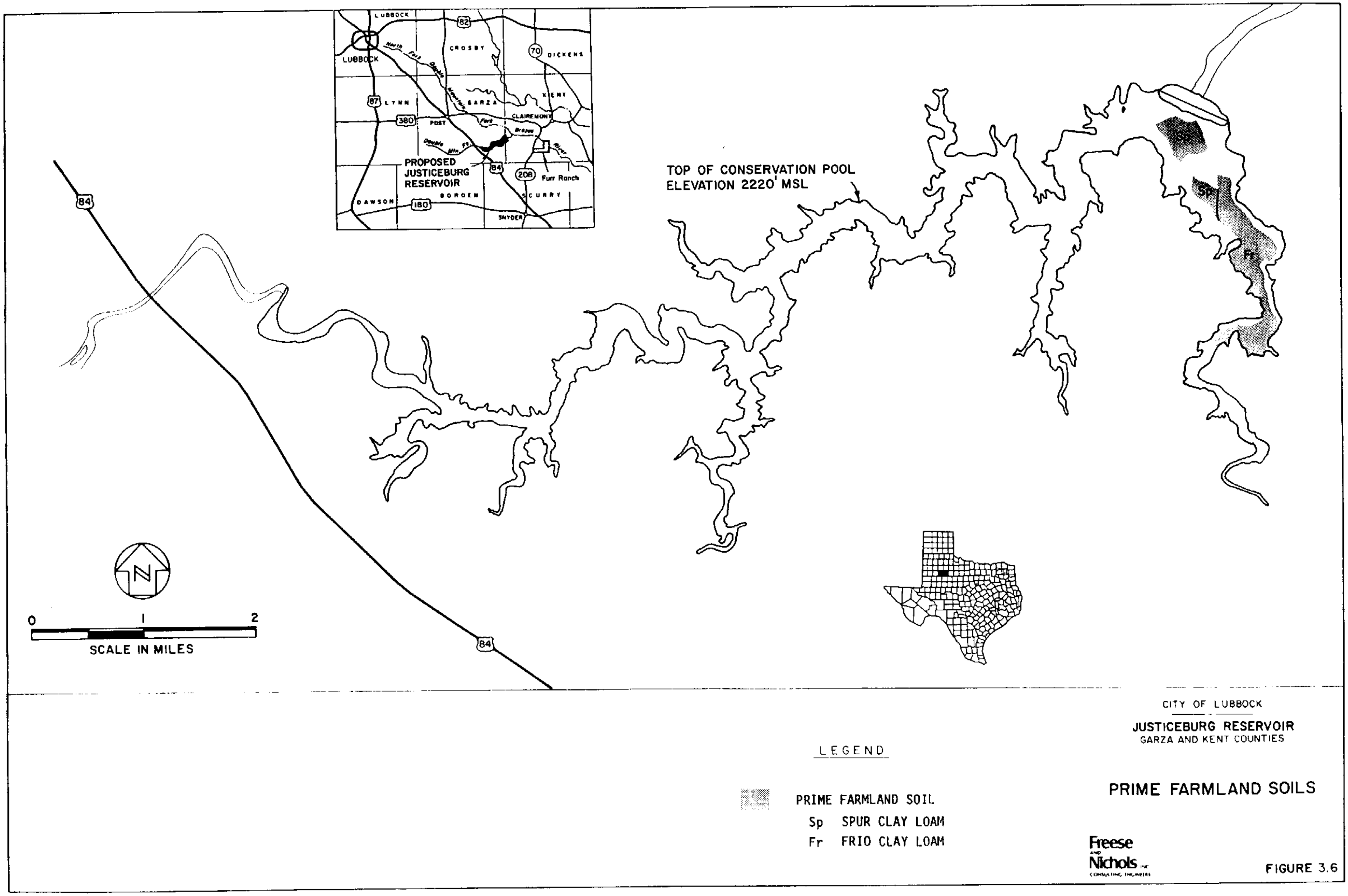
Soils of the Lincoln-Yahola series are nearly level, deep, loamy and sandy, calcareous soils of the Brazos River flood plain. These soils have formed on alluvial sands and sand-silt mixtures, and are subject to frequent flooding. Permeability is high, but fertility and water-holding capacity of the soils are low. Saline areas occur as scattered spots in these soil types. Both the Lincoln-Yahola complex and the Lincoln soils are mapped within the conservation pool. Due to frequent flooding, these soils are not used for cropland. They are, however, the most productive range sites in the counties (SCS, 1975).

Soils of the Mobeetie series consist of calcareous fine sandy loams and sandy clay loams. These soils are found on footslopes below the caprock escarpment, and on ridges and hillsides. Permeability is moderately rapid with some runoff. Wind and water erosion potential are moderate. The Mobeetie fine sand loam, 3 to 5 percent slopes, occurs within the reservior area. Most areas of this soil are used as native rangeland; only a few are farmed (SCS, 1975).

The Spade series are moderately deep and permeable upland soils. They occur on ridges, knobs, and slopes and are highly susceptible to water erosion. In some areas, water erosion is so severe that gullies are formed. The Spade fine sand loam, 3 to 5 percent slopes, occurs in the reservoir area. Most of the Spade soils are used for native rangeland (SCS, 1973).

The Spur series are nearly level, deep, moderately permeable bottomland soils. They occur in the flood plains of rivers, creeks, and drainageways. These soils are well-drained and subject to slight soil blowing. Occasional flooding occurs, but the floods are short-lived (SCS, 1975). In their native state, Spur clay loam soils are classified as prime farmland soils (SCS, 1982). They are suited for cultivation, but less than five percent are cultivated in Garza and Kent Counties. The remaining 95 percent are used for native rangeland (SCS, 1975).

Prime Farmland Soils. The Farmland Protection Policy Act (P.L. 97-


LUBBOCK
LUBBOCK
CROSBY
DICKENS
LYNN
GARZA
KENT
POST
CLAIREMONT
North Fork Double Mountain Fork Brazos River
Double Mtn Fk
PROPOSED
JUSTICEBURG
RESERVOIR
Furr Ranch
DAWSON
BORDEN
SCURRY
SNYDER
82
70
87
380
84
208
180
TOP OF CONSERVATION POOL
ELEVATION 2220' MSL
Sp
Fr
SCALE IN MILES
0
1
2
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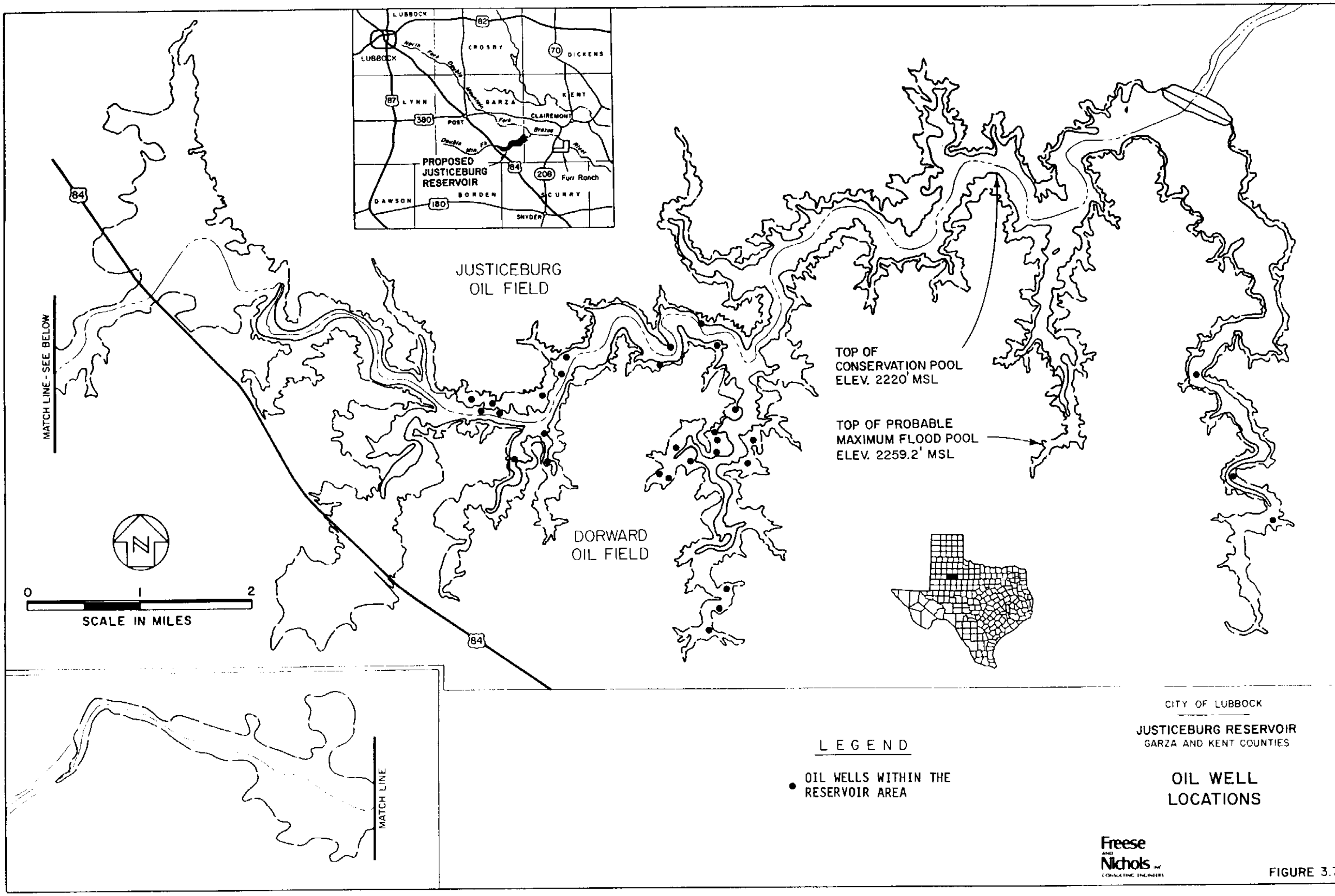
LEGEND
PRIME FARMLAND SOIL
Sp SPUR CLAY LOAM
Fr FRIO CLAY LOAM
CITY OF LUBBOCK
JUSTICEBURG RESERVOIR
GARZA AND KENT COUNTIES
PRIME FARMLAND SOILS
Freese and Nichols

FIGURE 3.6



CITY OF LUBBOCK

JUSTICEBURG RESERVOIR
GARZA AND KENT COUNTIES

OIL WELL
LOCATIONS

Freese and Nichols inc
CONSULTING ENGINEERS

FIGURE 3.7

98) directs federal agencies to identify any adverse effects of Federal actions on the preservation of prime farmland and to consider alternatives which could lessen adverse effects. Presumably, the U.S. Army Corps of Engineers will make such an evaluation during processing of the Section 404 permit for Justiceburg Reservoir.

The Frio clay loam and Spur clay loam soils, classified as prime farmland soils, occur within the conservation pool in the Grape Creek floodplain (Figure 3.6) (SCS, 1982). However, due to discontinuity in mapping, the nomenclature of the Frio clay loam was questioned. According to the Lubbock area soil scientist this soil is of the Lincoln-Yahola series rather than the Frio series, and is not considered a prime farmland soil (pers. com. Dan Blackstock, SCS). Therefore, the only prime farmland soils which occur in the conservation pool are 86 acres of Spur clay loam. None of this acreage is under cultivation.

3.2.3 Petroleum and Mineral Resources

The proposed reservoir site occurs within the areas of two oil fields: the Dorward Oil Field and the Justiceburg Oil Field (Fig. 3.7). These two fields are located along the Clear Fork and Glorieta Shelf Margins in the Eastern Shelf Permian Carbonate oil reserve. The Permian section is composed of dolomite, anhydrite, siltstone (red beds), and salt. Oil reserves occur primarily in areas of dolomite (Galloway, et al., 1983). The Dorward and Justiceburg fields are primarily oil-producing fields; only a small amount of natural gas is collected in the area.

The Justiceburg Oil Field was discovered in 1926 and occurs at a depth of 2480 feet. The Dorward Oil Field, discovered in 1950, occurs at a depth of 2456 feet. In some areas of the fields there are two or three oil-producing zones, some of which have not yet been developed. As of January 1, 1987, cumulative crude oil production for the Justiceburg Oil Field was 1,641 barrels, whereas, cumulative crude oil production for the Dorward Oil Field exceeded 16 million barrels (Railroad Commission of Texas, 1987). In 1983, the ultimate recovery for the Dorward Oil Field was projected at 16.1 million barrels (Galloway, et al., 1983).

The trapping mechanism for both fields is simple anticline or dome. The primary recovery method is solution-gas drive. This method is enhanced by secondary waterflood methods in some areas. The extent to which waterfloods are used varies with the response in each field (Bureau of Economic Geology, 1983).

Uranium-bearing strata occur in the project area, but no uranium has ever been mined. The uranium deposits occur within the Triassic age Dockum Group Formation (Bureau of Economic Geology, 1976; Ohl and McBride, 1987).

Other mineral resources in the project area include sands and gravels from alluvial terrace deposits; however, no active mining operations are located within the reservoir site.

3.3 Hydrology

3.3.1 Surface Water

Streamflow. The U.S. Geological Survey (USGS) operates a stream flow gage at the U.S. Highway 84 bridge at Justiceburg, approximately two river miles above the proposed reservoir conservation pool. Published data indicate that the Double Mountain Fork Brazos River is a flashy stream with little baseflow, as is typical of many West Texas streams. The maximum recorded discharge was 49,600 cubic feet per second (cfs) in May 1969, while the median daily flow at the gaging station was only 0.06 cubic feet per second (cfs), based on measurements from December 1, 1961, through September 30, 1987 (USGS, 1962-1987). There was no discharge 37 percent of the time. A duration curve of daily mean flow at the Justiceburg gage is presented in Figure 3.8.

Streamflow data from the Justiceburg gage were used to estimate monthly runoff between January 1940 and December 1961 for use in determining the potential yield of the proposed reservoir (Freese and Nichols, 1978). The correlation between flow measurements at the Justiceburg gage and the USGS gage near Aspermont, located approximately 109 river miles downstream, was used to extend the Justiceburg record. The flows were then adjusted to represent monthly runoff at the proposed dam site using the ratio of contributing drainage areas at the dam site and the Justiceburg gage (i.e., 394 square miles/244 square miles). The estimated monthly median flows at the dam site ranged from 10 acre-feet in January to 2,900 acre-feet in May, while all months except May, June,

DOUBLE MOUNTAIN FORK BRAZOS RIVER AT JUSTICEBURG, TEXAS: FLOW DURATION CURVE

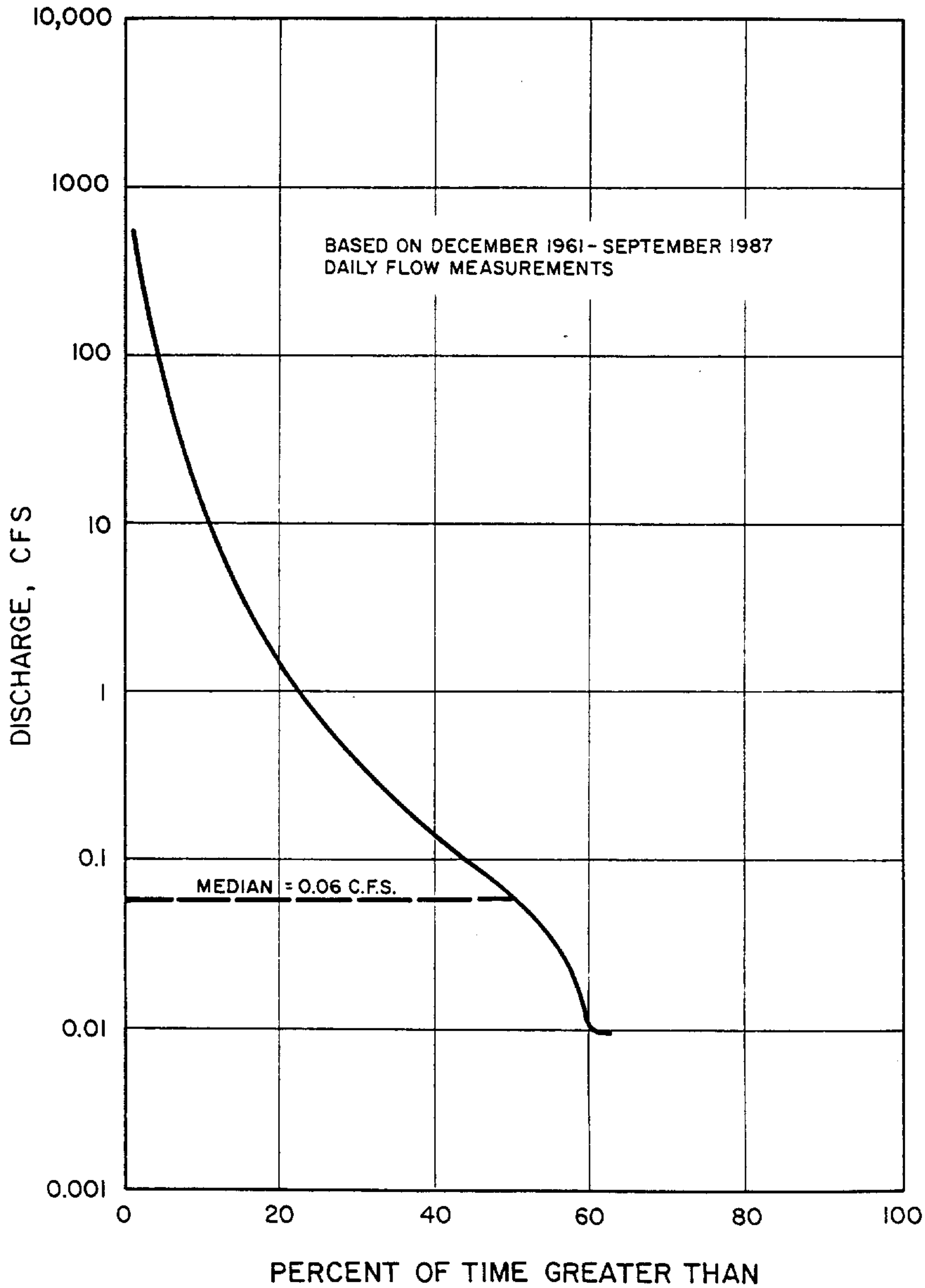


FIGURE 3.8

and August had zero flow at least 10 percent of the time during the 42-year period. The monthly flow characteristics are summarized in Table 3.1.

Surface Water Quality. Water quality sampling statistics for the Double Mountain Fork Brazos River at Justiceburg were compared to established drinking water criteria to evaluate the suitability of the water for public supply. Drinking water standards have been adopted by both the state and federal governments to protect public welfare. The National Secondary Drinking Water Regulations (Code of Federal Regulations, Title 40, Parts 141 and 143) and the Texas Drinking Water Standards (Texas Department of Health, 1987) established primary and secondary contaminant levels.

Primary contaminant levels are the maximum permissible limits of certain chemical constituents in a public water supply system. Secondary contaminant levels are recommended goals for certain constituents in public drinking water supplies. Secondary contaminant levels are established for parameters which are not necessarily health related, but may affect aesthetics (including taste) and other uses of water. State or federal regulatory authority approval of a water supply system may be obtained even though one or more constituents exceed secondary contaminant levels if local conditions such as availability of alternate supply sources or some other compelling factor dictates. The drinking water criteria pertaining to parameters which have been tested at the Justiceburg gage are presented in Table 3.2.

Table 3.1

Estimated Monthly Flow Characteristics of the Double Mountain Fork Brazos River at the Proposed Justiceburg Reservoir Dam Site (1940-1981)

Percent of Time Flow is Exceeded	Discharge in Acre-Feet per Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10%	634	1,536	3,933	9,187	41,302	27,664	24,632	8,879	20,890	25,645	2,787	1,458
20%	244	492	696	2,554	17,160	12,796	11,582	5,258	9,820	10,084	1,752	902
30%	40	82	218	1,105	7,566	5,978	5,437	4,193	5,262	2,110	586	169
40%	20	20	88	506	4,592	4,062	3,002	2,192	2,784	1,014	260	68
50%	10	15	15	175	2,900	2,895	1,240	1,645	1,795	510	140	30
60%	10	10	0	70	2,128	1,966	678	926	1,182	368	70	20
70%	0	0	0	19	1,289	1,143	138	532	219	204	30	10
80%	0	0	0	6	704	714	30	300	26	10	10	6
90%	0	0	0	0	167	348	0	72	0	0	0	0

Table 3.2

National and State Drinking Water Criteria for Parameters Sampled at the Justiceburg Gage on the Double Mountain Fork Brazos River

	National Criteria, (mg/l)	State Criteria, (mg/l)
Primary Constituents:		
Nitrate-nitrogen	10.0	10.0
Fluoride	4.0	4.0
Secondary Constituents:		
Chloride	250	300
Sulfate	250	300
Total Dissolved Solids	500	1,000
pH (Standard Units)	6.5-8.5	Greater than 7.0
Fluoride	2.0	2.0

Although water meeting the drinking water standards would be desirable, it is apparent that the City of Lubbock is unlikely to find a nearby supply source which will be consistently below the recommended levels of dissolved solids. Waters users in Lubbock are accustomed to drinking water from the Canadian River (Lake Meredith) which commonly exceeds 1,000 mg/l of TDS. The city staff indicates that the number of complaints about taste increases substantially when the TDS level exceeds 1,300 mg/l. This response indicates a threshold of acceptability which is somewhat higher than the established secondary contaminant level for TDS. Therefore, in addition to the drinking water criteria discussed previously, the observed level of TDS acceptability (i.e., 1300 mg/l) was also used as a criterion for assessing the suitability of the Double Mountain Fork Brazos River as a source of drinking water.

The USGS collected 16 water quality samples at the Justiceburg gage in the mid-1960s (Freese and Nichols, 1978). On a flow-weighted average basis, all of the measured constituents were within established criteria for public drinking water supplies, although individual fluoride, chloride, sulfate, and TDS levels occasionally exceeded secondary recommended limits. Flow-weighted average concentrations reflect the dissolved mineral levels that would be expected to occur if the runoff at a site was impounded in a reservoir. This is because flow-weighting accounts for the lower concentrations which occur during high-flow events, which will contribute most of the reservoir contents. The flow-weighted average concentrations of TDS, chloride, and sulfate were 437 mg/l, 78 mg/l, and 61 mg/l, respectively. Although the samples were analyzed primarily for dissolved minerals, nine samples were tested for fluoride and ten samples were analyzed for nitrate. Fluoride levels averaged 1.3 mg/l and the flow-weighted average concentration of nitrate-nitrogen was 0.3 mg/l. Based on these data, nutrient contributions at the site are probably relatively minor.

The City of Lubbock began sponsoring a more comprehensive monitoring program by the USGS at the site beginning in October 1975 and continuing to the present. Continuous measurement of water temperature and conductivity were included along with periodic measurements of dissolved minerals and other parameters. Nutrients were not included in the sampling program.

An inventory of the U.S. Environmental Protection Agency's STORET computer files was performed to evaluate chemical characteristics at the Justiceburg gage. Selected water quality statistics, based on the sampling data collected since 1975, are presented in Table 3.3.

The water quality samples were collected during flow conditions ranging from 0.01 cfs to 18,400 cfs. The average concentrations were generally similar in magnitude to the levels recorded in the mid-1960s samples, and the flow-weighted average concentrations met drinking water criteria. The flow-weighted average hardness (i.e., 98 mg/l) indicates that a reservoir on the Double Mountain Fork Brazos River would produce water of moderate hardness based on a rating scale used by the USGS (Hem, 1970). Water with a hardness level greater than 120 mg/l is generally

Table 3.3

Selected Water Quality Characteristics of the Double Mountain Fork Brazos River at Justiceburg, Texas based on USGS Sampling between 1975 and 1988

	Average	Median	15th Percentile	85th Percentile	Range	Number of Samples	Sampling Period
Temperature, C	16.3	17	7	24	0 - 35	94	10/01/75-03/08/88
Conductivity, umhos	652*	3,490	650	16,600	356 - 27,700	84	10/01/75-03/08/88
Chloride, mg/l	89*	1,500	90	5,400	31 - 9,500	80	10/01/75-03/08/88
Sulfate, mg/l	51*	290	58	630	32 - 1,800	80	10/01/75-03/08/88
Total Dissolved Solids, mg/l	454*	1,450	445	9,820	229 - 18,300	53	10/01/75-12/14/82
pH, standard units	8	7.9	7.8	8.3	7.6 - 9.0	60	10/01/75-03/08/88
Total Alkalinity, mg/l as $CaCO^3$	177	180	123	220	98 - 271	80	10/01/75-03/08/88
Total Hardness, mg/l as $CaCO^3$	98*	230	77	1,100	30 - 2,600	53	10/01/75-12/14/82
Dissolved Fluoride, mg/l	1*	1.2	0.8	1.4	0.2 - 2.6	74	10/01/75-03/08/88
Instantaneous Flow, cfs	882	15	0.12	985	0.01 - 18,400	97	10/01/75-03/08/88

* Indicates the value is a flow-weighted average.

Source: U.S. Environmental Protection Agency STORET computer data files.

considered to be hard and presents troublesome characteristics for domestic uses. Soap is not as effective in hard water and commonly leaves insoluble residues in bathtubs, sinks, and clothing. Additionally, hard water increases scale formation in hot water tanks, boilers, and pipes, reducing their capacity.

Results of a previous study indicated that although low flows contain relatively high concentrations of dissolved minerals, moderate and high flows yield water of substantially better chemical quality (Freese and Nichols, 1978). This correlation is reflected in the extremely wide sampling ranges of chloride, sulfate, TDS, total hardness, and conductivity in Table 3.3.

A more accurate estimate of dissolved mineral levels is provided by the monthly flow-weighted concentrations of chloride, sulfate, TDS, and hardness reported by the USGS based on continuous monitoring of conductivity at the Justiceburg gage from October 1975 through September 1987. The average monthly flow-weighted concentrations based on continuous monitoring were similar to the average levels of periodic samples reported in Table 3.3 except for monthly chloride levels, which averaged 245 mg/l. The periodic sampling results for TDS, sulfates and hardness apparently were more representative of the true mean concentrations than the results for chlorides at the site. It should be noted, however, that the monthly flow-weighted average chloride level is below the maximum recommended drinking water criterion.

3.3.2 Groundwater

Groundwater in the Justiceburg Vicinity. The Justiceburg Reservoir site lies outside the limits of any designated major or minor aquifer zone (Texas Water Commission, 1986). The primary water bearing strata in the proposed reservoir vicinity include the alluvial and terrace deposits along the Double Mountain Fork and its larger tributaries, although these deposits probably do not contain large quantities of groundwater due to their limited extent in the immediate area. Rocks of the Dockum Group and the Quartermaster Formation are known to yield only small amounts of groundwater in Kent and nearby counties (Cronin, 1972), and these rocks probably are comparable in water-bearing capacity in the reservoir area. The quantities of groundwater available in the reservoir vicinity would be useful primarily for domestic and stock wells but not sufficient for larger demands.

Groundwater recharge in the alluvial and terrace deposits occurs primarily by precipitation on the outcrop zones, while the streamflow provides some recharge to these aquifers during periods of high runoff. The Dockum Group and Quartermaster Formation are also recharged by precipitation over their outcrop areas, and the Dockum Group may receive some groundwater underflow from the west (Cronin, 1972). Natural discharge from the aquifers occurs through seeps and springs, evapotranspiration, and by discharge into the streams when the water table is above the stream bed elevation. Artificial discharge occurs through well pumping.

Groundwater Quality. Chemical quality of groundwater in alluvial and terrace deposits, and in the Dockum Group and Quatermaster Formation in Kent and Dickens Counties has been characterized (Cronin, 1972), but apparently little attention has been given to these aquifers in Garza County near the proposed reservoir site. Groundwater quality in the vicinity of the proposed reservoir is probably similar to the quality of groundwater in comparable strata in Kent and Dickens Counties.

Samples were reported from more than 100 wells and springs in the alluvial and terrace aquifers of Kent and Dickens Counties (Cronin, 1972). Chemical quality of the groundwater in these deposits was highly variable with TDS levels ranging from less than 500 mg/l in about 11 percent of the samples analyzed to more than 1,000 mg/l in approximately 73 percent of the samples; 16 percent of the samples contained between 500 mg/l and 1,000 mg/l of TDS. Chloride concentrations exceeded 250 mg/l in about 72 percent of the samples tested, while about 44 percent of the samples exceeded 250 mg/l of sulfate. Nitrate-nitrogen was above 10 mg/l in approximately 36 percent of the samples, and about one third of the samples had more than 1 mg/l of fluoride. While other characteristics varied widely, the water was found to be uniformly very hard.

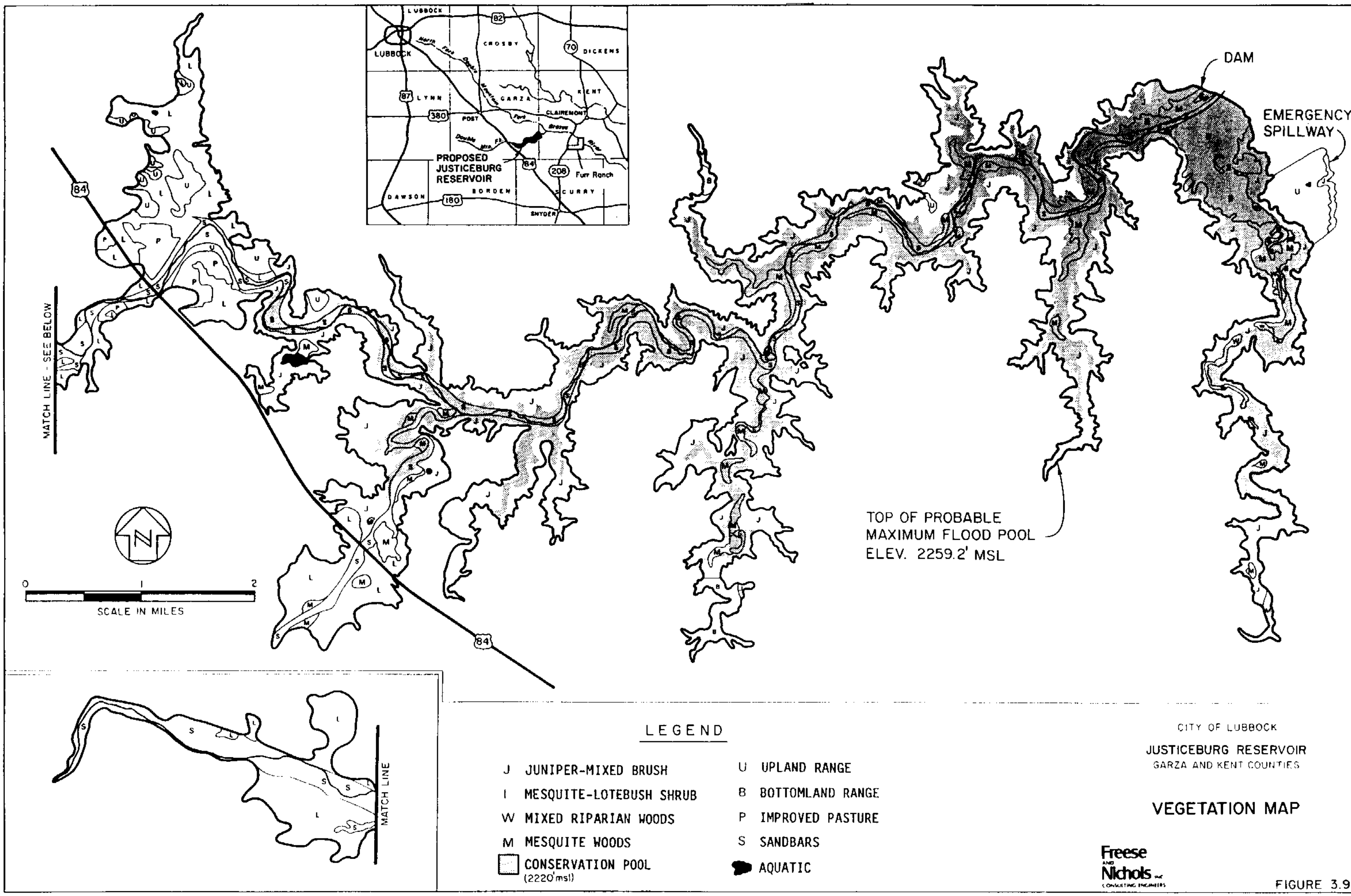
Total dissolved solids in 17 samples from Dockum Group rocks in Dickens County ranged from less than 300 mg/l to over 1,000 mg/l, with over half of the samples containing less than 500 mg/l (Cronin, 1972). Sulfate and chloride were less than 250 mg/l in all but two of the samples. Nitrate-nitrogen was below 10 mg/l in all of the samples, and fluoride concentrations were less than 1 mg/l in all but four samples. Water from this Group in Dickens County is considered very hard.

Chemical analysis of 17 samples collected from Permian System rocks (including the Quartermaster Formation) indicated that water was slightly saline to very saline with TDS concentrations varying from 1,060 mg/l to 8,520 mg/l (Cronin, 1972). The water was found to be uniformly very hard. Sulfate levels ranged from 187 mg/l to 3,270 mg/l, with only one sample below 300 mg/l, and 82 percent of the samples above 1,000 mg/l. Chloride concentrations ranged from 24 mg/l to 2,500 mg/l, with 53 percent of the samples having less than the state recommended drinking water limit of 300 mg/l. Nitrate-nitrogen ranged from 0.9 mg/l to 18.3 mg/l with four samples exceeding the recommended limit of 10 mg/l. Fluoride levels were within recommended drinking water limits with a range of 0.2 mg/l to 2.0 mg/l.

3.4 Biological Resources

3.4.1 Vegetation

The Justiceburg Reservoir site is located within the Rolling Plains vegetational area of Texas (Gould et al., 1960). The original prairie vegetation of tall and mid grasses has degraded from heavy grazing practices which have resulted in increased brush invaders as well as increased annual and perennial weeds (Gould et al., 1960). A vegetation map of the reservoir (Figure 3.9) was prepared from color-infrared USGS



CITY OF LUBBOCK

JUSTICEBURG RESERVOIR

GARZA AND KENT COUNTIES

VEGETATION MAP

Freese and Nichols inc. Consulting Engineers

FIGURE 3.9

National High Altitude Photography (NHAP) flown in October 1984 and February 1985. Based on the NHAP images, nine covers were defined in the reservoir area, including Juniper-Mixed Brush, Mesquite-Lotebush Shrub, Upland Range, Bottomland Range, Improved Pasture, Mixed Riparian Woods, Mesquite Woods, Sandbars and Aquatic. Acreage amounts of the cover types are listed in Table 3.4.

The Juniper-Mixed Brush (McMahon et al., 1984) is the dominant vegetation type, covering approximately 48 percent of the conservation pool area. It occurs on steep slopes of the river floodplain and intermittent drainages, and on gentler slopes of the hilly plains. The vegetation is characterized by red berry juniper (Juniperus pinchotii) and clumped grasses, including little bluestem (Schizachyrium scoparium var. frequens), sand bluestem (Andropogon hallii), side-oats grama (Bouteloua curtipendula) and blue grama (Bouteloua gracilis). Although rocky ledges almost exclusively support a juniper brush vegetation, other woody invaders are common on gentler slopes. Other common woody species include mesquite (Prosopis glandulosa), mountain mahogany (Ugnadia speciosa), lotebush (Ziziphus obtusifolia), yucca (Yucca spp.), wolfberry (Lycium sp.), ephedra (Ephedra antisyphyllitica), catclaw (Acacia greggii), tasajillo (Opuntia leptocaulis), and cholla (Opuntia imbricata). Shin oak (Quercus cf. mohriana) occurs infrequently in the reservoir area, but completely replaces juniper along the west-facing escarpment of the upper reaches of Grape Creek.

Mesquite-Lotebush Shrub occurs on the deep, nearly level clay loam

Table 3.4

Acreages of Vegetative Cover Types,
Justiceburg Reservoir

Cover Type	Conservation Pool (elev. 2,220.0)		Maximum Flood Pool (elev. 2,259.2)	
	Acres	Percent	Acres	Percent
Juniper Mixed Brush	1,391	.48	4,137	.48
Mesquite Woods	400	.14	546	.06
Mesquite-Lotebush Shrub	---	---	1,659	.19
Mixed Riparian Woods	33	.01	33	<.01
Upland Range	157	.06	429	.05
Bottomland Range	323	.11	400	.05
Improved Pasture	---	---	200	.02
Sandbars	491	.17	1,114	.13
Aquatic	89	.03	143	.02
TOTAL	2,884		8,661	

soils west of U.S. Highway 84 and north of Justiceburg. The climax vegetation is dominated by blue grama, with lesser amounts of western wheatgrass (Agropyron smithii), vine mesquite (Panicum obtusum), white tridens (Tridens albescens), and side-oats grama. Buffalograss (Buchloe dactyloides) and silver bluestem (Bothriochloa saccharoides) are the main increasers in deteriorated areas (SCS, 1973; 1975). In these areas, overgrazing has led to the invasion of brush species, including mesquite, lotebush, juniper, cholla and prickley pear (Opuntia spp.), and weedy species, such as western ragweed (Ambrosia psilostachya), greenthread (Thelesperma sp.), and common broomweed (Guttierreza dracunculoides).

The Upland Range is an infrequent vegetation type, occurring on the hilly plains above the river floodplain, but only in areas where the range has been maintained in good to excellent condition. In order to maintain a high quality rangeland, local ranchers root-plow their range sites. Upland Range occurs on sandy loam soils in two general areas within the reservoir site - in the area of the emergency spillway (Huddleston property) and in the vicinity of the town of Justiceburg. The climax vegetation consists of short and mid grasses including side-oats grama, little bluestem, blue grama, buffalograss, Arizona cottontop (Trichachne californica) and plains bristlegrass (Setaria macrostachya). Woody components, such as catclaw and sand sagebrush (Artemisia filifolia), are present in low frequency (SCS, 1973; 1975). Woody invaders become more abundant when these sites are overgrazed.

Bottomland Range occurs on loamy soils along Grape, Rocky and Gobbler

Creeks and the Double Mountain Fork Brazos River. This vegetation type is a high quality rangeland consisting of tall and mid grasses. It is also maintained through root-plowing. Dominant range species include big bluestem (Andropogon gerardii), sand bluestem, little bluestem, Indiangrass (Sorgastrum nutans), switchgrass (Panicum virgatum), Canada wildrye (Elymus canadensis), side-oats grama and western wheatgrass. Deterioration of the Bottomland Range results in an increase of weedy annuals, perennial forbs and brush species. Heavy grazing can result in dense mesquite infestation (SCS, 1973; 1975).

A few fields of Improved Pasture occur in the vicinity of the Justiceburg community, above the conservation pool elevation. These fields are used for grazing and cover, and are primarily planted in winter wheat, grazing sorghums and low yielding mixed grasses, and are used for grazing and cover (pers. com. Dan Blackstock, SCS).

Small areas of Mixed Riparian Woods occur along the upper reaches of Grape Creek. These woodlands consist of various hardwood species including hackberry (Celtis spp.), cottonwood (Populus deltoides), willow (Salix spp.), western soapberry (Sapindus saponaria), and live oak (Quercus cf. virginiana. Local ranchers have pointed out that these stands of live oak are the northwesternmost occurrence of live oak in Texas.

Mesquite Woods occur on sandy loam soils along the Double Mountain Fork Brazos River and the tributary creeks. These areas tend to consist of dense stands of mesquite. In some areas, such as below the Lake

Justiceburg dam, the Mesquite Woods contain very old single-trunk mesquite trees, up to 30-feet in height. Other hardwood species found in these areas include hackberry and cottonwood. Salt cedar (_Tamarix_ spp.) occurs in a very narrow zone along some stretches of the river, within the channels of some of the tributary creeks, and in wider expanses at the mouth of the creeks. Baccharis (_Baccharis_ spp.) occurs with salt cedar along some of the more saline creeks such as Sand Creek.

Other cover types mapped in Figure 3.8 include Sandbars and Aquatic habitats. Sandbars occur within the channel of the Double Mountain Fork Brazos River. Due to frequent flooding and deposition, these areas support no vegetation. All open water has been mapped in the Aquatic cover type. Included in this category are all stock tanks, ponds, Lake Justiceburg and the river. (N.B. Lake Justiceburg is a 25-acre impoundment located within the probable maximum flood pool near the community of Justiceburg. This small lake often goes dry.)

3.4.2 Wildlife and Fisheries

Wildlife. The project area occurs within the Mixed-grass Plains district of the Kansan faunal province of Texas (Blair, 1956). Although this area once had an abundance of wildlife, including buffalo, antelope, prairie dog and prairie chicken, buffalo hunters and overgrazing by livestock reduced or extirpated many of these native species (SCS, 1973).

In general, native vegetation in the reservoir area provides some of the best available wildlife habitat in Garza and Kent Counties. Since the reservoir site includes numerous water courses, water is adequate in most areas. Although the predominating Juniper-Mixed Brush vegetation has limited food value, it provides adequate cover for most kinds of wildlife. Grass and weed seeds from rangeland areas provide additional wildlife foods. Woodland vegetation along the stream courses likely supports the greatest diversity of wildlife species in the reservoir area.

Wildlife habitat is an important economic and recreational resource in Garza and Kent Counties. Principal game species are whitetail deer, mule deer, bobwhite quail, mourning dove, turkey, blacktail jackrabbit, and cottontail rabbit. Antelope and buffalo have also been restocked on ranches in both counties. Important furbearing species include raccoon, opossum, grey and red fox, and skunks.

Several large predators, including bobcat, cougar and coyote, are also known from the reservoir area. Other common wildlife species in the area are songbirds, raptors, snakes, and a variety of small mammals. The reservoir occurs within the central flyway region of North America. River bottoms and stock tanks in the area serve as seasonal stop-over points for numerous migratory birds.

Fisheries. Relatively little information is available on the existing stream fishery in the proposed reservoir area of the Double Mountain Fork Brazos River. Intermittent flow limits the fishery and, during times of drought, the receding water level forces fish downstream or into isolated pools in the riverbed.

The Texas Natural Heritage Program (TNHP) conducted a fish survey of the Brazos River system in August 1986. One survey collection site was located approximately 25 miles downstream from the proposed Justiceburg dam at S.H. 208 in Kent County. A list of the species from the S.H. 208 crossing is provided in Table 3.5. This species assemblage is assumed to be typical of intermittent saline streams in the upper Brazos basin, and it is likely that a similar assemblage exists in the reservoir ares. Although channel catfish (Ictalurus punctatus) were collected at the downstream site, virtually no sport fishery exists on the Double Mountain Fork in the area of the proposed reservoir (pers. com., Roy Bamberg, TPWD). The lack of a sport fishery and limited public access result in minimal public use of the stream fishery.

3.4.3 Endangered and Threatened Species

Protected Animal Species. Two endangered or threatened animals listed by the U.S. Fish and Wildlife Service (FWS, 1987) may potentially occur within the project area (TPWD, 1987). The bald eagle (*Haliaeetus leucocephalus*) and the Arctic peregrine falcon (*Falco peregrinus tundrius*) migrate through this region and may inhabit the project area on a temporary basis. The Justiceburg Reservoir project should not impact either the migration routes or stopover points for these species. There are no confirmed sightings in the project area of either of the two species.

The Texas Parks and Wildlife Department (TPWD) also has established a list of endangered and threatened species by county. In addition to the federally-listed species, TPWD lists one mammal, one bird, and one

Table 3.5

Checklist of Fish Species Sampled
from the Double Mountain Fork Brazos River
at S.H. 208 Kent County
August 1986

Red shiner	*Notropis lutrensis*
Silverband shiner*	*Notropis shumardi*
Sharpnose shiner*	*Notropis oxyrhynchus*
Chub shiner*	*Notropis potteri*
Plains minnow*	*Hybognathus placitus*
Speckled chub*	*Hybopsis aestivalis*
Channel catfish	*Ictalurus punctatus*
Mosquitofish	*Gambusia affinis*
Rio Grande Killifish*	*Fundulus zebrinus*

* obligate riverine species

Source: Murphy, 1987

reptile as threatened species occurring or potentially occurring in Garza and/or Kent counties (TPWD, 1987). These species and the likelihood of their occurrence in the counties are presented in Table 3.6.

The Palo Duro mouse (Peromyscus truei comanche), a federal category 2 species, has been recorded in the project area in Garza County (TNHP, 1988). In addition to Garza County, its distribution occurs along the caprock escarpment in Dickens, Armstrong, Haskell, Briscoe, and Randall Counties in Texas (Rappole and Tipton, 1987). It is known to prefer habitats on rocky slopes supporting dwarf juniper shrub with brush and grasses (TNHP, 1988). In addition to the TPWD listing, the Texas Organization for Endangered Species (TOES) has placed the Palo Duro mouse on their "watch list", designating that the species is potentially endangered or threatened in the U.S., especially in Texas (TOES, 1988). Specimens collected in the reservoir area and off the caprock excarpment (six miles east of Justiceburg) were placed in the Texas Tech University Museum collections. Although originally thought to be P. truei comanche, these specimens were later reidentified as Peromyscus attwatteri (pers. com., Robert Owen, Texas Tech University Museum), which is not a threatened species. Garza County collections from the caprock excarpment were placed in the University of Michigan Museum collections (Cooper Canyon, four miles southwest of Post). The site locality for these specimens is approximately 15 miles northwest of the upper end of the reservoir conservation pool. Although these specimens are no longer catalogued as P. truei comanche, further study is required before a

Table 3.6

Endangered and Threatened Species Occurring in Garza and Kent Counties

Common Name/Scientific Name	Status[1] FWS	Status[1] TPWD	Likelihood of Occurrence in Garza County[2]	Likelihood of Occurrence in Kent County[2]
Mammals:				
Palo Duro Mouse *Peromyscus truei comanche*	---	T	confirmed	probable
Birds:				
Bald Eagle *Haliaeetus leucocephalus*	E	E	possible	possible
Arctic Peregrine Falcon *Falco peregrinus tundrius*	T	T	possible	possible
White-faced Ibis *Plegadis chihi*	---	T	---	possible
Reptiles:				
Texas Horned Lizard *Phrynosoma cornutum*	---	T	confirmed	confirmed

1 Status according to U.S. Fish and Wildlife Service (1987) or Texas Parks and Wildlife Department (1987). E = Endangered T = Threatened

2 Probability of occurrence based on Endangered / Threatened Species Data File, TPWD, 20 April 1987.

definative determination of the taxon can be made (pers. com., Priscilla K. Tucker, University of Michigan Museum of Zoology).

The white-faced ibis (Plegadis chihi) is migratory through Texas. Although this species formerly bred further inland, in recent years it has been sighted primarily along the coast. It prefers habitats in marshes, rice fields, and swamps (Oberholser, 1974). Its occurrence within the project area would be extremely rare.

The Texas horned lizard (Phrynosoma cornutum) occurs throughout a broad range in Texas and adjoining states. It is known to prefer habitats in flat open terrain with sparse plant cover (Conant, 1958). The decline in the populations of the species is suspected to be related more to the use of pesticides and intensive agricultural practices than to loss of critical habitat (pers. com., Andrew Price, TNHP). The loss of habitat resulting from the Justiceburg Reservoir project is considered insignificant to the species as a whole or to individuals within Garza and Kent Counties.

In addition to these species, USFWS lists the smalleye shiner (Notropis buccola) as a Category 2 species (FWS, 1989), which identifies it for possible consideration for proposed listing upon further biological research. Although the species is not currently protected under state or federal law. The species is endemic to the Brazos River system and is recorded from only eight sites, most from the 1950's. The closest known collections are from the main fork of the Brazos River (approximately 170 river miles downstream at F.M. 267 near Rhineland, Knox County) and from the Salt Fork of the Brazos River (approximately 25 miles east northeast at the U.S. 380 crossing, Kent County). No collections are known from the Double Mountain Fork of the Brazos River. The rediscovery of the species in 1984 (Brazos River, Baylor Co.) led to a 1986 survey of the fish's range by TNHP. The survey resulted in no new records. No record of the species has ever been reported in the vicinity of the proposed Justiceburg Reservoir site.

Protected Plant Species. There are no federally-listed endangered or threatened plants (FWS, 1987) known from the vicinity of the project area. The State of Texas does not protect any additional plant species other than the federally protected species. Neither the Texas Organization for Endangered Species (TOES, 1983) nor the Texas Natural Heritage Program (TNHP, 1987) list any rare plants as occurring in Garza or Kent counties.

3.5 Air Quality

3.5.1 Climate

The climate of the Justiceburg area is characterized by extreme fluctuations in temperature and precipitation. Winter months are characteristically dry and cold, due to the occurrence of frequent, but short-lived cold fronts. The January minimum temperature averages 27°F. Summer months are characteristically hot with an average July maximum temperature of 95°F (SCS, 1973; 1975).

The average annual rainfall is 19 to 21 inches. However, the amount of rainfall is extremely variable from year to year. In 1955, the annual rainfall for Kent County was 30.33 inches whereas, in 1956, the annual rainfall was 5.91 inches. Due to the extreme variability in annual rainfall, periods of drought are quite common. Winter months are usually dry, with only occasional light precipitation. Infrequently, snow fall occurs but does not contribute a significant amount of moisture to the area. Heavy thunderstorms are frequent during summer months, with maximum rainfall occurring in May. Due to the frequent thunderstorms, approximately 75 percent of the annual rainfall occurs from April to October (SCS, 1973; 1975).

3.5.2 Existing Air Quality

The Justiceburg Reservoir site is located within the Texas Air Control Board's (TACB) Regions 1 and 2. TACB does not maintain a Continuous Air Monitoring Station (CAMS) within this region since no historical air quality problems are known. The closest CAMS site is located in Odessa (Region 6), approximately 117 miles southwest of the project site. Air quality at this site is likely to be worse than in the project area because of its metropolitan location. Since Odessa routinely meets EPA standards for sulfur dioxide, nitrogen dioxide, carbon monoxide, and ozone, it has been designated as an attainment area for these pollutants (TACB, 1980-1984).

The TACB has maintained several stations in Regions 1 and 2 for monitoring total suspended particulates. The closest stations have been located in Lubbock (approximately 56 miles northwest of the dam site).

Table 3.7 provides a five year summary of the suspended particulate data. Although Lubbock is considered an attainment area for suspended particulates, the national standards are occasionally exceeded due to naturally occurring blowing dust (TACB, 1983-1986). Dust days commonly occur from February to April when frequent weather changes occasionally produce strong continuous winds. Since cropland is commonly bare during these months, wind erosion can result in large dust storms (SCS, 1973; 1975). Except for 1984, summary data excluding dust days falls within an acceptable range of pollutant health effects for suspended particulates (TACB, 1983-1987).

3.6 Socioeconomics

Socioeconomic data for the Justiceburg Reservoir project area were analyzed at three levels of detail. Existing land uses and population within the conservation pool boundary of 2,220 ft msl were assumed to be directly affected by the project. All of these areas will be inundated and acquired by the City of Lubbock. Land acquisition will involve a total of 16 property owners.

In addition, the land use adjacent to the reservoir may be influenced by the presence of the reservoir. Therefore, an additional area located within one mile of the 2,220-foot contour was assessed. The direct influence of a reservoir on land use and land value diminishes beyond one mile. This also corresponds with recent enabling legislation which would allow county zoning control within 5,000 feet of future lake shorelines.

Table 3.7

Comparison Summary of Total Suspended Particulates with Ambient Air Standards, Region 2, 1983-1987 (ug/m3)

Year		TSP Maximum 24 Hour[1]	TSP Maximum Geometric Mean[1]
Maximum Allowable Ambient Air Standards:			
	Primary Standard	260	75
	Secondary Standard	150	60
Year	Station Location:		
1987	Lubbock	128 (126)	69 (68)
1986	Lubbock	328 (119)	69 (62)
1985	Lubbock	163 (137)	65 (62)
1984	Lubbock	390 (390)	71 (65)
1983	Lubbock (Roof Central Fire Station)	155 (153)	68 (64)

[1] Summary excluding dust days given in parentheses.

Within this area, the City will obtain a restrictive flood easement on perimeter lands between elevation 2,220 and 2,245 ft msl or within a horizontal distance of 300 feet from elevation 2,220, whichever is greater. The City will also limit the use of these areas by prohibiting construction of permanent structures or facilities. Although each landowner will be allowed to build two boat ramps (boat docks will not be allowed), the landowners have expressed a desire to minimize public access to their properties.

Since Justiceburg Reservoir will be located in Garza and Kent Counties, these two counties were chosen as the overall study area for evaluation of existing and future socioeconomic conditions. This analysis includes existing population trends, employment statistics, land uses, recreational needs, economic effects of reservoir construction, and the effect on local government revenues as a result of this project.

3.6.1 Existing Population

According to the 1980 Census, the population of Garza County was 5,336 persons and Kent County was 1,145 persons. The combined total population for the two counties in 1980 was 6,481 persons. As shown in Table 3.8, the combined population of the two counties has shown a consistent decline from a maximum of 9,437 persons in 1930 to a minimum of 6,481 persons in 1980. Since 1980, data released from the State Data Center (1989) suggests that the population of the two county area has remained fairly stable, increasing slightly in Garza County (+2.1 percent) and decreasing slightly in Kent County (-1.3 percent).

Table 3.8

Historical Population of
Garza and Kent Counties, 1930-1987

	1900[1]	1910[2]	1920[3]	1930[4]	1940[4]	1950[4]	1960[5]	1970[5]	1980[5]	1985[6]	1987[6]	Percent Change 1980-87
Garza County	185	1,995	4,253	5,586	5,678	6,281	6,611	5,289	5,336	5,493	5,450	+2.1
Kent County	899	2,655	3,335	3,851	3,413	2,249	1,727	1,434	1,145	1,251	1,130	-1.3
Totals	1,084	4,650	7,588	9,437	9,091	8,530	8,338	6,723	6,481	6,744	6,580	+1.5

1 U.S. Census Office, 1902
2 Bureau of Census, 1913
3 Bureau of Census, 1921
4 Bureau of Census, 1951
5 Bureau of Census, 1982
6 Texas State Data Center, 1989

Population in both counties rose slightly through the early 1980s in response to the oil boom. The population decline in the mid to late 1980s follows the oil crash and general economic downturn in Texas.

The racial character of the two counties is predominantly white. The white population in 1980 consisted of 5,044 persons, or 77.8 percent of the total. Blacks totaled 345 persons (5.3 percent of the population), American Indians totaled 113 persons (1.7 percent), Asian Indian totaled 11 persons (0.2 percent) and other racial categories totaled 968 (14.9 percent). Spanish Origin, which according to the Census, "can be of any race", totaled 1,377 persons or 21.2 percent of the total (Bureau of Census, 1982).

The median age in Garza County in 1980 was 30.2 years. In Kent County, the median age was 41.5 years. By contrast, the median age for the State of Texas was 28.0 years. Thus, the populations residing within the two counties were generally older that the state average. The high median age suggests that the younger population is migrating from these counties.

Incorporated cities and towns within the two-county study area include Post and Jayton, the county seats of Garza and Kent Counties, respectively. In 1980, Post had a population of 3,961 persons and Jayton had 630 persons (Bureau of Census, 1982). These two principal cities had a combined population of 4,599 persons, which was 71.0 percent of the two-county total. In 1987, Post had an estimated population of 4,012 and Jayton had a population of 631 (Texas State Data Center, 1989). These figures indicate a modest gain in population for the City of Post and a slight loss in population for Jayton.

Unincorporated communities near the project site include Clairemont, with an estimated 1987 population of 15 persons; Polar, with an estimated population of 10 persons; Justiceburg, with an estimated population of 76 persons. Clairemont is located 18.5 miles east northeast of the Justiceburg dam. The Polar community is 4.4 miles southeast of the dam site and Justiceburg is located at the upper end of the reservoir conservation pool at U.S. 84. All of the communities in the area are rural in character. Table 3.9 provides a summary of rural and urban population in the two counties.

Garza County encompasses 895 square miles and Kent County covers 878 square miles. At the top of the conservation pool, the reservoir will cover 2,884 acres, of which 85 percent will be in Garza County and 15 percent will be in Kent County. This constitutes less than 0.43 percent of the total land in Garza County and less than 0.07 percent of the area of Kent County.

There are no dwelling units located within the conservation pool elevation or the flood easement limit at elevation 2,245 ft msl. The local population will not be displaced by the project. Within one mile of the conservation pool elevation, there are four structures housing an estimated 12 persons. These residences will most likely be enhanced by the presence of the reservoir.

Table 3.9

1987 Urban and Rural Population Estimates, Garza and Kent Counties

	Population	
Garza County		
Post	4,012[1]	
Urban Population	4,012	(73.6%)
Southland	168[2]	
Justiceburg	76[2]	
Graham	183[2]	
Verbena	N/A[2]	
Close City	107[2]	
Other Rural	904	
Rural Population	1,438	(26.4%)
Total County	5,450[1]	
Kent County		
Jayton	631[1]	
Clairemont	15[2]	
Girard	125[2]	
Polar	10[2]	
Other Rural	349	
Rural Population	1,130[1]	(100%)
Total County	1,130	
Two-County Total		
Urban Population	4,012	
Rural Population	2,568	
Total	6,580	

[1] Texas State Data Center, 1989

[2] Texas Almanac, 1987. These are unincorporated communities.

3.6.2 Existing Employment

Agriculture has dominated the economy since the counties were settled. Oil and its related businesses also have played a significant role in employment since the discovery of oil in the area in the 1920s. The two-county study area had an estimated total of 2,676 employees in 1980 (Bureau of Census, 1983). The largest categories of employment included agriculture (19.8 percent), manufacturing (18.2 percent), services (17.9 percent), and mining (11.6 percent, including the oil industry). The manufacturing category was predominantly (cotton) textile mill and finished textile products (accounting for 15.2 percent of the two-county employment total), however, the large Postex Mill has since closed. Other significant employment categories included retail (9.3 percent), construction (6.3 percent), and transportation and public utilities (6.5 percent).

The average household income for Garza County in 1979 was $18,942. Kent County was 14.2 percent lower at $16,256. These income levels were comparable with the statewide 1979 average household income of $16,708.

Approximately 34.2 percent of households in the two counties obtain income through Social Security, and 10.2 percent from public assistance. Statewide, 22.3 percent of households receive Social Security and 6.2 percent receive public assistance, indicating that Garza and Kent Counties have a higher percentage of the elderly population. Dependence on public assistance is somewhat greater in these two counties than in the state as a whole. It should be noted that the above data is based on 1980 census information, before the oil economy had begun its downturn.

In October 1988, the unemployment rate for Garza County was 6.4 percent (Bureau of Labor Statistics, 1989), and in Kent County was 1.3 percent. The overall rate for the State of Texas was 6.8 percent (Table 3.10) The unemployment rate for Garza County is consistently higher and more closely reflects the statewide unemployment rate than does Kent County. Overall, the recent unemployment rate in the two counties has been declining, though it is unknown whether this trend will continue.

Approximately 1,180 persons (18.2 percent of the total population) within Garza and Kent Counties had incomes which fell at or below the poverty level in 1979 ($7,412 for a family of four). Statewide, the corresponding figure was 14.7 percent of the total population. Of the total persons below poverty level, 35.3 percent are children and 20.3 percent are over the age of 65. Approximately 14.5 percent of all families in the two counties fall below the poverty level; whereas, the statewide figure was 11.1 percent of all families, indicating that the two counties have a greater number of persons below the poverty line than the Texas average.

3.6.3 Existing Land Use

Current land use in Garza and Kent Counties is largely agricultural in nature. Total acreage of the land in agricultural uses over the past 30 years are presented in Tables 3.11 and 3.12. These tables show that farming and ranching activities in the two counties have remained fairly

Table 3.10

Unemployment Rates, Garza and Kent Counties
August - October 1988

	Aug	Sep	Oct
Garza County	9.1%	8.1%	6.4%
Kent County	2.0%	1.9%	1.3%
State of Texas	6.7%	7.1%	6.8%

Source: Bureau of Labor Statistics, 1989

Table 3.11

Land Use:
Garza County since 1958

	1958[1]	1967[1]	1987[2]
Cropland	110,000	107,444	108,950
Pasture / Hayland	-	-	600
Range	466,600	467,674	453,320
Other Lands:	1,300	2,229	10,474
On Farm Rural, Ponds, Roads, etc.	-	-	(6,942)
Conservation Reserve Program	-	-	(17,000)
Irrigated Land	-	(12,483)	(10,000)
Urban	-	-	(1,408)
Total Agricultural Inventory	577,900	577,347	573,344[3]

[1] Texas Soil and Water Conservation Needs Committee, 1970
[2] SCS, 1987
[3] Bureau of Census, 1980

Table 3.12

Land Use:
Kent County Since 1958

	1958[1]	1967[1]	1980[2]	1987[3]	1988[2]
Cropland	81,000	71,680	78,000	75,160	72,013
Pasture / Hayland	-	422	-	2,500	-
Range	475,100	467,180	455,000	462,570	462,000
Other Lands	1,800	5,912	28,920	34,280	27,907
On Farm Rural, Ponds, Roads, etc.	-	-	-	-	-
Conservation Reserve	-	-	-	-	(18,000)
Irrigated Lands	-	-	-	(500)	-
Urban	-	-	-	641	-
Recreation	-	-	-	163	-
Wildlife	-	-	-	1,500	-
Total Agricultural Inventory	558,700	545,194	561,920	576,173	561,920

1 Texas Soil and Water Conservation Needs Committee, 1970
2 Pers. com., Jim Guess, SCS
3 SCS, 1987

constant during the 30-year period. Farming is not as extensive in Kent County compared to Garza County due to the poorer soils below the caprock escarpment and resulting lower crop yields. The local outlook is generally positive in Garza County, where the farming economy continues to be doing well. In Kent County, the agricultural community has suffered from recent crop losses.

The main crop grown in Garza County is cotton. Some feed grains, forage sorghums, and alfalfa are also grown and used primarily for hay or grazing. The primary crops grown in Kent County are cotton and winter wheat. Farmers in Garza County use some supplemental irrigation and have had good cotton crops for the last two years. In Kent County where no irrigation is used, drought conditions and boll weevil infestations have resulted in severe losses in the cotton crop (pers. com., Jim Guess, SCS). Participation in farm programs is high and both counties have reached their limits in the Conservation Reserve Program.

Ranching has also remained fairly constant in both counties with the same producers and little change in ownership. The oil price drop has apparently increased participation in farm and wildlife programs. Conversion of additional acreage to improved and native grasses has not increased the number of livestock, but has reduced the amount of winter feed that local ranchers must purchase.

Oil production is also a major land use activity in both counties. Oil businesses in both counties were very active before the oil price drop. Following a decrease in activity, permitting and drilling are now on the increase. Both Convest and Exxon have projects partially in the reservoir area in Garza County. Convest has wells in the Grape Creek area and Exxon is operating in the Dorward Field. Mobil has been expanding their facilities in Kent County.

The only urbanized communities in the two counties are Post and Jayton. Roughly 74 percent of the residents of Garza County reside in the City of Post; 56 percent of the residents of Kent County live in Jayton. The remaining population lives in rural areas or unincorporated communities. Since the project occurs outside of any incorporated community, no land use plans have been developed for the project vicinity. Major highways in the area are U.S. 380 which traverses the two counties east to west (north of Justiceburg Reservoir), and U.S. 84 which crosses Garza County northwest to southeast, linking Lubbock to Snyder and Interstate Highway 20. State Highway 208 crosses Kent County north to south and would link U.S. 380 to U.S. 84 east of Justiceburg Reservoir. A few Farm-to-Market and county roads connect the scattered rural communities. U.S. 380 and U.S. 84 are the principal roads from Lubbock to the proposed lake area.

3.6.4 Existing Recreation Activities and Needs

The 1985 Texas Outdoor Recreation Plan (TPWD, 1985) divides Garza and Kent Counties into two different state planning regions. Garza County is in the South Plains region (which also includes the City of Lubbock), while Kent County is located in the West Central Texas region. Principal recreational resources for the South Plains region include Muleshoe

National Wildlife Refuge, Mackensie State Recreation Area, White River Lake, Buffalo Springs Lake, Yellow House Canyon Lakes and the Double Mountain Fork Brazos River. Findings of the recreation plan indicate that recreational water is scarce or inaccessible in the South Plains region. Although the West Central Texas region has a relative abundance of recreational lakes, the Plan found that these lakes are often low and crowded. The Plan projects a need for additional reservoir surface acreage to meet future recreation demands in the South Plains region. In addition, the Plan identifies the need for many reservoir-related recreational facilities for both regions, including additional boat ramps, camp sites, picnic tables, hiking trails, fresh water swimming areas, and additional fishing access facilities such as piers, barges, and marinas.

3.7 Cultural Resources

Cultural resources investigations have been undertaken in the Justiceburg project area to identify archeological and historic sites, and to determine which sites may be eligible for inclusion in the National Register of Historic Places. Approximately 8,600 acres were subjected to 100 percent pedestrian survey. This acreage includes the conservation pool at elevation 2220 ft msl, and the restrictive flood easement at elevation 2245 ft msl, or 300 feet from elevation 2220, whichever is greater. Also included were the damsite and borrow areas, public use and access areas, haul roads and other known construction areas. The survey was completed in 1987 by Prewitt and Associates, Inc., and the results of investigations are available in a two-volume final report (Boyd et al., 1989). Testing to determine National Register eligibility was undertaken by Prewitt and Associates, Inc. during the summer of 1988. The results of this investigation will be available in draft form in September 1989.

The survey resulted in the identification of 375 archeological and historical sites. These sites include 45 isolated finds, 74 rock art sites, 243 prehistoric sites, and 30 historic period sites. The total for all categories above is greater than the total number of sites in the project area because some sites have more than one component (e.g. a site with both Native American rock art and historic period artifacts would be considered two components although it is one site).

3.7.1 Federal and State Requirements

Because a federal permit is involved, the project must comply with Section 106 of the National Historic Preservation Act of 1966, as amended (NHPA), and its implementing regulations 36 CFR Part 800. The NHPA requires the head of a federal agency granting a permit, license or funding to take into account the effects of its undertaking on significant cultural properties, and to allow the Advisory Council on Historic Preservation an opportunity to comment. The archeology staff of the Fort Worth District U.S. Army Corps of Engineers has taken an active role in project planning and execution, ensuring that the work accomplished meets federal standards. A Programmatic Agreement for this project is currently being negotiated. Ratification will serve as the comments of the Council.

The State of Texas Antiquities Code applies to the project as well. This state law requires that archeological sites on lands owned or controlled by the state, including its political subdivisions, must be investigated under a permit granted by the Texas Antiquities Committee. The City of Lubbock as a political subdivision of the State of Texas falls within the jurisdiction of the Antiquities Code. The work conducted to date has met the requirements of the Antiquities Code.

3.7.2 Description of Cultural Properties

Various kinds of sites were identified in the project area during the survey, and a selection of these have undergone testing to determine whether the criteria of eligibility for inclusion in the National Register of Historic Places are met. Analysis is currently underway, with a report of investigations due September 1989. No conclusive determinations of eligibility have been made thus far, although preliminary recommendations were made by the contractor in the survey report. Sites vary in age from prehistoric, or the earliest evidence of humans in the area, to the entry of Europeans through the historic period.

Isolated finds consist of isolated artifacts or sparsely distributed cultural debris not associated with other cultural materials, often so widely scattered that the materials lack context. Isolated finds are included in the total site count because each expression of cultural material was assigned a site number. None of these sites are recommended for additional work.

Prehistoric Sites. Prehistoric sites are those sites which are associated with Native American occupation prior to the arrival of Europeans, and thus prior to written history in the region. Based on survey results, site density of prehistoric sites was calculated at 18 sites per square mile, or one site for every 35 acres. This acreage distribution assumes equal occupation of all topographic zones, which is not correct. Certain topographic features and zones were preferred site locations. The area surveyed was biased, limited by project definition to the Brazos floodplain, terraces and upland edges. Upland areas surveyed included the public use areas, haul roads and powerline routes, and those upland areas included in the 300-foot distance from elevation 2,220 ft msl. Prehistoric sites by topographic setting are presented in Table 3.13. Sites identified in an upland zone comprise 44.9 percent of the data base, while only half this number were identified on terraces. It is likely that desirable resources were available in the upland areas as well as in the floodplain and terraces. It is possible, however, that additional sites are present in the terraces but are not visible because they have been subsequently buried.

The prehistoric sites have been further classified according to function, an assignment based on the cultural materials noted at the site. These prehistoric site types include lithic procurement areas, open campsites, combination campsite/procurement, rockshelters, faunal

Table 3.13

Prehistoric Sites by Topographic Setting

Topographic Setting	Number of Sites*	Percent of Sites
Upland	109	44.9
Bluff Edge	5	2.1
Talus slope	1	0.4
Lower alluvial terrace	37	15.2
Upper alluvial terrace	19	7.8
Eolian dunes on alluvial terraces	3	1.2
Erosional remnant	45	18.5
Isolated mesa	4	1.6
Bedrock terrace	20	8.2
Total:	243	99.9

* Excludes 45 isolated finds

Source: Boyd et al., 1989

localities, and lithic scatters. The survey report provides detailed descriptions of each site type, with discussion of the cultural implications of the various site types by landform and temporal affiliation (Boyd et al., 1989).

Chronology is one of the most problemmatic issues affecting interpretation of cultural processes in the Justiceburg project area. Many sites lack diagnostic artifacts, making temporal assignment difficult. An attempt has been made to derive temporal information from associated noncultural data including soils, humates and other organic remains, and relative dating of geologic strata. Temporal classification in the project area follows traditional periods and stages for the region.

The Paleoindian Stage dates from the earliest documented occupation of humans in the New World to the end of the Pleistocene or approximately 10,000 B.P.(Before Present). No Paleoindian sites have been documented in the project area, although soil strata have been identified that correspond to this time period. Paleoindian lifeways are characterized as following migratory herds of large mammals such as mammoth and bison; current research suggests that a more diverse resource base is represented during this period. Excavations at the Lake Theo site in Briscoe County revealed not only a bison kill site, but an associated Paleoindian camp (Harrison and Killen, 1978). Johnson, on the basis of work at the Lubbock Lake site, suggests that previous ideas about Paleoindian life were oversimplified and that a more diverse economy is represented (Johnson, 1977).

The Archaic Stage is associated with a change in climate, gradually shifting from cooler and wetter to warmer and dryer conditions. Pollen studies suggest that local conditions may have varied from the more general regional trends, although subtle environmental changes are not well documented in the pollen record. Approximately 24 sites from the Justiceburg project area can be assigned to the Archaic Stage.

The Archaic is generally divided into three periods, each corresponding to climatic shifts with attendant shifts in material culture. No Early Archaic sites are known to be present in the Justiceburg project area at this time although the potential for occupation during this period has been documented through geomorphic investigations. Dates for this period in the project area are tenuous, approximately 8000 to 6500 B.P. The Middle Archaic is represented in the project area at four sites, defined on the basis of projectile point styles. The cultural adaptations and economic strategies for this period in the region are not well defined, in part due to the lack of a resource base. The Late Archaic period is the best represented of all Archaic periods in numbers of sites not only in the project area, but in the general region. Again, temporal assignments were made on the basis of diagnostic artifacts such as projectile points.

The Late Prehistoric Stage dates to approximately the last 2000 years and is characterized by a change in tool types and material culture. The bow and arrow replaces the spear, and ceramics are introduced. There is a shift in some areas from hunter/gathering economy to semisedentary subsistence, with less emphasis on gathering. This is the best documented period, with 24 sites assigned to this stage. Various regional complexes have been defined for this period within the Southern Plains, and it is not yet clear whether one particular complex is dominant within the Justiceburg area.

Sites which date to the period of Spanish entradas (initial expeditions into unexplored areas) in the Southern Plains, approximately A.D. 1541 through A.D. 1700, have been identified in the project area. These sites are of particular importance because few are know in the state, and they represent a limited period of time in which European traditions rapidly affected Native American groups. This acculturation is evident to some extent by the material culture of the groups inhabiting the area, and by the literature from this period which describes the entradas of the Spanish and their reception by local groups. It is not known whether direct contact was made during this early time with groups inhabiting the Justiceburg project area, or whether contact was indirect, through neighboring groups who traded European goods. Lifeways of the Native American groups in this portion of Texas were not substantially changed until after approximately A.D. 1700 when adjacent groups, primarily Comanche, migrated south into areas which had most recently been occupied by Apaches.

<u>Historic Sites</u>. The Historic period begins with European entry into the area, but permanent European occupation of the area did not occur

until after the Civil War. Military excursions are documented throughout the upper Brazos River basin prior to the Civil War, but intensive permanent settlements by Anglos did not occur until the 1870s. The development of the railroad and the end of the open range encouraged new settlement in the region. Historic site types common in the project area include dugouts associated with the early ranching period, approximately around the turn of the century, and possible association with buffalo hunters who ranged through the area prior to the 1880s. Other historic site types include dumps, ranch headquarters, line camps, homesteads and cemeteries.

The effect of the railroad was felt in many ways. The project area experienced a population boom during the period prior to 1911 during construction of the line. Justiceburg Lake was constructed as water supply for the steam engines, and became a popular recreation area during the 1930s. A number of small frame and stone residences and cabins were built around the lake, two of which are still present today.

Two townsites, Burnham and Justiceburg, were platted about 1910. By the 1930s, Justiceburg was the more successful community with various commercial facilities, a post office, railroad depot, church, school and residences (Freeman, 1989). Many of the buildings in Burnham were moved to Justiceburg after World War I.

Oil production was initiated by James Minus Boren in the early 1920s, but production was not strong until the 1950s. The economic basis for the area has been primarily dependent on farming and ranching, which remains true up to the present.

Rock Art. Rock art comprises one of the most significant site types in the project area, with 74 sites containing rock art components. The rock art has been recorded in detail by Prewitt and Associates, using photography, reduced and actual scale drawings, and archival sources as methods. Prewitt and Associates has proposed additional methods to recover more information from these sites including pigment analysis, additional photographic techniques, and possible removal of panels for placement in a museum or curation facility.

The 33 Native American rock art components comprise an important data source for the area, but presents problems as well. Assigning dates to the panels is difficult in most instances because no directly associated cultural material is present to provide absolute chronological control. Ease of interpretation varies, with some figures clearly reflecting European dress and theme, while other panels cannot be interpreted. Most panels consist of petroglyphs--incising into the rock--with only one site containing pictographs, or painting. Subject matter includes geometric symbols such as parallel lines or motifs that do not represent recognizable elements, animal representations, and anthropomorphic representations. Assigning stylistic attributes to a particular tribe or cultural group is difficult. Attributes of some panels clearly represent Plains Indian rock art styles, but other panels are unassignable to time period or group.

The 54 historic Anglo rock art components cluster around the turn of the twentieth century, which represents the most populous period in the history of the project area. The survey report provides an annotated cross-referenced biographical concordance of the historic rock art inscriptions (Freeman, 1989).

4. ENVIRONMENTAL IMPACTS

4.1 Geological Resources

4.1.1 Prime Farmland Soils

Approximately 86 acres of prime farmland soils (Spur soils) will be inundated by the construction of Justiceburg Reservoir. None of this acreage is in cultivation. As mentioned previously, soils of the Frio series (approximately 184 acres in the conservation pool) have been reclassified in the Lincoln-Yahola series, and are no longer considered prime farmland soils (pers. com., Dan Blackstock, SCS).

4.1.2 Petroleum and Mineral Resources

The construction of Justiceburg Reservoir will impact the retrieval of oil in the project area. A total of 31 oil wells occurs in the reservoir area: 10 in the conservation pool (below elevation 2220 ft msl), 11 in the flood easement (between elevations 2220 and 2245 ft msl), and 10 in the probable maximum flood pool (between elevations 2245 and 2259.2 ft msl). While it must be recognized that the construction of a lake might cause some currently producing wells to be capped, profitable wells located in the shallow portions of the reservoir could be raised and production continued. Because of the variations in the price of oil and production costs, it is not possible to identify at this time which wells will be retained using platforms or levees. Since the lake is so narrow, all oil under the lake is considered retrievable from directional drilling or from existing wells above the conservation pool.

Although uranium is not presently mined in the reservoir area, the filling of Justiceburg Reservoir will preclude any future uranium mining from the area of the conservation pool. However, extensive deposits of uranium occur north and south of the project area.

Construction of the reservoir will also preclude sand and gravel mining within the conservation pool. Although no active mining operations will be impacted, there is one existing sand and gravel lease within the conservation pool area.

4.2 Hydrologic and Water Quality Impacts

Effects on Surface Water Hydrology. The proposed Justiceburg Reservoir will convert the intermittently wet existing channel to a permanent pool upstream from the dam, while occasional reservoir spills will provide intermittent runoff downstream from the dam. Since the intended purpose of the reservoir is for water supply and the semi-arid conditions produce no flow approximately 37 percent of the time, no continuous downstream releases are planned. The estimated spills based on simulated operation of the reservoir under 1940-1981 hydrologic conditions, are compared to historical maximum streamflow in Table 4.1.

An analysis of water level fluctuations in the proposed reservoir was performed to provide a basis for evaluating impacts on reservoir uses. The analysis was based on simulated operation of the reservoir under hydrologic conditions from 1940 through 1981. The simulated conditions included a variable rate of demand which was dependent on reservoir contents (Freese and Nichols, 1978). The top of conservation storage in

Table 4.1

Comparison of Historical Discharge at the Dam Site to Simulated Spills from the Proposed Justiceburg Reservoir Based on 1940-1981 Hydrologic Conditions

Month	Simulated Spills			Historical
	Number	Minimum ac-ft/month	Maximum ac-ft/month	Maximum Discharge, ac-ft/month
January	0	-	-	1,140
February	0	-	-	5,670
March	0	-	-	8,110
April	1	10,444	10,444	30,830
May	1	67,232	67,232	68,820
June	4	4,350	28,132	49,000
July	5	1,780	27,674	32,380
August	1	871	871	40,550
September	3	1,506	62,218	70,500
October	3	27,586	52,496	60,090
November	0	-	-	5,490
December	0	-	-	3,760

Justiceburg Reservoir would be elevation 2,220 ft msl. At that level the reservoir would cover approximately 2,884 acres and contain 115,937 acre-feet under initial area and capacity conditions. The mean depth at the maximum capacity would be approximately 40 feet, while the maximum depth would be approximately 100 feet near the dam.

Simulated reservoir fluctuations in Justiceburg Reservoir are characterized in Figures 4.1, 4.2, and 4.3. The reservoir would be full (2,220 ft msl) approximately four percent of the time, as shown in Figure 4.1 The median simulated water level was 2,198 ft msl.

The range of simulated elevations of Justiceburg Reservoir on a monthly basis is shown in Figure 4.2. The minimum end-of-month elevations, which reflected the drought conditions of the late 1970s, ranged from approximately 2,138 ft msl in April, to about 2,162 ft msl in June. The simulated lake levels would fluctuate between 2,173 ft msl and 2,219 ft msl approximately 70 percent of the time as depicted by the area between the 15th and 85th percentiles in Figure 4.2, and the monthly levels would be above 2,194 ft msl more than 50 percent of the time (median) in every month. Maximum water levels would be expected to range from 2,216 ft msl in March to 2,220 ft msl in April through November.

The magnitude and frequency of simulated monthly water level fluctuations in Justiceburg Reservoir are shown in Figure 4.3. The bracketed, dashed vertical lines indicate the greatest water level increases and decreases which would be expected to occur from month to month during the simulated period, while the solid vertical lines

JUSTICEBURG RESERVOIR
END-OF-MONTH WATER LEVEL
DURATION CURVE

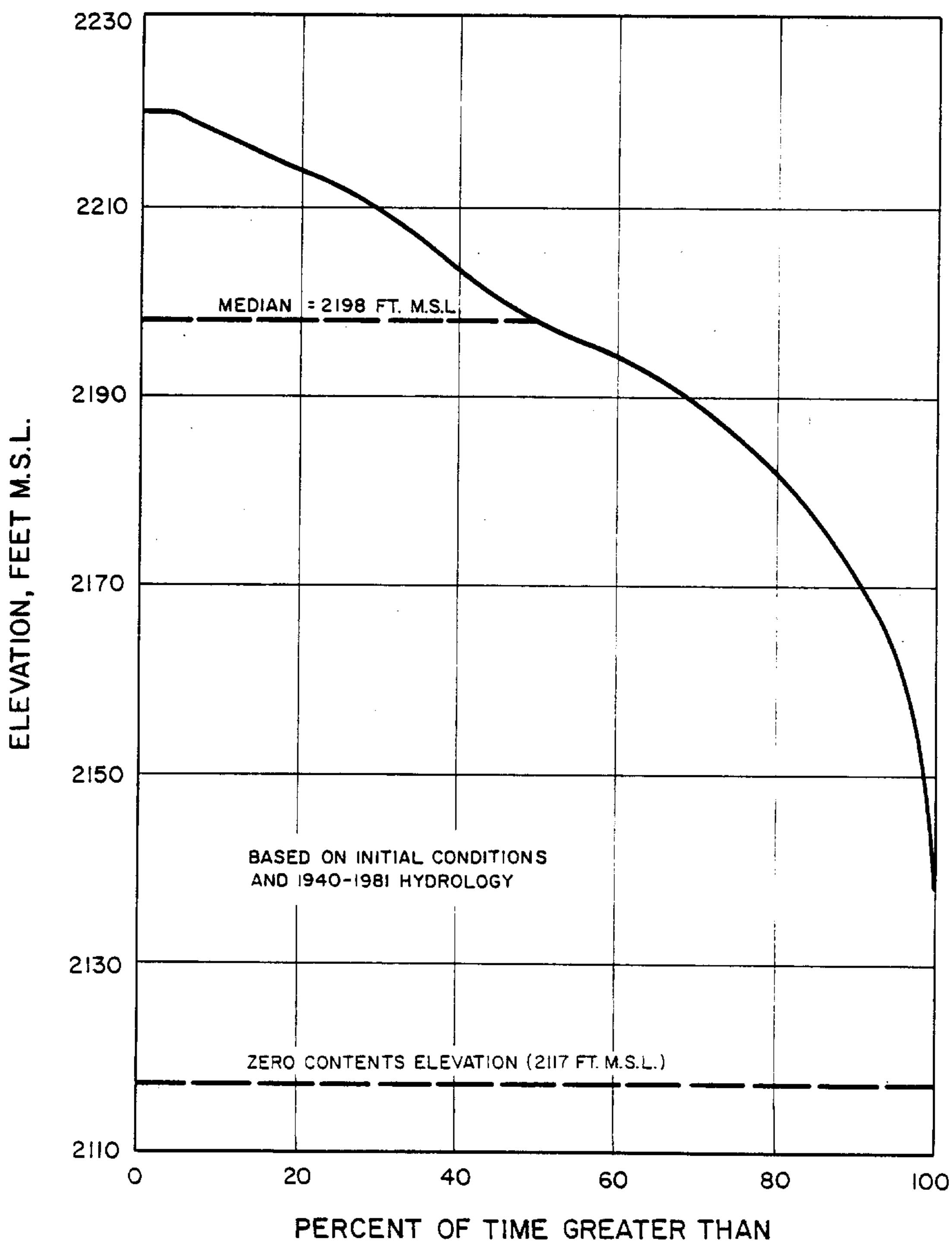


FIGURE 4.1

JUSTICEBURG RESERVOIR END OF MONTH WATER LEVELS

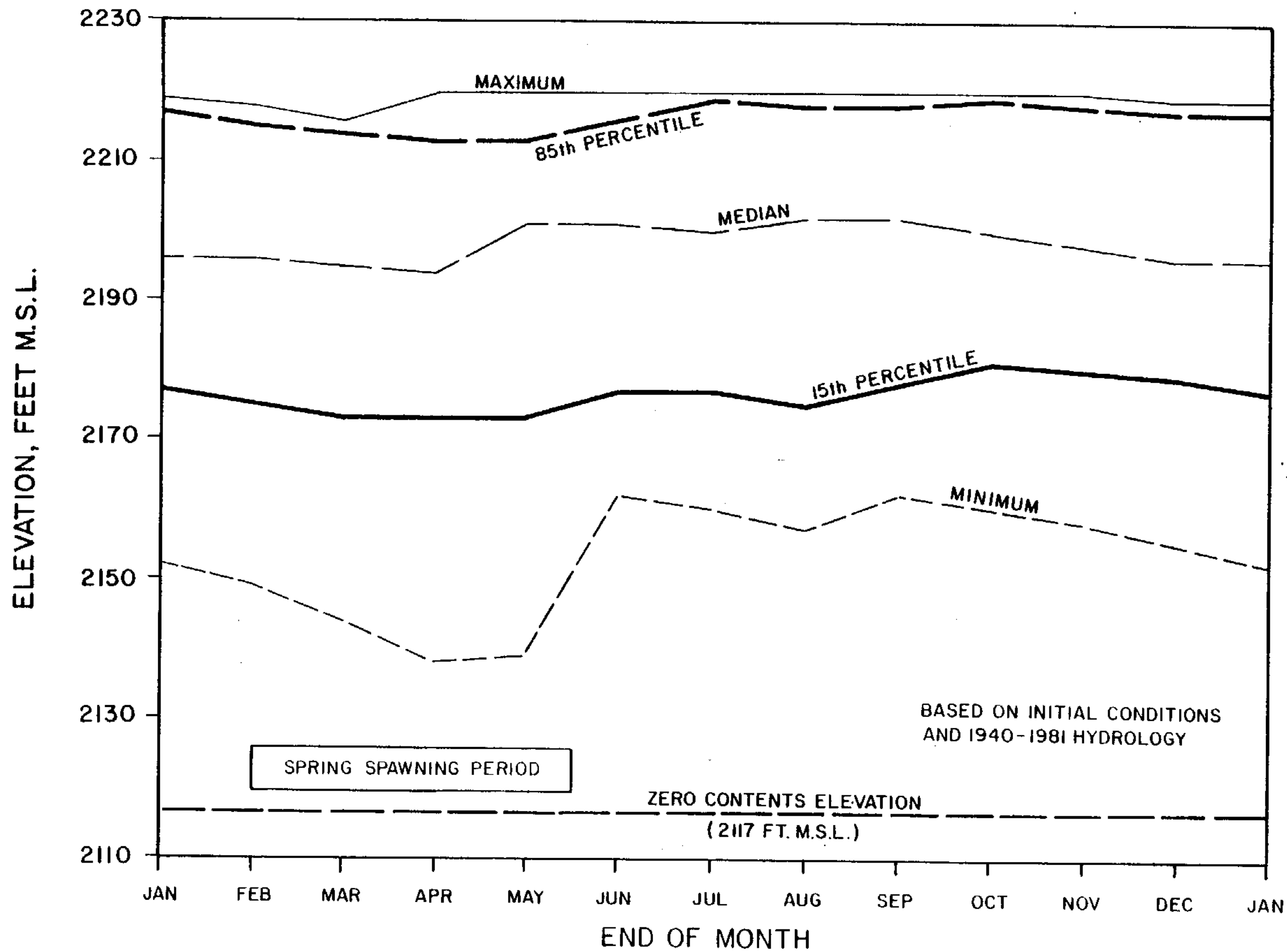


FIGURE 4.2

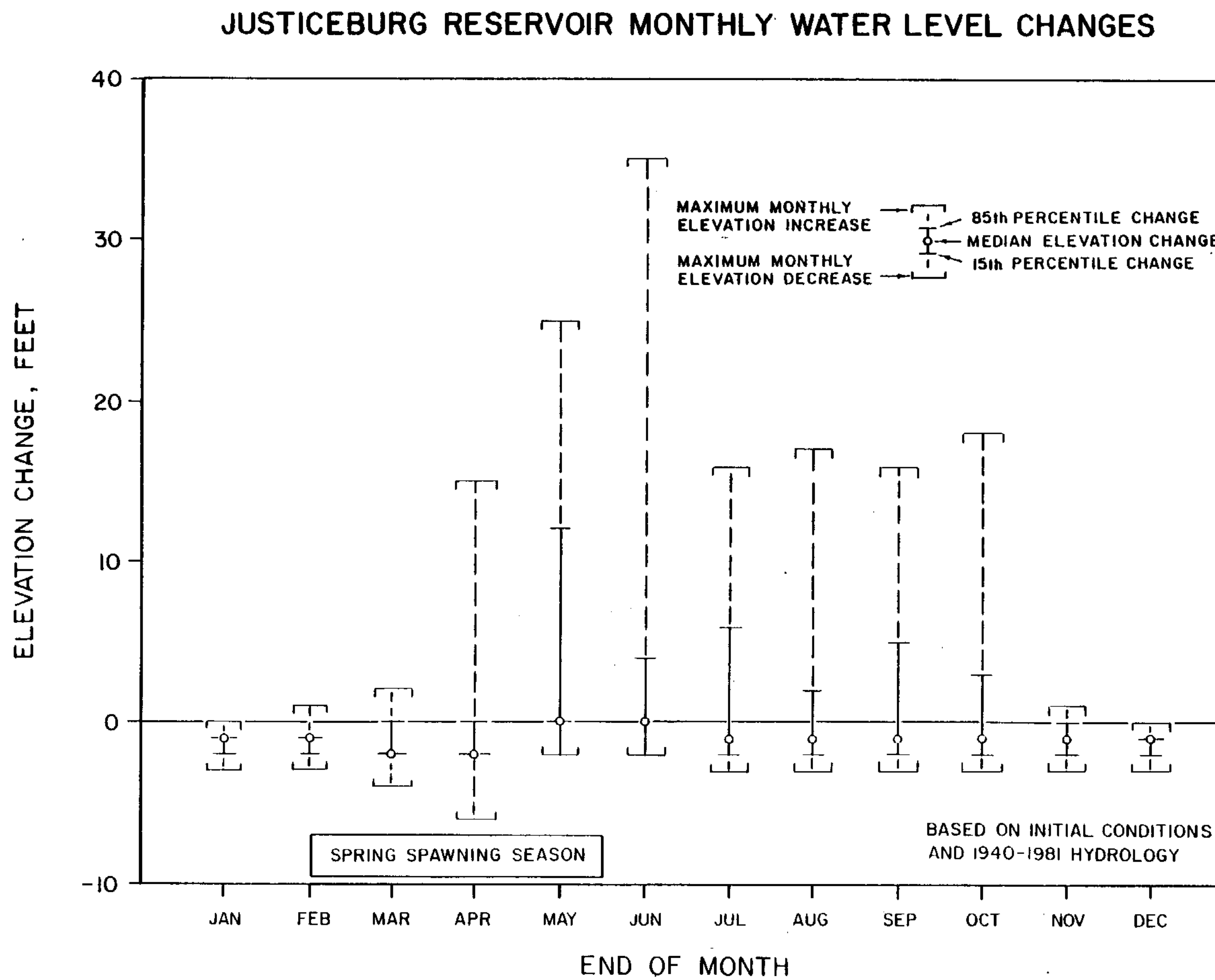

JUSTICEBURG RESERVOIR MONTHLY WATER LEVEL CHANGES
ELEVATION CHANGE, FEET
40
30
20
10
0
-10
MAXIMUM MONTHLY ELEVATION INCREASE
MAXIMUM MONTHLY ELEVATION DECREASE
85th PERCENTILE CHANGE
MEDIAN ELEVATION CHANGE
15th PERCENTILE CHANGE
SPRING SPAWNING SEASON
BASED ON INITIAL CONDITIONS AND 1940-1981 HYDROLOGY
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
END OF MONTH

FIGURE 4.3

indicate the range within which 70 percent of all the monthly water level changes would occur (i.e., the range between the 15th and 85th percentiles). Values of simulated monthly elevation changes in the proposed Justiceburg Reservoir are summarized in Table 4.2.

The magnitude of water level increases were larger than water level decreases in Justiceburg Reservoir (see Figure 4.3). This pattern of reservoir fluctuations suggests that reservoir drawdowns generally would be more gradual than increases in reservoir stage under the conditions used in the simulated operation. The greatest monthly decrease in simulated water levels occurred during drought conditions in April 1978, when the water level dropped 6 feet from 2,144 ft msl to 2,138 ft msl. The greatest monthly increase in simulated water surface elevations occurred in June 1979 when the stage changed 35 feet from 2,139 ft msl to 2,174 ft msl in response to a large June inflow volume (25,890 acre-feet).

Effects on Surface Water Quality. Construction of Justiceburg Reservoir will temporarily increase suspended solids and turbidity in the Double Mountain Fork Brazos River. Erosion control techniques such as temporary seeding during construction, permanent seeding of the dam and other appropriate measures will help minimize sediment loading to the river. Suspended solids and turbidity concentrations downstream of the reservoir will return to pre-construction levels after completion of the dam.

Table 4.2

Justiceburg Reservoir, Initial Conditions:
Summary of Simulated Monthly Elevation Changes Based on 1940-1981 Hydrology

Month	Greatest Decrease	Monthly Elevation Change, Feet: 15th Pctl	Median	85th Pctl	Greatest Increase
January	-3	-2	-1	-1	0
February	-3	-2	-1	-1	1
March	-4	-2	-2	0	2
April	-6	-2	-2	0	15
May	-2	-2	0	12	25
June	-2	-2	0	4	35
July	-3	-2	-1	6	16
August	-3	-2	-1	2	17
September	-3	-2	-1	5	16
October	-3	-2	-1	3	18
November	-3	-2	-1	0	1
December	-3	-2	-1	-1	0

Reservoir water chemistry is influenced not only by the characteristics of the incoming runoff, including water quality and quantity, but also by the physical attributes of the reservoir such as the depth, surface area, volume, and other factors. Thus, the existing surface water chemistry at the reservoir site will change primarily in response to alteration of flow and water storage conditions.

The proposed reservoir probably will stratify thermally during the late spring, summer, and early fall. Thermal stratification is common to most Texas reservoirs with a maximum depth greater than approximately 30 feet. Stratification in Justiceburg Reservoir may exhibit some similarities, such as timing and depth of stratification, to conditions observed in Possum Kingdom Reservoir, which lies approximately 150 miles east of the Justiceburg site but at nearly the same latitude. In Possum Kingdom Reservoir, thermal stratification normally occurs by late April or May as increasing daylight and air temperatures warm the surface waters so that three distinct temperature zones develop (Freese and Nichols, 1987). The warmer, less dense surface water layer (the epilimnion) is separated from the cooler, denser layer (the hypolimnion) by a zone where the temperature decreases rapidly with depth. This layer of maximum temperature decrease is known as the thermocline and occurs at a depth of about 20 to 40 feet below the surface. Stratification persists throughout the summer, and sometimes into the fall, until day length, air temperature and autumn winds cause the lake gradually to cool and mix so that temperatures become relatively uniform throughout the water column.

In conjunction with the onset of thermal stratification and the development of a hypolimnion, chemical stratification also is likely to occur in the proposed reservoir. The epilimnion should contain higher dissolved oxygen levels than the hypolimnion due to continuous reaeration from surface diffusion and algal productivity. In contrast, dissolved oxygen in the hypolimnion is expected to be depleted sometime after the onset of thermal stratification. Anaerobic conditions develop in the hypolimnion because the thermocline becomes a barrier to mixing of the oxygenated epilimnetic water with the deeper water, light intensities are too low for effective algal oxygen production, and biochemical processes consume all the available oxygen.

Water in the anaerobic hypolimnion would be objectionable for drinking because of the presence of dissolved gases such as hydrogen sulfide and other compounds which would impart undesirable taste and odor. In addition, the hypolimnion would be unsuitable for many fish species, especially sportfish such as largemouth bass, striped bass, crappie, etc., due to the lack of sufficient dissolved oxygen. However, during warm months when the reservoir is stratified, the epilimnion should contain water of adequate quality and quantity to support municipal demands as well as fish populations comparable to those found in other west Texas reservoirs.

Since dissolved solids are elevated naturally in the stream above the proposed dam site, potential TDS concentrations within Justiceburg

Reservoir were evaluated under the planned operation. Dissolved solids concentrations in the proposed reservoir were estimated using a mass balance procedure in the reservoir operation computer model (see Appendix A). The simulated parameters included monthly inflow volume and quality, reservoir evaporation, variable water demand, and reservoir spills. As discussed previously, simply taking the arithmetic average of individual samples for dissolved solids in a stream does not accurately reflect the expected levels of dissolved solids in a proposed reservoir. Flow-weighted average mineral concentrations should be used to evaluate the probable water quality in a reservoir to account for the inverse relationship between salt concentrations and streamflow.

Justiceburg Reservoir inflow quality was derived from regression analysis of observed monthly flow-weighted concentrations of TDS at the USGS Justiceburg gage from October 1975 through September 1977 (Freese and Nichols, 1978). The measurements made at the gaging station were adjusted mathematically to reflect the quality at the proposed dam site. Analysis indicated that the monthly flow-weighted average TDS concentration at the dam site could be estimated using the following equations:

a. For runoff less than 25 acre-feet per month.

$$TDS = 6{,}912 \times Q^{-0.066}$$

b. For runoff from 25 to 250 acre-feet per month.

$$TDS = 45{,}574 \times Q^{-0.652}$$

c. For runoff more than 250 acre-feet per month.

$$TDS = 3{,}536 \times Q^{-0.189}$$

where TDS is in mg/l and Q is the monthly runoff in acre-feet per month.

Results of the reservoir water quality simulation over the 42 year simulation period indicated that TDS levels would not exceed the 1,300 mg/l threshold of acceptability observed for Lubbock water users. The median simulated total dissolved solids level in Justiceburg Reservoir was about 776 mg/l. Simulated TDS concentrations ranged from 546 mg/l to 1,210 mg/l. The impoundment of runoff at the dam site will cause the lower concentration flood waters to dilute the more mineralized low flows, resulting in a buffering effect on the existing wide fluctuation of dissolved solids found in the Double Mountain Fork Brazos River at Justiceburg.

Based on characteristics of the contributing drainage area and limited nitrogen data, the proposed reservoir is not expected to be highly eutrophic, although adequate nutrients should exist to maintain an average level of algal production compared to other Texas reservoirs. Nutrient contributions to the reservoir will be primarily from nonpoint sources. The Justiceburg Reservoir watershed is dominated by rural land uses including farming, ranching, and petroleum production, and there are no permitted point source wastewater discharges upstream from the reservoir site. The only nutrient data available for the site, ten samples tested for nitrate in the mid-1960s, indicate that nitrogen inputs are relatively low (i.e., less than 0.1 mg/l to 0.5 mg/l).

Effects on Groundwater Hydrology. A groundwater mound will develop gradually beneath and around the fringe of the reservoir. The extent of the mound will depend on continuity and permeability of the underlying and adjacent strata. Alluvial deposits in the reservoir vicinity will offer lower resistance to water movement than other rock units in the area, and thus, water movement into these deposits probably will exhibit a greater response to the reservoir. The heterogeneous nature of other geological units in the region will tend to retard water movement. Therefore, the reservoir is not expected to induce a significant amount of regional recharge. While the groundwater mound might be perceived as a loss of water from the reservoir, on the contrary, it effectively will increase the yield by providing additional storage. Water will move into the mound along the wetted perimeter of the reservoir. As the water level drops below the saturated zone around the reservoir, water from the mound will migrate back into the reservoir pool. This process is directly analogous to bank storage in a stream, whereby water moves into the steambank during periods of runoff and then returns to the stream and helps to maintain dry-weather flows after the stream level drops.

Effects on Groundwater Quality. Chemical quality in groundwater bearing formations which are hydraulically connected to Justiceburg Reservoir generally will reflect the quality of the reservoir, which is expected to be suitable for most uses. Some enhancement may occur in adjacent saline groundwater deposits as less mineralized water from the reservoir migrates into these areas and dilutes the existing concentrations. As mentioned previously, groundwater recharge from the reservoir is not expected to be extensive. Therefore, the impacts of the reservoir on regional groundwater quality probably will be negligible.

4.3 Biological Resources

4.3.1 Terrestrial Biological Resources

The filling of Justiceburg Reservoir will inundate most vegetation and wildlife habitat in the conservation pool area. Although wildlife species which currently inhabit the conservation pool will probably relocate to adjacent areas during reservoir filling, it is unlikely that the temporary increase in populations could be completely supported. The reservoir will provide some value to terrestrial species (in particular, to waterfowl) that will utilize the inundated brush and marshy areas that may form in shallow areas of the lake. However, the construction and filling of the reservoir will result in a net loss of wildlife habitat.

Project losses associated with the construction and filling of Justiceburg Reservoir were determined using the Texas Parks and Wildlife Department's (TPWD) Wildlife Habitat Appraisal Procedure (WHAP). The WHAP field survey was performed on the reservoir site in August 1986 by representatives of TPWD, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers (USACE), and the City of Lubbock. Results of the WHAP analysis (Appendix B) indicated that one hundred percent compensation would require 2,944 acres of inkind habitat replacement, assuming a similar baseline habitat quality and moderate management (75 percent of the improvement potential). This represents a slightly greater than acre-for-acre replacement for the 2,884 acre reservoir project. The resource agencies indicated they would request that this level of compensation be required for project mitigation.

In order to satisfy the WHAP estimate, the City of Lubbock is investigating several alternative sites for potential use as mitigation tracts. The Furr Ranch, located in Kent County, has been determined to be the preferred alternative because the property contains habitats similar to the reservoir site, the rangeland is in good condition (the ranch has not been grazed in three years) and the area has an interesting topographic relief.

In September 1987, the interagency team performed a WHAP field survey on the Furr Ranch. Habitat quality, as indicated by Habitat Suitability Index (HSI) values, was almost identical to that in the vicinity of the reservoir site. Since the two areas were so similar, the agencies agreed to use the same management assumptions that had been used previously in the August 1986 analysis. Results of the Furr Ranch analysis indicated that one hundred percent compensation would require 3,038 acres for inkind habitat replacement for riparian habitat, mesquite-lotebush shrubland and mesquite-juniper shrubland; and equal replacement for rangeland (Appendix B). Since the condition of the vegetation is already near optimum for this region, deliberate habitat manipulation efforts are likely to result in only minimal habitat improvement. For this reason, the interagency team, was agreeable to allow the mitigation area to be left in its existing "natural" condition and no habitat improvements are required or recommended.

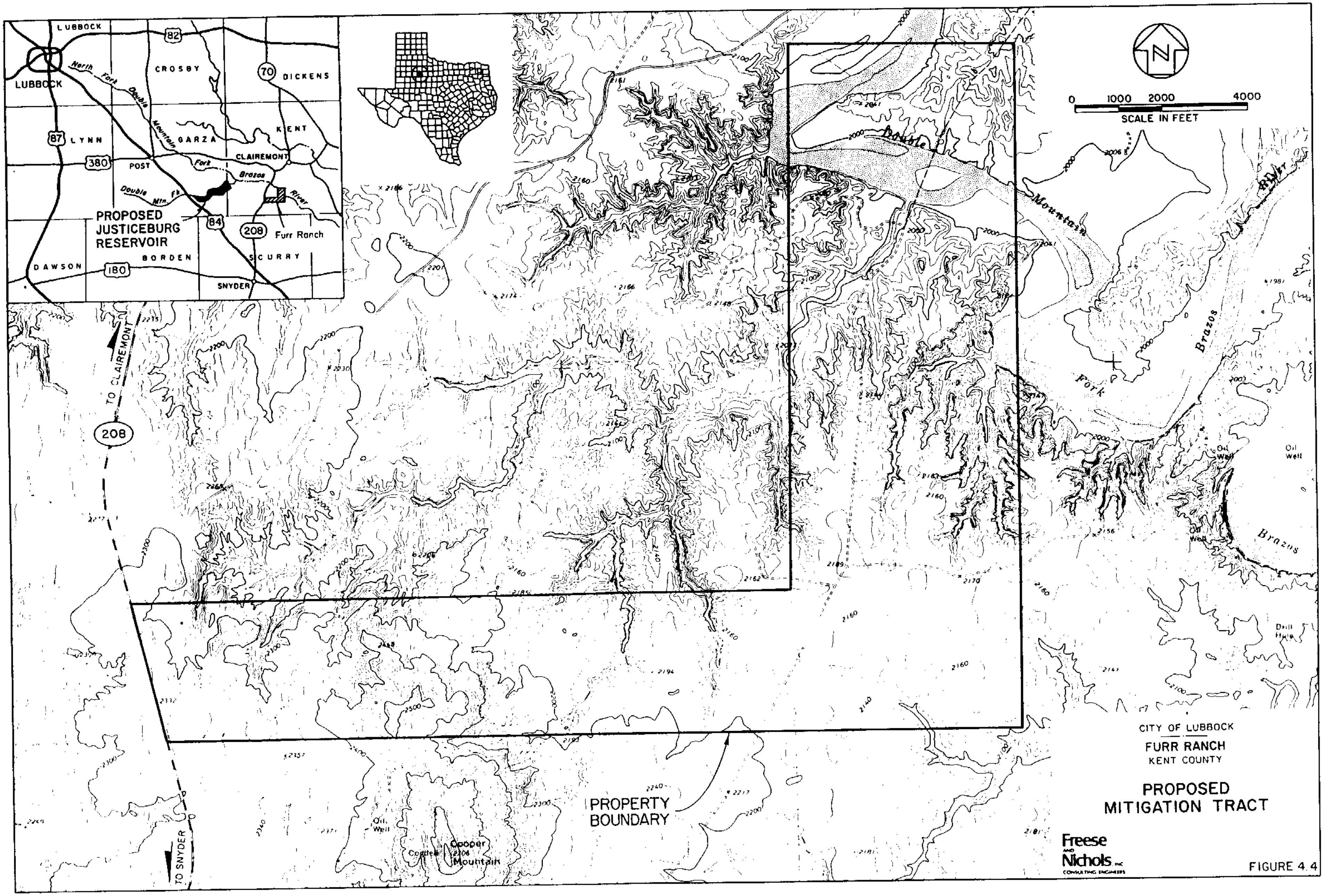
In order to satisfy the wildlife mitigation requirements of the USACE Section 404 Permit regulations, the City of Lubbock proposes to purchase a 3,038-acre tract on the Furr Ranch property, as shown in Figure 4.4. Acquisition and management of the tract will provide one hundred percent compensation of terrestrial habitat losses due to construction of Justiceburg Reservoir.

A preliminary management plan for the Furr Ranch (submitted as a separate document) has been developed to mitigate wildlife habitat losses associated with the construction of the Justiceburg Reservoir project and to comply with requirements of the U.S. Army Corps of Engineers Section 404 Permit application process.

The City of Lubbock proposes to manage the Furr Ranch as a wilderness area. The City's primary objective is to preserve the property so that it will serve as a refuge for the native plant communities and wildlife of the region. The City views their mitigation obligation as an opportunity to acquire and maintain a sanctuary park for non-consumptive and low-impact educational, research and aesthetic uses for the citizens of Lubbock.

4.3.2 Aquatic Biological Resources

The temporary increase in suspended solids and turbidity during reservoir construction may reduce habitat suitability for aquatic organisms, although the intermittent flow conditions will continue to be the primary limiting factor in the aquatic ecosystem downstream of the dam. Once construction is completed the levels of suspended solids and



CITY OF LUBBOCK

FURR RANCH

KENT COUNTY

PROPOSED MITIGATION TRACT

Freese and Nichols, Inc.
Consulting Engineers

FIGURE 4.4

turbidity are expected to return to those levels that existed before construction. Approximately 14.6 miles of riverine habitat will be inundated and converted to lacustrine habitat when the conservation pool is full. Obligate riverine species (see Table 3.5), which occur in the Double Mountain Fork only on a temporal basis, will not survive the lacustrine conditions, but will still occur up and downstream of the reservoir when flow conditions are adequate. Lacustrine species (those which prefer standing water conditions), such as gizzard shad (Dorosoma cepedianum), blacktail shiner (Notropis venustus), yellow bullhead (Ictalurus natalis), black bullhead (Ictalurus melas), brook silverside (Labidesthes sicculus), black crappie (Pomoxis nigromaculatus), and bluegill (Lepomis macrochirus), will be introduced into the reservoir from surrounding stock tanks upstream of the dam and from TPWD stocking operations. Lacustrine species will populate the newly created habitat and expand their populations within the reservoir.

Water supply reservoirs are designed to have their contents nearly empty at the end of a critical drought. During these periods, reservoir fisheries adjust to the changing conditions. Under the proposed operation, reservoir levels will fall at a gradual rate allowing for populations to adjust to a reduced carrying capacity. However, as levels continue to drop, fish will seek refuge in pools within the old channel as they would do under drought conditions in a riverine environment. Stream flow would be low to zero during these same periods without Justiceburg Dam in place.

During the spring spawning period, which is considered to extend from the end of February through mid-June, the proposed reservoir is expected to remain above 2,166 ft msl 90 percent of the time. Table 4.3 provides some estimates of potential spawning habitat area available in the proposed reservoir at various levels and frequencies based on the 42-year operation model.

Monthly reservoir fluctuations were evaluated for potential effects on fisheries within the impoundment. In general, increasing pool elevations are more beneficial than declining levels because the higher surface level usually will provide a larger littoral zone and inundate more vegetation, which will offer cover and protection for fish. During the spawning season, falling reservoir levels could expose spawning beds and force fry into deeper water with less protective cover, whereas rising water levels will not expose spawning beds and can provide fry with additional protective areas. The monthly elevation changes resulting from the proposed operation of the reservoir indicate normally only small decreases during the spring spawning season (see Figure 4.3 and Table 4.2). In contrast, the increases can, under unusual conditions, be as great as 38 feet when high runoff fills the reservoir following a drought period.

Due to the stocking operations by Texas Parks and Wildlife Department (TPWD), Justiceburg Reservoir will contain various forage and sport fishes necessary to develop a fishery (personal communication from Charles D. Travis, TPWD, 11 July 1989). TPWD plans to stock: blue

Table 4.3

Potential Spawning Habitat[1]
in the Proposed Justiceburg Reservoir

% of Time Area Less than or Equal	Potential Spawning Habitat (Acres)					Elevation
	Feb	Mar	Apr	May	Jun	Range, ft msl
100	437	429	447	447	447	2216 - 2220
90	427	420	421	420	445	2215 - 2220
80	412	412	401	406	411	2211 - 2213
70	390	387	381	392	393	2206 - 2210
60	359	354	356	379	379	2197 - 2206
50	351	351	351	368	365	2194 - 2202
40	350	349	349	351	353	2190 - 2196
30	332	327	322	321	345	2185 - 2192
20	306	298	299	293	288	2181 - 2183
10	279	275	273	276	275	2166 - 2169

[1] Potential spawning habitat is considered to be areas of the reservoir where water is 10 feet deep or less during the spring spawning months.

catfish (Ictalurus furcatus), channel catfish (Ictalurus punctatus), flathead catfish (Pylodictis olivaris), largemouthbass (Micropterus salmoides), smallmouth bass (Micropterus dolomieui), white crappie (Pomoxis annularis), and walleye (Stizostedion vitreum). They may also stock striped bass (Morone saxatilis) or a hybrid striped bass (pers. com., Roy Bamberg, TPWD). Recreational sport fishing is expected to increase due to the construction of Justiceburg Reservoir and TPWD's stocking operations.

4.3.3 Endangered and Threatened Species

None of the endangered or threatened species listed as occurring in Garza and Kent Counties will be impacted by the Justiceburg Reservoir project. Although the bald eagle (Haliaeetus leucocephalus), Arctic peregrine falcon (Falco peregrinus tundrius) and white-faced ibis (Plegadis chihi) migrate through the project area, the construction of Justiceburg Reservoir should not impact either the migration routes or stopover points for these species. Specimens thought to be the Palo Duro mouse (Peromyscus truei comanche), which were collected in the project area were later reidentified as Peromyscus attwatteri, which is not a threatened species. Other specimens (P. attwateri, P. boylii, P. difficilis nasutus and P. leucopus tornillo) which may require reexamination were collected from the caprock escarpment 15 miles northwest of the upper end of the reservoir conservation pool. Although the Texas horned lizard (Phrynosoma cornutum) is known to prefer habitats like those found in the project area, the loss of habitat resulting from the Justiceburg Reservoir project is considered insignificant to the species as a whole or to individuals within Garza and Kent Counties. The smalleye shiner (Notropis buccola) has never been collected from the Double Mountain Fork of the Brazos River.

4.4 Air Quality

Temporary air pollution can be expected in the form of dust generated from land clearing, earth moving, and other construction activities. If objectionable dust levels occur, dust can be controlled by timely applications of water and temporary seeding to the areas of construction. Other than construction impacts, there should be no long-term impacts on air quality from operation of the proposed dam and reservoir.

4.5 Noise

Local areas will be subjected to temporary increases in noise associated with construction and land clearing activities. However, since the reservoir area is unpopulated and the closest residences are approximately 1.7 miles from the dam, noise generated from construction and land clearing activities will have little impact. Due to the unpredictable movement of heavy machinery, construction noise will not be continuous at any given area; therefore, it is impossible to predict construction noise levels.

The standard specifications for the project construction require that the contractor be familiar with, observe, and comply with all federal, state and local laws, ordinances, and regulations which in any manner affect the conduct of the work. This requires the contractor to make every reasonable effort to minimize construction noise through abatement measures such as work hour controls and maintenance of muffler systems.

4.6 Socioeconomics

4.6.1 Future Population

The population of Garza County has fluctuated around 6,000 persons since 1930. The lack of substantial growth in the County is a result of a stable, but limited agricultural and petroleum-based economy. In comparison, Kent County has shown a constant decline in population since 1930. Kent County has less of an agricultural economy, with only 36 percent of the ranch livestock revenues and 85 percent of the farmland in Garza County. However, oil reserves in Kent County are significantly larger than those in Garza County, and therefore, the oil industry is a greater factor in the local economy.

Although Garza and Kent Counties did not exhibit significant population gain from 1980 through 1988, projections by the Texas Water Development Board (Table 4.4) indicate that the two-county area will have a steady increase in population (since the Garza County gains significantly outnumber the projected losses in Kent County). The Board's projections are based on a cohort-survival-migration model, with the High Series based on migration rates of the 1970s and the Low Series based on migration over the period of 1950-1980. Historical and

Table 4.4

TWDB Population Projections for Garza and Kent Counties, 1980-2040

	1980	1985	1990	2000	2010	2020	2030	2040
Garza County								
High Series	5,336	5,493	5,531	6,182	7,193	8,776	10,724	11,860
Low Series	5,336	5,493	5,361	5,805	6,611	7,811	9,197	9,982
Kent County								
High Series	1,145	1,251	1,063	950	875	853	834	834
Low Series	1,145	1,251	1,024	860	790	769	752	752
Two - County Total								
High Series	6,481	6,744	6,594	7,132	8,068	9,629	11,558	12,694
Low Series	6,481	6,744	6,385	6,665	7,401	8,580	9,949	10,734

Source: Texas Water Development Board, 1988

projected high series populations for each county are presented in Figure 4.5.

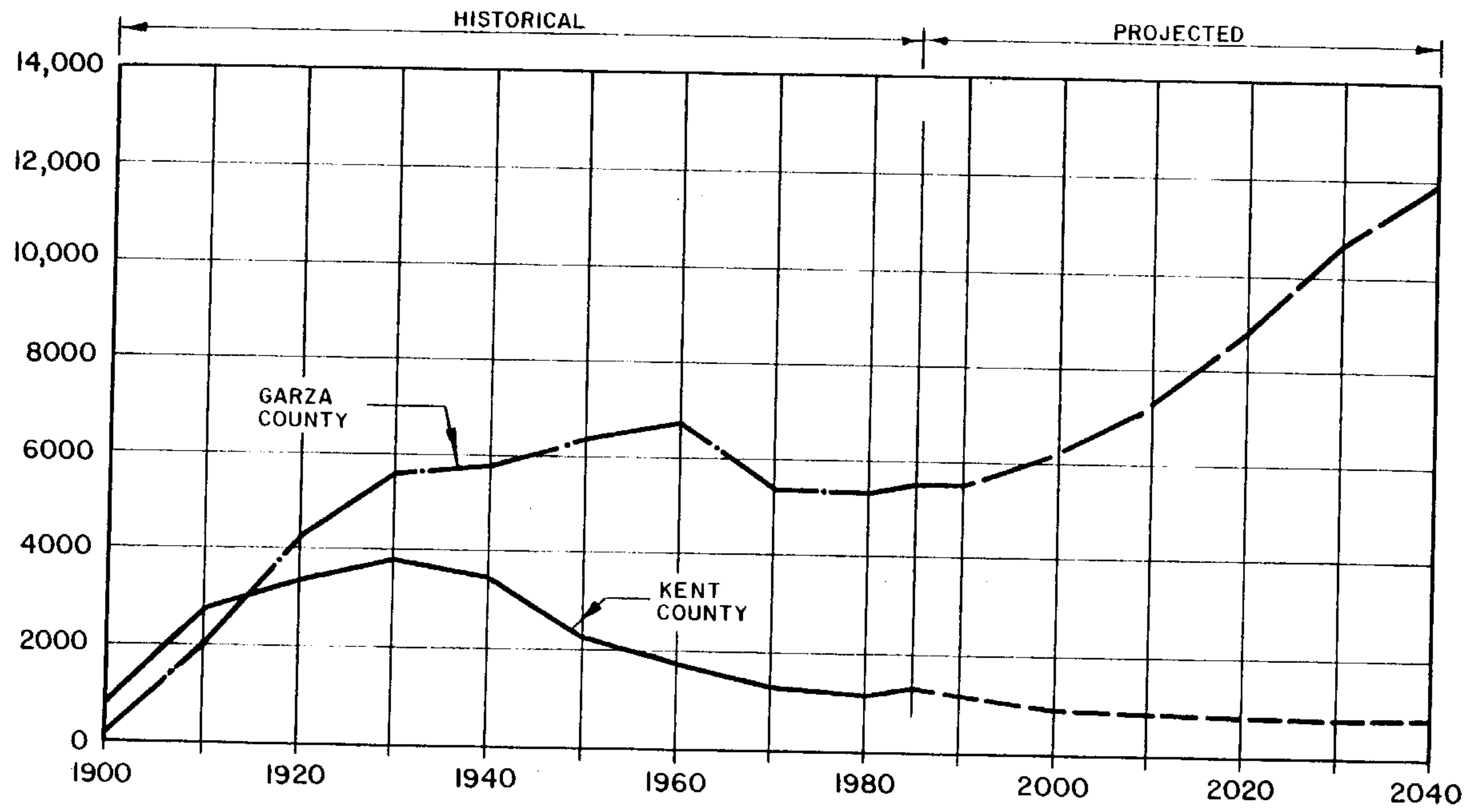
The location of a reservoir does not create additional population, but can serve as a stimulus for the relocation of population who might have chosen to live elsewhere without the reservoir in place. Garza County has already experienced an increase in the development of rural weekend homes for people wanting an escape from the city life of Lubbock (pers. com., Jean Westfall, Garza County Appraisal District Office). Except for a resurgence in the oil industry, there appear to be no other economic factors which would cause migration to Garza and Kent Counties. As a result, it may be reasonable to expect total county populations with the project to fall between the High and Low Series. It is also expected that the central city in each county (i.e., Post and Jayton) will continue to capture its share of increased population growth in the same proportion as their current population share.

4.6.2 Future Economy

The Garza and Kent County economy has been affected by the decline in oil prices in the mid-1980s; however, the economic outlook reportedly is positive. Economic growth in the area is tied to the oil and agricultural industries and is likely to remain so for the foreseeable future. Therefore, future economic growth without Justiceburg Reservoir will be dependent on the future price of oil and agricultural products, unless a more diversified economic base is developed.

Construction and operation of a lake such as Justiceberg Reservoir

POPULATION TRENDS, GARZA AND KENT COUNTIES, 1900-2040



SOURCE : BUREAU OF CENSUS, 1902-1983; TEXAS WATER DEVELOPMENT BOARD, 1988

FIGURE 4.5

will have a beneficial impact on the two counties in which it is located. Since approximately 85 percent of the lake will be located in Garza County, it will receive proportionately greater benefits from the project. Initial construction of the dam will bring contractors to the area. These persons will patronize local commercial, retail and service establishments and, during construction, some individuals may temporarily relocate to the site or to nearby communities such as Post. In addition, the project will create an estimated 75 to 100 jobs for local construction workers. It is impossible at this point in time to determine the total construction payroll, but construction costs are estimated to be approximately $35 million. Although a portion of the payroll will undoubtedly leave the two counties, it is clear that a substantial portion will remain in the local economy where it will circulate among many service and support businesses.

A completed lake such as the proposed Justiceburg Reservoir has the potential to create numerous service related jobs in the area. Additional employment will be associated with the direct operation of the dam, lake patrols, grocery, bait and tackle shops.

In general the topography surrounding Justiceburg Reservoir is not ideal for residential development. Steep drop-offs around the deeper portions of the lake will make lake access difficult and in some areas dangerous. Additionally, the small number of adjacent landowners and their desires to limit public access may stall development until a change in current ownership. For these reasons, major lakeside development is not anticipated in the immediate future.

It is likely that some residential areas and private marinas will be developed once the lake begins to attract a significant number of visitors to the public recreation site. The demand for additional access and facilities will likely be an economic incentive for the sale of lakeside property. Potential employment opportunities which could be created as a result of residential growth at Justiceburg Reservoir include construction, craftsmen, retail, motel employment, marinas, police and fire. These additional jobs would not be possible without a lake to attract business to the area.

The inundation of the lake will remove approximately 2,304 acres of rangeland from the two counties. This acreage represents approximately 0.25 percent of the total rangeland within the two counties. Local ranchers who currently graze these areas will either have to reduce their stock, or lease or purchase additional rangeland acreage. Although the average stocking rate for Garza County is 32 acres per animal unit, in the rugged Justiceburg site stocking rates are considerably lower at 64 acres per animal unit (pers. com., Victor Ashley, ASCS, Garza County). Based on the lower rate, the loss of rangeland would reduce stock by approximately 36 animal units. The displaced stock would require approximately the same amount of similar quality rangeland or 1,152 acres of nonrugged range (better quality). At an average lease cost of $4 per acre (pers. com., Victor Ashley, ASCS, Garza Co.), replacement would cost local ranchers an estimated $4,608.00 annually for the nonrugged land.

The reservoir will also eliminate future oil exploration and production from within the reservoir pool; however, all oil under the lake is considered retrievable since the lake is so narrow. Production in the two counties has been declining in recent years and it may be possible that much of the oil and gas resources of the area already have been extracted. While it must be recognized that the construction of a lake might cause some currently producing wells to be capped, profitable wells located in the shallow portions of the reservoir could be raised and production continued. Oil under the lake could be retreived through directional drilling. Because of the variations in the price of oil and production costs, it is uncertain at this time as to which wells are likely to be retained using platforms or levees. Since all oil under the lake is considered retrievable, construction of the reservoir will result in an insignificant loss of oil and gas income.

In summary, construction of the lake will create new job opportunities in the area, both during and after construction. Lake associated businesses will be located in the area, as well as employment in new business and tourism. On the other hand, removal of rangeland from production will reduce agricultural cash receipts if ranchers reduce their stock. If ranchers maintain their current stock, they may lease or purchase replacement rangeland.

4.6.3 Future Land Use

Without any new economic incentive, there is little reason to expect land uses to change significantly within the project limits or one-mile adjacent area. The projected populations are relatively low and it is expected that most of these people will reside in Post or Jayton.

Construction of Justiceburg Reservoir will have significant direct effects on land uses within the project limits. Within the conservation pool (elevation 2,220 ft msl), all 2,884 acres will be converted from their present use to aquatic and aquatic-related uses. Seventy-five percent of the time the reservoir will be at or below elevation 2,212 ft msl, leaving approximately 375 acres exposed. This land will be in the form of beaches, shoreline, and other altered use.

The City of Lubbock will have a restrictive flood easement on lands between elevations 2,220 and 2,245 ft msl. Adjacent landowners will be allowed access to the perimeter and reservoir areas and the restrictions will not change the present use of the 5,600 acres of perimeter land. The City of Lubbock will allow each landowner to construct two boat ramps on their perimeter land, but will restrict construction of boat docks, structures, and other uses. The perimeter lands will not be fenced and grazing by livestock on this property will be allowed. In addition, the City of Lubbock has purchased a 550-acre tract to be managed by the State, local government, private concession or the City itself. The tract, located on the north shore of the lake (see Figure 3.1), will have picnic facilities, camp sites and a boat ramp. Final plans for the recreation area have not been made by the City.

Potential changes in land use above elevation 2,245 ft msl are beyond the control and jurisdiction of the City of Lubbock. No other governmental body has control over the use of land within the one-mile area. Recent state legislation enables counties to zone land adjacent to future lakes for a distance of 5,000 feet from the shoreline. This requires approval by the voters of the county. If local county officials decide to enact a zoning ordinance within the limits prescribed by state law, it is presumed that a land use plan would be prepared at that time. Garza County officials have indicated that they do intend to pursue some type of zoning regulation around the lake.

Probable future development around Justiceburg Reservoir will occur primarily on the north shoreline, since the majority of existing access to the area is from the north, and there is a larger population from which to draw. At some point in the future, residential areas will likely develop around Justiceburg Reservoir as they have around other regional lakes. Limited residential development probably will be "nestled" in areas along the shoreline with waterfront lots, and on higher ground to take advantage of views and vistas. Though it is possible for residential development to be scattered along the shoreline at nearly any point, development will probably occur in lakeside subdivisions, similar to those found at White River Lake. These subdivisions will be limited to areas which have reasonable access and acceptable topography.

4.6.4 Future Effect on Local Government

Revenues. Construction of Justiceburg Reservoir will convert approximately 3,929 acres in Garza County and 1,612 acres in Kent County from private to public ownership, thereby removing it from the local tax base. This acreage includes the reservoir, recreation area, and all uneconomic remainders that the City of Lubbock will be required to purchase. Almost all of this land is rangeland. The average assessed value of these lands is $100 per acre. Table 4.5 presents the distribution of land within each county by category and average assessed value. Both counties provide agricultural exemptions to landowners, based on the productivity value of the land. These exemptions average approximately 70 percent of the market value for rangeland. The corresponding assessments with the exemptions are also shown in Table 4.5.

Because the project lies outside of the corporate limits of any municipality, the only local taxing entities are the County, the Post school district, and the Post hospital. The assessed value of land (including exemptions) to be acquired for the Justiceburg Reservoir in Garza County is $81,246. This is approximately two-hundredths of one percent of the $480,042,292 total assessed value for the county. The estimated assessed value of lands to be acquired in Kent County is $61,256, which is less that one-hundredth of one percent of the $628,258,898 total assessed value of the county.

The current tax rate in Garza County is 17.5 cents per $100 valuation. Thus, the direct loss of tax revenues to Garza County would be $142 annually. The current tax rate in Kent County is 20.9 cents per $100 valuation, resulting in a direct loss of $128 annually.

Table 4.5

Estimated Assessed Tax Value of Rangelands within Justiceburg Reservoir (elevation 2220 ft msl)

	Acres	Assessed Market Value ($/acre)	Total Assessed Market Value	Average Assessed Value with Agricultural Exemptions ($/acre)	Total Assessed Value with Agricultural Exemptions
Garza County[1]					
Native Pasture	2,621 (2/3)	100	262,100	30	78,630
Minimum Use Areas (gullies, sandbars, etc.)	1,308 (1/3)	50	130,800	2	2,616
Total	3,929		$392,900	20	$81,246
Kent County[2]					
Loamy Bottomland	1,612	100	161,200	38	61,256
Total	1,612		$161,200	38	$61,256

1 Pers. com., Jean Westfall, Garza County Tax Appraisal District Office
2 Pers. com., Betty Prince, Kent County Tax Appraisal District Office

The project lies within the jurisdiction of the Post Independent School District which also assesses ad valorem taxes in both counties. The project would remove lands assessed at $81,246 (including agricultural exemptions) from this district (none of the Kent County land occurs within the district), which is less that two-hundredths of one percent of the total assessed value of the district. At a tax rate of 75 cents per $100 evaluation, the direct tax revenue loss would be $609 annually. Post Hospital District also assesses ad valorem taxes in Garza County. At a rate of 10.5 cents per $100 valuation, the project would result in a direct tax revenue loss of $85 from the hospital's annual income. The total loss in tax revenues from the project is listed in Table 4.6.

Although acquisition of land for the reservoir will have a direct negative value on taxing entities, the presence of the reservoir is expected to have long-term beneficial effects on the assessed value of adjacent lands. Of course, the induced residential growth is expected to be delayed or to occur gradually while the land acquisition results in a direct reduction in tax revenues. However, it is likely that a sufficient number of residences will be constructed in the years following completion of the dam to generate a sufficient increase in ad valorem taxes to offset the direct loss resulting from the project. Garza County currently taxes rural weekend homes at a rate comparable to that for residences within the City of Post (pers. com., Jean Westfall, Garza County Appraisal District Office). Although local government will

Table 4.6

Net Annual Loss in Tax Revenues
Resulting from Justiceburg Reservoir

	Direct Loss
Garza County	$142
Kent County	128
Post Independent School District	609
Post Hospital District	85
Total	$964

be operating with slightly less revenue in the years between land acquisition and project completion, these losses are likely to be more than offset by the increased revenues in following years.

In addition to the effects on ad valorem taxes, it is expected that the project will increase sales tax receipts by generating additional annual business for the two-county area. Local governments can currently charge up to one percent on most retail sales. It is expected that most of the sales will occur in Post and Jayton. Additional revenues may result from various user fees and permits (such as park entry fees), which cannot be determined at this time.

Services. Concurrent with the increase in population, sales, and ad valorem tax revenues, local governments will need to provide additional services to meet the needs of the increased population and activity in the vicinity of the lake. County governments will be expected to maintain existing and new county roads in the vicinity of the new reservoir which may receive greater use and wear once the reservoir is built (the City of Lubbock will maintain access roads to the dam and public recreation area). Since the reservoir is outside of any municipality, the County Sheriff will be the principal law enforcement for the area immediately surrounding the reservoir. Finally, the local municipalities of Post and Jayton may need to provide additional services to visitors and residences as a result of Justiceburg Reservoir. It is expected that increased tax revenues will be adequate to cover the additional services required.

4.6.5 Future Recreation Opportunities

Lakes are a major source of recreational opportunity in Texas. Lakes such as White River Lake and Lake Meredith are regional attractions (TWDB, 1985) and provide opportunities for camping, fishing, boating, and water skiing. In 1986, lakes operated by the U.S. Army Corps of Engineers attracted an average of 2.3 million visitors each (Kingston, 1987).

Justiceburg Reservoir will be able to provide many recreational opportunities within the South Plains and West Central Texas regions and will fulfill many of the recreational needs identified in the 1985 Texas Outdoor Recreation Plan (TPWD, 1985). Simply using the standard conversion factor for freshwater surface acres used by the Texas Parks and Wildlife Department (TPWD, 1985) would indicate the potential for 779,000 annual opportunity days for Justiceburg Reservoir. Many other recreational opportunities will be available through public and private facilities, such as boat ramps, camp grounds, picnic tables, fishing piers, and hiking trails. Justiceburg Reservoir will serve an area much larger than Garza and Kent Counties. It is anticipated that the lake will attract people from as far away as Lubbock, Big Spring and Snyder.

Recreational development at Justiceburg Reservoir may be limited because of the relative inaccessibility of some portions of the lake (due to the rugged topography and private land ownership), though this does not preclude the existence of privately developed recreational facilities. Detailed plans for the design and management of the public recreation area (see Figure 1.1) have not yet been developed by the City of Lubbock.

4.7 Cultural Resources

Cultural resources in the project area will be subjected to adverse effects from the construction, filling and operation of Justiceburg Reservoir. Sites identified in the cultural resources investigation have been classified into two main impact zones, termed primary and secondary impact (Boyd et al., 1989). These two zones reflect the kinds of foreseeable effects on the known sites. The primary impact zone includes the conservation pool, the construction areas and the public access areas. The secondary impact zone includes the restrictive flood easement and sites that may be subjected to erosion, wave action, vandalism or other effects after the reservoir is constructed.

Federal law requires that the effects of Justiceburg Reservoir be taken into account by the head of the reviewing federal agency. In this case, the Fort Worth District Corps of Engineers has drafted a Programmatic Agreement which will be ratified by the Advisory Council on Historic Preservation, the Texas State Historic Preservation Officer, the Fort Worth Corps of Engineers District Engineer, and the City of Lubbock. This document defines the steps to be taken to mitigate the adverse effects on significant historic properties. Mitigation may consist of archeological excavation, preservation in place, monitoring of specific sites over time, recordation of standing structures to the Secretary of Interior's Standards and Guidelines (National Park Service, 1983), and reanalysis of artifact collections that were made in the 1960s and 1970s by local archeologists and individuals. All mitigation activities will be fully documented in a final report of findings to be made available to the local landowners, libraries, interested citizens, and professional archeological and historical communities.

Mitigation has not yet been defined because conclusive statements about eligibility to the National Register of Historic Places have not yet been made. The archeological contractor (Prewitt and Associates, Inc.) is currently conducting analysis of testing data to determine eligibility, and will provide a research design which justifies the significance of selected sites according to regional data needs. This research design will identify those sites which may fill data gaps. Mitigation activities will consist of collection of significant data from sites which will be adversely affected by the project.

In addition to mitigation through data recovery, the project will include an operations management plan that will identify sites that are eligible for inclusion in the National Register of Historic Places that should be monitored over the life of the reservoir. These may include archeological sites within the flood easement area on private land for which access could not be obtained, or for which some measure of mitigation has occurred but significant elements of the site remain in place. Since shoreline erosion may expose new sites, the management plan will also include procedures to investigate newly identified sites within the reservoir after construction.

5. SUMMARY OF FINDINGS

Increasing population growth and decreasing water supplies have required the City of Lubbock to pursue the development of new sources of water supply. The City has considered a wide range of alternatives, including the development of new reservoir sites, increased utilization of groundwater, desalting of mineralized water, long-range importation from East Texas, reclamation of municipal wastewater and conservation.

Using only conservation measures and existing supplies clearly was not adequate to meet all future needs. Lubbock already has facilites for reclaiming its municipal wastewater for secondary applications. Recycling for drinking water is not considered a feasible alternative. Importation of water into the High Plains region via the Trans-Texas Canal system is infeasible at this time since no surplus water exists within Texas and no source outside the state has been identified. Desalting would be much more costly than the construction of a nearby reservoir and undesirable environmentally and economically due to the brackish wastewater disposal problem created. Due to intensive agricultural use of groundwater resources in the High Plains region, there are very few economically developable groundwater reserves available to the City of Lubbock. Groundwater in the Ogallala Aquifer is being pumped at rates faster than natural recharge is occurring. The aquifer is basically a nonrenewable resource that would become depleted, leaving Lubbock in the position of having to replace a water supply as well as possibly needing to develop additional sources for future population increases.

Investigation of new reservoir sites in the Canadian, Red, Brazos and Colorado River basins resulted in very few viable options. Due to the lack of appropriate sites and to the prevalence of gypsum in the region, many sites had both limited yield and poor water quality. Of the potential sites investigated, the Middle Pease, Aspermont, Munday, Rotan, and Flat Top sites were considered infeasible due to unsatisfactory water quality. Of the remaining five sites (North Pease, South Pease, Post, Justiceburg, and Reynolds Bend), Justiceburg Reservoir optimizes the characteristics of firm yield and distance to Lubbock. The Reynolds Bend site would produce a greater yield but would be more costly in terms of capital and operating expenses because of its larger size and pumping distance. Post Reservoir would be about 12 miles closer to Lubbock, but it would provide only about 40 percent of the firm yield of the Justiceburg site. The City selected Justiceburg Reservoir as the preferred alternative because it provided the best balance of acceptable water quality, sufficient yield, pumping distance, and low cost water.

In order to meet future water demand the City proposes to construct the Justiceburg dam and reservoir on the Double Mountain Fork Brazos River in Garza and Kent Counties. The reservoir conservation pool will have an estimated initial capacity of 115,937 acre-feet and an estimated average yield of 30,200 acre-feet per year. Based on the results of studies using data from a USGS water quality monitoring program, it is expected that water in Justiceburg Reservoir will be of better quality than Lake Meredith, the City's current primary supply source.

The proposed project would inundate 2,884 acres of land at the top of the conservation pool. Unavoidable project impacts include a loss of 2,884 acres of wildlife habitat; a decrease in flood flows below the dam; a loss of 10 existing oil wells in the reservoir pool area; a loss of undeveloped sand, gravel, and uranium resources; a loss of 84 acres of prime farmland soils; a loss of active ranchland; a loss of county, school and hospital tax base; a loss of tax revenue from oil wells; and a loss of in-place cultural resources. No residential displacements are required by the project. A mitigation proposal, involving purchase of a 3,038-acre tract in Kent County has been submitted to the U.S. Army Corps of Engineers to compensate for fish and wildlife impacts. A program of cultural resources investigations has already been implemented as part of the cultural resources mitigation.

In addition to providing a reliable water supply for the City of Lubbock, the reservoir project will have a positive impact on Garza and Kent Counties, due primarily to the recreational potential of the lake. In addition to providing freshwater contact recreational opportunities, the City's proposed development of a 550-acre recreation area will provide camping, picnicking and boating facilities for the South Plains region. It is anticipated that the lake will draw tourism and weekend residents to the area, increasing local sales, demand for local services, and ultimately, increasing the local tax base through the development of weekend homes. The reservoir project will increase employment through local construction payrolls.

Upon approval of the U.S. Army Corps of Engineers Section 404 Permit, it is estimated that the project will require about two years to construct and three years to fill, under average flow conditions. Capital cost, including construction, engineering, testing, land acquisition and mitigation, is estimated at $46.7 million.

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APPENDIX A

Monthly Simulated Reservoir Operation

JUSTICEBURG RESERVOIR TDS - INITIAL CONDITIONS - TRS
JANUARY 12, 1988 LUB85052

*** THE DEMAND VARIES WITH THE RESERVOIR CONTENT. ***

THERE ARE 1 OPERATION STUDIES IN THIS RUN.

RUN #	MAXIMUM CAPACITY	START. CONTENT	1ST DEMAND	1ST CONTROL	2ND DEMAND	2ND CONTROL	3RD DEMAND	3RD CONTROL	4TH DEMAND	4TH CONTROL
1	115937.	115937.	35000.	60000.	25000.	30000.	20000.	0.	0.	0.

THE DEMAND PATTERN (IN PERCENT OF ANNUAL) IS:

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
8.49	7.66	8.49	8.22	8.49	8.22	8.49	8.52	8.22	8.49	8.22	8.49

THE DOWNSTREAM RELEASE IS NOT AFFECTED BY INFLOW.

THE DOWNSTREAM RELEASE IS CONSTANT. MONTHLY RELEASES ARE GIVEN BELOW (IN ACRE-FEET):

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

JUSTICEBURG RESERVOIR TDS - INITIAL CONDITIONS - TRS
JANUARY 12, 1988 LUB85052

MAXIMUM CAPACITY = 115937. ACRE-FEET.
STARTING CONTENT = 115937. ACRE-FEET.
DEMAND VS. CONTENT =
/ 35000./ 60000./ 25000./ 30000./ 20000./ 0./ 0./ 0./

DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	-------END OF MONTH------- CONTENT *AC-FT*	ELEV. *FT*	QUALITY *MG/L*
1940										
1	257.	2972.	20.	5672.	0.	0.	0.	112728.	2218.3	803.
2	112.	2681.	190.	1489.	0.	0.	0.	110125.	2217.9	805.
3	1266.	2972.	0.	0.	0.	0.	0.	105887.	2216.4	814.
4	995.	2877.	570.	1066.	0.	0.	0.	102585.	2215.2	823.
5	1482.	2972.	2650.	797.	0.	0.	0.	100781.	2214.5	834.
6	1269.	2877.	5570.	693.	0.	0.	0.	102205.	2215.0	837.
7	2686.	2972.	100.	2263.	0.	0.	0.	96647.	2212.8	861.
8	1541.	2982.	15780.	569.	0.	0.	0.	107904.	2217.1	831.
9	2131.	2877.	6280.	677.	0.	0.	0.	109126.	2217.5	839.
10	1067.	2972.	0.	0.	0.	0.	0.	105087.	2216.1	847.
11	108.	2877.	2910.	783.	0.	0.	0.	105012.	2216.1	846.
12	428.	2969.	130.	1907.	0.	0.	0.	101745.	2214.9	851.
	13392.	35000.	34200.		0.	0.	0.			
1941										
1	314.	2972.	0.	0.	0.	0.	0.	98459.	2213.6	854.
2	232.	2681.	870.	984.	0.	0.	0.	96416.	2212.8	857.
3	52.	2972.	5530.	694.	0.	0.	0.	98922.	2213.7	849.
4	496.	2877.	30830.	501.	0.	0.	10444.	115937.	2220.0	771.
5	-1384.	2972.	68820.	431.	0.	0.	67232.	115937.	2220.0	640.
6	1009.	2877.	21700.	536.	0.	0.	17814.	115937.	2220.0	630.
7	1442.	2972.	11210.	607.	0.	0.	6796.	115937.	2220.0	636.
8	1817.	2982.	5670.	690.	0.	0.	871.	115937.	2220.0	648.
9	519.	2877.	10730.	612.	0.	0.	7334.	115937.	2220.0	648.
10	-808.	2972.	54660.	450.	0.	0.	52496.	115937.	2220.0	584.
11	747.	2877.	2500.	806.	0.	0.	0.	114813.	2219.6	593.
12	398.	2969.	890.	980.	0.	0.	0.	112336.	2218.7	598.
	4832.	35000.	213410.		0.	0.	162987.			
1942										
1	504.	2972.	250.	1245.	0.	0.	0.	109110.	2217.5	602.
2	686.	2681.	40.	4113.	0.	0.	0.	105783.	2216.3	607.
3	1019.	2972.	10.	5938.	0.	0.	0.	101802.	2214.9	614.
4	212.	2877.	3250.	767.	0.	0.	0.	101963.	2214.9	620.
5	1702.	2972.	760.	1009.	0.	0.	0.	98049.	2213.4	634.
6	1290.	2877.	3530.	755.	0.	0.	0.	97412.	2213.2	646.
7	1575.	2972.	650.	1040.	0.	0.	0.	93515.	2211.6	660.
8	1343.	2982.	7360.	657.	0.	0.	0.	96550.	2212.8	668.
9	-78.	2877.	9400.	627.	0.	0.	0.	103151.	2215.4	664.
10	331.	2972.	13950.	582.	0.	0.	0.	113798.	2219.2	656.
11	960.	2877.	730.	1017.	0.	0.	0.	110691.	2218.1	664.
12	-362.	2969.	1430.	896.	0.	0.	0.	109514.	2217.7	665.
	9182.	35000.	41360.		0.	0.	0.			

JUSTICEBURG RESERVOIR TDS - INITIAL CONDITIONS - TRS
JANUARY 12, 1988 LUB85052

DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	END OF MONTH CONTENT *AC-FT*	END OF MONTH ELEV. *FT*	END OF MONTH QUALITY *MG/L*
1943										
1	578.	2972.	700.	1025.	0.	0.	0.	106664.	2216.6	671.
2	945.	2681.	40.	4113.	0.	0.	0.	103078.	2215.4	678.
3	925.	2972.	620.	1049.	0.	0.	0.	99801.	2214.1	687.
4	1345.	2877.	970.	964.	0.	0.	0.	96549.	2212.8	699.
5	689.	2972.	3000.	779.	0.	0.	0.	95888.	2212.6	706.
6	1426.	2877.	4190.	731.	0.	0.	0.	95775.	2212.5	718.
7	1293.	2972.	3050.	776.	0.	0.	0.	94560.	2212.0	729.
8	2773.	2982.	0.	0.	0.	0.	0.	88805.	2209.7	752.
9	1409.	2877.	0.	0.	0.	0.	0.	84519.	2207.9	764.
10	1227.	2972.	0.	0.	0.	0.	0.	80320.	2206.1	775.
11	696.	2877.	0.	0.	0.	0.	0.	76747.	2204.5	782.
12	-22.	2969.	0.	0.	0.	0.	0.	73800.	2203.2	782.
	13284.	35000.	12570.		0.	0.	0.			
1944										
1	64.	2972.	0.	0.	0.	0.	0.	70764.	2201.7	783.
2	104.	2681.	20.	5672.	0.	0.	0.	67999.	2200.4	785.
3	588.	2972.	0.	0.	0.	0.	0.	64439.	2198.7	792.
4	939.	2877.	60.	3158.	0.	0.	0.	60683.	2196.7	806.
5	786.	2972.	3510.	756.	0.	0.	0.	60435.	2196.6	814.
6	1282.	2877.	990.	960.	0.	0.	0.	57265.	2195.0	834.
7	849.	2123.	6250.	678.	0.	0.	0.	60544.	2196.7	830.
8	1242.	2982.	540.	1077.	0.	0.	0.	56860.	2194.7	850.
9	601.	2055.	220.	1353.	0.	0.	0.	54424.	2193.4	861.
10	569.	2123.	590.	1059.	0.	0.	0.	52322.	2192.2	872.
11	226.	2055.	300.	1203.	0.	0.	0.	50341.	2191.0	878.
12	17.	2120.	920.	974.	0.	0.	0.	49124.	2190.4	880.
	7267.	30809.	13400.		0.	0.	0.			
1945										
1	184.	2123.	60.	3158.	0.	0.	0.	46877.	2188.9	886.
2	211.	1915.	20.	5672.	0.	0.	0.	44771.	2187.5	892.
3	534.	2123.	570.	1066.	0.	0.	0.	42684.	2186.2	905.
4	592.	2055.	170.	1601.	0.	0.	0.	40207.	2184.5	921.
5	932.	2123.	230.	1315.	0.	0.	0.	37382.	2182.6	946.
6	1116.	2055.	3910.	741.	0.	0.	0.	38121.	2183.1	952.
7	759.	2123.	12140.	598.	0.	0.	0.	47379.	2189.3	878.
8	859.	2130.	0.	0.	0.	0.	0.	44390.	2187.3	895.
9	961.	2055.	2020.	839.	0.	0.	0.	43394.	2186.6	912.
10	216.	2123.	10990.	609.	0.	0.	0.	52045.	2192.0	853.
11	553.	2055.	60.	3158.	0.	0.	0.	49497.	2190.6	865.
12	319.	2120.	0.	0.	0.	0.	0.	47058.	2189.1	871.
	7236.	25000.	30170.		0.	0.	0.			

JUSTICEBURG RESERVOIR TDS - INITIAL CONDITIONS - TRS
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DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	END OF MONTH CONTENT *AC-FT*	END OF MONTH ELEV. *FT*	END OF MONTH QUALITY *MG/L*
1946										
1	130.	2123.	0.	0.	0.	0.	0.	44805.	2187.6	873.
2	439.	1915.	0.	0.	0.	0.	0.	42451.	2186.0	882.
3	589.	2123.	0.	0.	0.	0.	0.	39739.	2184.2	895.
4	838.	2055.	10.	5938.	0.	0.	0.	36856.	2182.3	916.
5	723.	2123.	1100.	941.	0.	0.	0.	35110.	2181.1	935.
6	942.	2055.	2680.	795.	0.	0.	0.	34793.	2180.9	949.
7	1194.	2123.	330.	1182.	0.	0.	0.	31806.	2178.6	986.
8	952.	2130.	4180.	731.	0.	0.	0.	32904.	2179.6	982.
9	444.	2055.	4840.	711.	0.	0.	0.	35245.	2181.2	958.
10	196.	2123.	13740.	584.	0.	0.	0.	46666.	2188.8	854.
11	420.	2055.	320.	1189.	0.	0.	0.	44511.	2187.4	864.
12	223.	2120.	2470.	808.	0.	0.	0.	44638.	2187.4	866.
	7090.	25000.	29670.		0.	0.	0.			
1947										
1	78.	2123.	240.	1279.	0.	0.	0.	42677.	2186.1	869.
2	350.	1915.	0.	0.	0.	0.	0.	40412.	2184.6	877.
3	205.	2123.	10.	5938.	0.	0.	0.	38094.	2183.1	882.
4	507.	2055.	0.	0.	0.	0.	0.	35532.	2181.4	895.
5	168.	2123.	47310.	462.	0.	0.	0.	80551.	2206.2	646.
6	1519.	2877.	2700.	794.	0.	0.	0.	78855.	2205.5	663.
7	1753.	2972.	1060.	948.	0.	0.	0.	75190.	2203.8	682.
8	1803.	2982.	100.	2263.	0.	0.	0.	70505.	2201.6	701.
9	2236.	2977.	1130.	936.	0.	0.	0.	66522.	2199.7	728.
10	1199.	2972.	540.	1077.	0.	0.	0.	62891.	2197.9	745.
11	425.	2877.	30.	4962.	0.	0.	0.	59619.	2196.2	752.
12	228.	2120.	2350.	815.	0.	0.	0.	59621.	2196.2	757.
	10471.	30016.	55470.		0.	0.	0.			
1948										
1	244.	2123.	10.	5938.	0.	0.	0.	57264.	2195.0	761.
2	206.	1915.	4380.	725.	0.	0.	0.	59523.	2196.1	761.
3	768.	2123.	290.	1211.	0.	0.	0.	56922.	2194.3	774.
4	1036.	2055.	0.	0.	0.	0.	0.	53831.	2193.0	788.
5	798.	2123.	1560.	881.	0.	0.	0.	52470.	2192.3	803.
6	1061.	2055.	10120.	619.	0.	0.	0.	59474.	2196.1	786.
7	1429.	2123.	15350.	572.	0.	0.	0.	71272.	2202.0	756.
8	1699.	2982.	2300.	819.	0.	0.	0.	68891.	2200.9	776.
9	1407.	2877.	30.	4962.	0.	0.	0.	64637.	2198.8	795.
10	792.	2972.	2040.	838.	0.	0.	0.	62913.	2197.9	806.
11	807.	2877.	4220.	730.	0.	0.	0.	63449.	2198.1	811.
12	640.	2969.	10.	5938.	0.	0.	0.	59850.	2196.3	820.
	10887.	29194.	40310.		0.	0.	0.			

DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	-------END OF MONTH------- CONTENT *AC-FT*	ELEV. *FT*	QUALITY *MG/L*
1949										
1	-226.	2123.	0.	0.	0.	0.	0.	57953.	2195.3	817.
2	314.	1915.	0.	0.	0.	0.	0.	55724.	2194.1	822.
3	539.	2123.	0.	0.	0.	0.	0.	53062.	2192.6	830.
4	422.	2055.	1290.	913.	0.	0.	0.	51875.	2191.9	838.
5	36.	2123.	9420.	627.	0.	0.	0.	59136.	2195.9	806.
6	655.	2055.	12340.	596.	0.	0.	0.	68766.	2200.8	776.
7	1122.	2972.	120.	2010.	0.	0.	0.	64792.	2198.8	792.
8	1295.	2982.	270.	1227.	0.	0.	0.	60785.	2196.8	810.
9	677.	2877.	10450.	615.	0.	0.	0.	67681.	2200.3	788.
10	448.	2972.	1220.	923.	0.	0.	0.	65481.	2199.2	796.
11	930.	2877.	140.	1817.	0.	0.	0.	61814.	2197.3	810.
12	439.	2969.	10.	5938.	0.	0.	0.	58416.	2195.6	817.
	6651.	30043.	35260.		0.	0.	0.			
1950										
1	500.	2123.	10.	5938.	0.	0.	0.	55803.	2194.1	825.
2	433.	1915.	130.	1907.	0.	0.	0.	53585.	2192.9	834.
3	772.	2123.	0.	0.	0.	0.	0.	50690.	2191.2	847.
4	659.	2055.	3650.	750.	0.	0.	0.	51626.	2191.8	850.
5	287.	2123.	19950.	544.	0.	0.	0.	69166.	2201.0	767.
6	888.	2877.	1790.	858.	0.	0.	0.	67191.	2200.1	779.
7	269.	2972.	5370.	698.	0.	0.	0.	69320.	2201.1	776.
8	1235.	2982.	1260.	917.	0.	0.	0.	66363.	2199.6	793.
9	392.	2877.	19770.	545.	0.	0.	0.	82864.	2207.2	738.
10	1577.	2972.	360.	1162.	0.	0.	0.	78675.	2205.4	755.
11	1173.	2877.	10.	5938.	0.	0.	0.	74635.	2203.5	767.
12	708.	2969.	10.	5938.	0.	0.	0.	70968.	2201.8	775.
	8893.	30865.	52310.		0.	0.	0.			
1951										
1	479.	2972.	10.	5938.	0.	0.	0.	67527.	2200.2	781.
2	364.	2681.	0.	0.	0.	0.	0.	64482.	2198.7	786.
3	744.	2972.	0.	0.	0.	0.	0.	60766.	2196.8	795.
4	924.	2877.	20.	5672.	0.	0.	0.	56985.	2194.8	809.
5	702.	2123.	2800.	789.	0.	0.	0.	56960.	2194.8	818.
6	1203.	2055.	9650.	624.	0.	0.	0.	63352.	2198.1	804.
7	1472.	2972.	790.	1002.	0.	0.	0.	59698.	2196.2	826.
8	961.	2130.	5170.	703.	0.	0.	0.	61777.	2197.3	829.
9	1389.	2877.	210.	1395.	0.	0.	0.	57721.	2195.2	850.
10	917.	2123.	10.	5938.	0.	0.	0.	54691.	2193.5	865.
11	587.	2055.	0.	0.	0.	0.	0.	52049.	2192.0	875.
12	569.	2120.	0.	0.	0.	0.	0.	49360.	2190.5	884.
	10311.	29957.	18660.		0.	0.	0.			

JUSTICEBURG RESERVOIR TDS - INITIAL CONDITIONS - TRS
JANUARY 12, 1988 LUB85052

DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	END OF MONTH CONTENT *AC-FT*	END OF MONTH ELEV. *FT*	END OF MONTH QUALITY *MG/L*
1952										
1	335.	2123.	0.	0.	0.	0.	0.	46902.	2188.9	891.
2	566.	1915.	0.	0.	0.	0.	0.	44421.	2187.3	902.
3	323.	2123.	0.	0.	0.	0.	0.	41475.	2185.3	919.
4	387.	2055.	0.	0.	0.	0.	0.	39033.	2183.7	928.
5	639.	2123.	4940.	709.	0.	0.	0.	41211.	2185.2	916.
6	1444.	2055.	170.	1601.	0.	0.	0.	37882.	2183.0	953.
7	834.	2123.	2300.	319.	0.	0.	0.	37175.	2182.5	967.
8	1394.	2130.	340.	1175.	0.	0.	0.	33991.	2180.4	1008.
9	982.	2055.	170.	1601.	0.	0.	0.	31124.	2178.1	1042.
10	990.	2123.	0.	0.	0.	0.	0.	28011.	2175.4	1077.
11	494.	1644.	90.	2424.	0.	0.	0.	25963.	2173.7	1101.
12	271.	1698.	20.	5672.	0.	0.	0.	24014.	2172.1	1117.
	9209.	24167.	3030.		0.	0.	0.			
1953										
1	378.	1698.	0.	0.	0.	0.	0.	21938.	2170.3	1135.
2	278.	1532.	10.	5938.	0.	0.	0.	20138.	2168.4	1153.
3	350.	1698.	160.	1666.	0.	0.	0.	18250.	2166.3	1178.
4	514.	1644.	540.	1077.	0.	0.	0.	16632.	2164.6	1210.
5	563.	1698.	5140.	703.	0.	0.	0.	19511.	2167.7	1115.
6	971.	1644.	670.	1034.	0.	0.	0.	17566.	2165.6	1171.
7	770.	1698.	2810.	788.	0.	0.	0.	17908.	2166.0	1162.
8	648.	1704.	4540.	720.	0.	0.	0.	20096.	2168.4	1102.
9	809.	1644.	60.	3158.	0.	0.	0.	17703.	2165.7	1157.
10	180.	1698.	22670.	531.	0.	0.	0.	38495.	2183.4	802.
11	401.	2055.	1020.	955.	0.	0.	0.	37059.	2182.4	814.
12	430.	2120.	70.	2856.	0.	0.	0.	34579.	2180.8	828.
	6292.	20833.	37690.		0.	0.	0.			
1954										
1	425.	2123.	20.	5672.	0.	0.	0.	32051.	2179.8	841.
2	533.	1915.	10.	5938.	0.	0.	0.	29613.	2176.8	858.
3	642.	1698.	0.	0.	0.	0.	0.	27273.	2174.8	877.
4	443.	1644.	22990.	530.	0.	0.	0.	48176.	2189.8	722.
5	57.	2123.	25360.	520.	0.	0.	0.	71356.	2202.0	652.
6	1866.	2877.	2030.	838.	0.	0.	0.	68643.	2200.7	675.
7	2067.	2972.	0.	0.	0.	0.	0.	63604.	2198.2	696.
8	1508.	2982.	0.	0.	0.	0.	0.	59114.	2195.9	713.
9	1723.	2055.	0.	0.	0.	0.	0.	55336.	2193.9	735.
10	1053.	2123.	0.	0.	0.	0.	0.	52160.	2192.1	750.
11	812.	2055.	260.	1236.	0.	0.	0.	49553.	2190.6	764.
12	570.	2120.	0.	0.	0.	0.	0.	46863.	2188.9	773.
	11699.	26687.	50670.		0.	0.	0.			

JUSTICEBURG RESERVOIR TDS - INITIAL CONDITIONS - TRS
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DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	-------END OF MONTH------- CONTENT *AC-FT*	ELEV. *FT*	QUALITY *MG/L*
1955										
1	291.	2123.	10.	5938.	0.	0.	0.	44459.	2187.3	779.
2	332.	1915.	1620.	875.	0.	0.	0.	43832.	2186.9	789.
3	1019.	2123.	6970.	664.	0.	0.	0.	47660.	2189.5	787.
4	978.	2055.	160.	1666.	0.	0.	0.	44787.	2187.5	807.
5	591.	2123.	46440.	464.	0.	0.	0.	88513.	2209.6	635.
6	1276.	2877.	13480.	586.	0.	0.	0.	97840.	2213.3	636.
7	1531.	2972.	24380.	524.	0.	0.	1780.	115937.	2220.0	622.
8	2165.	2982.	910.	976.	0.	0.	0.	111700.	2218.5	636.
9	1168.	2877.	70500.	429.	0.	0.	62218.	115937.	2220.0	561.
10	952.	2972.	31510.	499.	0.	0.	27586.	115937.	2220.0	553.
11	1428.	2877.	940.	970.	0.	0.	0.	112572.	2218.8	563.
12	1314.	2969.	460.	1110.	0.	0.	0.	108749.	2217.4	572.
	13045.	30865.	197380.		0.	0.	91584.			
1956										
1	348.	2972.	280.	1219.	0.	0.	0.	105209.	2216.1	579.
2	696.	2681.	100.	2263.	0.	0.	0.	101932.	2214.9	584.
3	1567.	2972.	20.	5672.	0.	0.	0.	97413.	2213.2	594.
4	1799.	2877.	10.	5938.	0.	0.	0.	92747.	2211.3	606.
5	1300.	2972.	5010.	707.	0.	0.	0.	93485.	2211.6	620.
6	1554.	2877.	690.	1028.	0.	0.	0.	89714.	2210.1	634.
7	2233.	2972.	510.	1088.	0.	0.	0.	85019.	2208.1	653.
8	2457.	2982.	620.	1049.	0.	0.	0.	80200.	2206.1	675.
9	2275.	2877.	0.	0.	0.	0.	0.	75048.	2203.7	695.
10	1376.	2972.	320.	1189.	0.	0.	0.	71020.	2201.9	711.
11	729.	2877.	40.	4113.	0.	0.	0.	67454.	2200.2	720.
12	806.	2969.	20.	5672.	0.	0.	0.	63699.	2198.3	731.
	17670.	35000.	7620.		0.	0.	0.			
1957										
1	467.	2972.	0.	0.	0.	0.	0.	60260.	2196.5	736.
2	233.	2681.	5670.	690.	0.	0.	0.	63016.	2197.9	735.
3	772.	2972.	110.	2127.	0.	0.	0.	59382.	2196.1	747.
4	245.	2055.	17620.	557.	0.	0.	0.	74702.	2203.6	705.
5	-228.	2972.	43810.	469.	0.	0.	0.	115768.	2219.9	615.
6	1182.	2877.	32360.	497.	0.	0.	28132.	115937.	2220.0	598.
7	2241.	2972.	3920.	740.	0.	0.	0.	114644.	2219.5	614.
8	2464.	2982.	1770.	860.	0.	0.	0.	110968.	2218.2	631.
9	1755.	2877.	2810.	788.	0.	0.	0.	109146.	2217.5	645.
10	280.	2972.	6760.	668.	0.	0.	0.	112654.	2218.8	648.
11	142.	2877.	5490.	695.	0.	0.	0.	115125.	2219.7	651.
12	965.	2969.	150.	1737.	0.	0.	0.	111341.	2218.3	658.
	10518.	34178.	120470.		0.	0.	28132.			

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DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	-------END OF MONTH------- CONTENT *AC-FT*	ELEV. *FT*	QUALITY *MG/L*
1958										
1	83.	2972.	60.	3158.	0.	0.	0.	108346.	2217.3	660.
2	246.	2681.	80.	2618.	0.	0.	0.	105499.	2216.2	663.
3	-134.	2972.	210.	1395.	0.	0.	0.	102871.	2215.3	664.
4	319.	2877.	2560.	802.	0.	0.	0.	102235.	2215.0	669.
5	413.	2972.	15300.	572.	0.	0.	0.	114150.	2219.4	659.
6	1734.	2877.	3160.	771.	0.	0.	0.	112699.	2218.8	672.
7	1982.	2972.	270.	1227.	0.	0.	0.	108015.	2217.1	685.
8	2201.	2982.	1030.	953.	0.	0.	0.	103862.	2215.6	702.
9	1341.	2877.	4100.	734.	0.	0.	0.	103744.	2215.6	712.
10	743.	2972.	430.	1124.	0.	0.	0.	100459.	2214.4	719.
11	702.	2877.	530.	1080.	0.	0.	0.	97410.	2213.1	726.
12	534.	2969.	30.	4962.	0.	0.	0.	93937.	2211.8	732.
	10164.	35000.	27760.		0.	0.	0.			
1959										
1	423.	2972.	10.	5938.	0.	0.	0.	90552.	2210.4	736.
2	486.	2681.	0.	0.	0.	0.	0.	87385.	2209.1	740.
3	1135.	2972.	0.	0.	0.	0.	0.	83278.	2207.4	750.
4	690.	2877.	170.	1601.	0.	0.	0.	79881.	2205.9	758.
5	519.	2972.	2240.	823.	0.	0.	0.	78630.	2205.4	764.
6	-148.	2877.	28180.	510.	0.	0.	0.	104081.	2215.7	695.
7	919.	2972.	31380.	500.	0.	0.	15633.	115937.	2220.0	657.
8	2215.	2982.	4310.	727.	0.	0.	0.	115050.	2219.7	672.
9	2205.	2877.	0.	0.	0.	0.	0.	109968.	2217.8	685.
10	703.	2972.	6820.	667.	0.	0.	0.	113113.	2219.0	688.
11	1122.	2877.	260.	1236.	0.	0.	0.	109374.	2217.6	697.
12	777.	2969.	3760.	746.	0.	0.	0.	109388.	2217.6	703.
	11046.	35000.	77130.		0.	0.	15633.			
1960										
1	138.	2972.	380.	1151.	0.	0.	0.	106658.	2216.6	706.
2	244.	2681.	240.	1279.	0.	0.	0.	103973.	2215.7	709.
3	611.	2972.	70.	2856.	0.	0.	0.	100460.	2214.4	714.
4	1192.	2877.	0.	0.	0.	0.	0.	96391.	2212.7	723.
5	1165.	2972.	1310.	911.	0.	0.	0.	93564.	2211.6	734.
6	896.	2877.	1590.	878.	0.	0.	0.	91381.	2210.8	744.
7	27.	2972.	32380.	497.	0.	0.	4825.	115937.	2220.0	679.
8	2473.	2982.	460.	1110.	0.	0.	0.	110942.	2218.2	696.
9	1603.	2877.	20.	5672.	0.	0.	0.	106482.	2216.6	707.
10	0.	2972.	60090.	442.	0.	0.	47663.	115937.	2220.0	613.
11	1061.	2877.	1830.	855.	0.	0.	0.	113829.	2219.2	622.
12	85.	2969.	1020.	955.	0.	0.	0.	111795.	2218.5	626.
	9495.	35000.	99390.		0.	0.	52488.			

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DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	-------END OF MONTH------- CONTENT *AC-FT*	ELEV. *FT*	QUALITY *MG/L*
1961										
1	224.	2972.	1140.	935.	0.	0.	0.	109739.	2217.8	630.
2	28.	2681.	1200.	926.	0.	0.	0.	108230.	2217.2	634.
3	601.	2972.	810.	997.	0.	0.	0.	105467.	2216.2	640.
4	1365.	2877.	180.	1543.	0.	0.	0.	101405.	2214.7	650.
5	1069.	2972.	50.	3556.	0.	0.	0.	97414.	2213.2	659.
6	710.	2877.	26460.	516.	0.	0.	4350.	115937.	2220.0	632.
7	404.	2972.	31050.	501.	0.	0.	27674.	115937.	2220.0	609.
8	1460.	2982.	1780.	859.	0.	0.	0.	113275.	2219.0	621.
9	1824.	2877.	600.	1055.	0.	0.	0.	109174.	2217.6	633.
10	1423.	2972.	280.	1219.	0.	0.	0.	105059.	2216.1	643.
11	404.	2877.	2110.	832.	0.	0.	0.	103888.	2215.6	650.
12	425.	2969.	30.	4962.	0.	0.	0.	100524.	2214.4	654.
	9937.	35000.	65690.		0.	0.	32024.			
1962										
1	312.	2972.	20.	5672.	0.	0.	0.	97260.	2213.1	657.
2	737.	2681.	10.	5938.	0.	0.	0.	93852.	2211.7	662.
3	819.	2972.	0.	0.	0.	0.	0.	90061.	2210.3	668.
4	797.	2877.	10.	5938.	0.	0.	0.	86397.	2208.7	675.
5	1873.	2972.	0.	0.	0.	0.	0.	81552.	2206.6	690.
6	1272.	2877.	10680.	613.	0.	0.	0.	88023.	2209.4	691.
7	1036.	2972.	3490.	757.	0.	0.	0.	87565.	2209.2	701.
8	1455.	2982.	2210.	825.	0.	0.	0.	85338.	2208.3	716.
9	368.	2877.	35350.	439.	0.	0.	1506.	115937.	2220.0	651.
10	885.	2972.	480.	1101.	0.	0.	0.	112560.	2218.8	658.
11	727.	2877.	20.	5672.	0.	0.	0.	108976.	2217.5	663.
12	411.	2969.	340.	1175.	0.	0.	0.	105936.	2216.4	667.
	10692.	35000.	52610.		0.	0.	1506.			
1963										
1	484.	2972.	40.	4113.	0.	0.	0.	102520.	2215.1	672.
2	395.	2681.	20.	5672.	0.	0.	0.	99464.	2214.0	675.
3	927.	2972.	80.	2618.	0.	0.	0.	95645.	2212.5	683.
4	1229.	2877.	60.	3158.	0.	0.	0.	91599.	2210.9	694.
5	-26.	2972.	12740.	592.	0.	0.	0.	101393.	2214.7	681.
6	470.	2877.	39630.	478.	0.	0.	21739.	115937.	2220.0	628.
7	2075.	2972.	100.	2263.	0.	0.	0.	110990.	2218.2	641.
8	1688.	2982.	560.	1069.	0.	0.	0.	106880.	2216.7	654.
9	1380.	2877.	900.	978.	0.	0.	0.	103523.	2215.5	665.
10	1514.	2972.	1820.	856.	0.	0.	0.	100857.	2214.5	678.
11	863.	2877.	1700.	867.	0.	0.	0.	98817.	2213.7	687.
12	539.	2969.	10.	5938.	0.	0.	0.	95319.	2212.3	692.
	11538.	35000.	57660.		0.	0.	21739.			

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DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	-------END OF MONTH------- CONTENT *AC-FT*	ELEV. *FT*	QUALITY *MG/L*
1964										
1	502.	2972.	480.	1101.	0.	0.	0.	92325.	2211.1	697.
2	369.	2681.	20.	5672.	0.	0.	0.	89295.	2209.9	701.
3	1080.	2972.	0.	0.	0.	0.	0.	85243.	2208.2	710.
4	1511.	2877.	0.	0.	0.	0.	0.	80855.	2206.3	723.
5	1181.	2972.	2370.	814.	0.	0.	0.	79072.	2205.6	736.
6	1101.	2877.	2920.	783.	0.	0.	0.	78014.	2205.1	748.
7	1735.	2972.	0.	0.	0.	0.	0.	73307.	2202.9	766.
8	1303.	2982.	2120.	831.	0.	0.	0.	71142.	2201.9	781.
9	860.	2877.	1570.	880.	0.	0.	0.	68975.	2200.9	793.
10	1123.	2972.	0.	0.	0.	0.	0.	64880.	2198.9	806.
11	650.	2877.	210.	1395.	0.	0.	0.	61563.	2197.2	817.
12	382.	2969.	490.	1097.	0.	0.	0.	58702.	2195.7	824.
	11797.	35000.	10180.		0.	0.	0.			
1965										
1	649.	2123.	0.	0.	0.	0.	0.	55930.	2194.2	833.
2	541.	1915.	0.	0.	0.	0.	0.	53474.	2192.8	842.
3	526.	2123.	100.	2263.	0.	0.	0.	50925.	2191.4	853.
4	650.	2055.	640.	1043.	0.	0.	0.	48860.	2190.2	866.
5	576.	2123.	26260.	517.	0.	0.	0.	72421.	2202.5	748.
6	1161.	2877.	810.	997.	0.	0.	0.	69193.	2201.0	763.
7	1471.	2972.	30.	4962.	0.	0.	0.	64730.	2198.8	782.
8	955.	2982.	12110.	598.	0.	0.	0.	72953.	2202.8	762.
9	724.	2877.	1570.	880.	0.	0.	0.	70922.	2201.8	773.
10	1184.	2972.	210.	1395.	0.	0.	0.	66976.	2200.0	788.
11	763.	2877.	10.	5938.	0.	0.	0.	63346.	2198.1	798.
12	370.	2969.	940.	970.	0.	0.	0.	60947.	2196.9	805.
	9570.	30865.	42680.		0.	0.	0.			
1966										
1	171.	2972.	30.	4962.	0.	0.	0.	57834.	2195.3	810.
2	148.	1915.	10.	5938.	0.	0.	0.	55781.	2194.1	813.
3	665.	2123.	20.	5672.	0.	0.	0.	53013.	2192.6	824.
4	279.	2055.	11560.	603.	0.	0.	0.	62239.	2197.5	788.
5	484.	2972.	2100.	833.	0.	0.	0.	60883.	2196.8	795.
6	946.	2877.	600.	1055.	0.	0.	0.	57660.	2195.2	811.
7	880.	2123.	30.	4962.	0.	0.	0.	54687.	2193.5	826.
8	438.	2130.	4800.	712.	0.	0.	0.	56919.	2194.8	822.
9	421.	2055.	720.	1020.	0.	0.	0.	55163.	2193.8	831.
10	909.	2123.	10.	5938.	0.	0.	0.	52141.	2192.1	846.
11	674.	2055.	10.	5938.	0.	0.	0.	49422.	2190.5	859.
12	368.	2120.	10.	5938.	0.	0.	0.	46944.	2189.0	866.
	6383.	27520.	19900.		0.	0.	0.			

JUSTICEBURG RESERVOIR TDS - INITIAL CONDITIONS - TRS
JANUARY 12, 1988 LUB85052

DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	-------END OF MONTH------- CONTENT *AC-FT*	ELEV. *FT*	QUALITY *MG/L*
1967										
1	210.	2123.	0.	0.	0.	0.	0.	44611.	2187.4	870.
2	313.	1915.	10.	5938.	0.	0.	0.	42393.	2186.0	878.
3	391.	2123.	4440.	723.	0.	0.	0.	44319.	2187.2	870.
4	596.	2055.	1150.	933.	0.	0.	0.	42818.	2186.2	883.
5	581.	2123.	920.	974.	0.	0.	0.	41034.	2185.1	898.
6	1190.	2055.	49000.	459.	0.	0.	0.	86789.	2208.9	665.
7	1074.	2972.	23340.	528.	0.	0.	0.	106083.	2216.4	642.
8	1556.	2982.	60.	3158.	0.	0.	0.	101605.	2214.8	653.
9	422.	2877.	2680.	795.	0.	0.	0.	100986.	2214.6	660.
10	1643.	2972.	1560.	881.	0.	0.	0.	97931.	2213.4	674.
11	485.	2877.	10.	5938.	0.	0.	0.	94579.	2212.0	678.
12	350.	2969.	10.	5938.	0.	0.	0.	91270.	2210.7	681.
	8811.	30043.	83180.		0.	0.	0.			
1968										
1	98.	2972.	700.	1025.	0.	0.	0.	88900.	2209.8	685.
2	121.	2681.	1300.	912.	0.	0.	0.	87398.	2209.1	689.
3	-144.	2972.	2750.	792.	0.	0.	0.	87320.	2209.1	691.
4	593.	2877.	370.	1156.	0.	0.	0.	84220.	2207.8	698.
5	766.	2972.	1070.	946.	0.	0.	0.	81552.	2206.6	707.
6	910.	2877.	1170.	930.	0.	0.	0.	78935.	2205.5	718.
7	937.	2972.	1350.	905.	0.	0.	0.	76376.	2204.4	730.
8	1050.	2982.	1740.	863.	0.	0.	0.	74084.	2203.3	744.
9	1024.	2877.	0.	0.	0.	0.	0.	70183.	2201.5	754.
10	683.	2972.	330.	1182.	0.	0.	0.	66858.	2199.9	764.
11	205.	2877.	3710.	748.	0.	0.	0.	67486.	2200.2	765.
12	303.	2969.	60.	3158.	0.	0.	0.	64274.	2198.6	771.
	6546.	35000.	14550.		0.	0.	0.			
1969										
1	294.	2972.	0.	0.	0.	0.	0.	61008.	2196.9	774.
2	133.	2681.	10.	5938.	0.	0.	0.	58204.	2195.5	777.
3	131.	2123.	2700.	794.	0.	0.	0.	58650.	2195.7	780.
4	545.	2055.	2550.	803.	0.	0.	0.	58600.	2195.7	788.
5	131.	2123.	35450.	488.	0.	0.	0.	91796.	2210.9	674.
6	1324.	2877.	1160.	932.	0.	0.	0.	88755.	2209.7	688.
7	1646.	2972.	10.	5938.	0.	0.	0.	84147.	2207.7	701.
8	1424.	2982.	3290.	765.	0.	0.	0.	83031.	2207.3	716.
9	514.	2877.	17510.	558.	0.	0.	0.	97150.	2213.0	691.
10	-236.	2972.	9480.	626.	0.	0.	0.	103894.	2215.6	684.
11	482.	2877.	2450.	809.	0.	0.	0.	102985.	2215.3	690.
12	449.	2969.	50.	3556.	0.	0.	0.	99617.	2214.0	695.
	6837.	32480.	74660.		0.	0.	0.			

JUSTICEBURG RESERVOIR TDS - INITIAL CONDITIONS - TRS
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DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	-------END OF MONTH------- CONTENT *AC-FT*	ELEV. *FT*	QUALITY *MG/L*
1970										
1	439.	2972.	20.	5672.	0.	0.	0.	96226.	2212.7	699.
2	480.	2681.	10.	5938.	0.	0.	0.	93075.	2211.4	703.
3	203.	2972.	8110.	645.	0.	0.	0.	98010.	2213.4	700.
4	1224.	2877.	240.	1279.	0.	0.	0.	94149.	2211.9	710.
5	1437.	2972.	4670.	716.	0.	0.	0.	94410.	2212.0	721.
6	1470.	2877.	690.	1028.	0.	0.	0.	90753.	2210.5	735.
7	2006.	2972.	0.	0.	0.	0.	0.	85775.	2208.4	752.
8	1333.	2982.	320.	1189.	0.	0.	0.	81780.	2206.7	765.
9	550.	2877.	2260.	821.	0.	0.	0.	80613.	2206.2	772.
10	789.	2972.	400.	1140.	0.	0.	0.	77252.	2204.8	782.
11	964.	2877.	0.	0.	0.	0.	0.	73411.	2203.0	792.
12	807.	2969.	0.	0.	0.	0.	0.	69635.	2201.2	801.
	11702.	35000.	16720.		0.	0.	0.			
1971										
1	577.	2972.	0.	0.	0.	0.	0.	66086.	2199.5	807.
2	558.	2681.	0.	0.	0.	0.	0.	62847.	2197.8	814.
3	962.	2972.	0.	0.	0.	0.	0.	58913.	2195.8	827.
4	928.	2055.	10.	5938.	0.	0.	0.	55940.	2194.2	842.
5	1170.	2123.	3360.	762.	0.	0.	0.	56007.	2194.3	854.
6	1048.	2055.	770.	1007.	0.	0.	0.	53674.	2192.9	873.
7	1338.	2123.	1130.	936.	0.	0.	0.	51343.	2191.6	896.
8	415.	2130.	9530.	626.	0.	0.	0.	58328.	2195.5	859.
9	617.	2055.	21370.	537.	0.	0.	0.	77026.	2204.7	778.
10	462.	2972.	1060.	948.	0.	0.	0.	74652.	2203.6	785.
11	494.	2877.	40.	4113.	0.	0.	0.	71321.	2202.0	792.
12	314.	2969.	80.	2618.	0.	0.	0.	68118.	2200.5	798.
	8883.	29984.	37350.		0.	0.	0.			
1972										
1	528.	2972.	20.	5672.	0.	0.	0.	64638.	2198.8	806.
2	492.	2681.	10.	5938.	0.	0.	0.	61475.	2197.1	813.
3	817.	2972.	10.	5938.	0.	0.	0.	57696.	2195.2	825.
4	898.	2055.	0.	0.	0.	0.	0.	54743.	2193.5	838.
5	556.	2123.	1650.	872.	0.	0.	0.	53714.	2193.0	848.
6	740.	2055.	4860.	711.	0.	0.	0.	55779.	2194.1	847.
7	881.	2123.	3990.	738.	0.	0.	0.	56765.	2194.7	852.
8	637.	2130.	40550.	476.	0.	0.	0.	94548.	2212.0	698.
9	656.	2877.	3410.	760.	0.	0.	0.	94425.	2212.0	705.
10	575.	2972.	710.	1022.	0.	0.	0.	91588.	2210.9	712.
11	392.	2877.	100.	2263.	0.	0.	0.	88419.	2209.6	717.
12	406.	2969.	50.	3556.	0.	0.	0.	85094.	2208.2	722.
	7578.	30306.	55360.		0.	0.	0.			

JUSTICEBURG RESERVOIR TDS - INITIAL CONDITIONS - TRS
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DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	-------END OF MONTH------- CONTENT *AC-FT*	ELEV. *FT*	QUALITY *MG/L*
1973										
1	164.	2972.	740.	1014.	0.	0.	0.	82698.	2207.1	726.
2	139.	2681.	1730.	864.	0.	0.	0.	81608.	2206.7	730.
3	435.	2972.	1950.	845.	0.	0.	0.	80151.	2206.0	737.
4	584.	2877.	110.	2127.	0.	0.	0.	76800.	2204.6	744.
5	1351.	2972.	120.	2010.	0.	0.	0.	72597.	2202.6	760.
6	1621.	2877.	240.	1279.	0.	0.	0.	68339.	2200.6	779.
7	1007.	2972.	2680.	795.	0.	0.	0.	67040.	2200.0	791.
8	1463.	2982.	270.	1227.	0.	0.	0.	62865.	2197.8	811.
9	741.	2877.	2150.	829.	0.	0.	0.	61397.	2197.1	821.
10	873.	2972.	10.	5938.	0.	0.	0.	57562.	2195.1	834.
11	751.	2055.	0.	0.	0.	0.	0.	54756.	2193.5	845.
12	746.	2120.	0.	0.	0.	0.	0.	51890.	2191.9	857.
	9875.	33329.	10000.		0.	0.	0.			
1974										
1	431.	2123.	0.	0.	0.	0.	0.	49336.	2190.5	865.
2	619.	1915.	0.	0.	0.	0.	0.	46802.	2188.9	876.
3	612.	2123.	0.	0.	0.	0.	0.	44067.	2187.1	888.
4	928.	2055.	210.	1395.	0.	0.	0.	41294.	2185.2	910.
5	1006.	2123.	140.	1817.	0.	0.	0.	38305.	2183.2	936.
6	1070.	2055.	40.	4113.	0.	0.	0.	35220.	2181.2	967.
7	1188.	2123.	140.	1817.	0.	0.	0.	32049.	2178.8	1005.
8	422.	2130.	990.	960.	0.	0.	0.	30487.	2177.5	1017.
9	220.	2055.	5220.	701.	0.	0.	0.	33432.	2180.0	976.
10	187.	2123.	2740.	792.	0.	0.	0.	33862.	2180.3	967.
11	302.	2055.	140.	1817.	0.	0.	0.	31645.	2178.5	979.
12	239.	2120.	10.	5938.	0.	0.	0.	29296.	2176.5	989.
	7224.	25000.	9630.		0.	0.	0.			
1975										
1	266.	1698.	10.	5938.	0.	0.	0.	27342.	2174.9	1000.
2	105.	1532.	40.	4113.	0.	0.	0.	25745.	2173.5	1008.
3	448.	1698.	0.	0.	0.	0.	0.	23599.	2171.7	1027.
4	513.	1644.	30.	4962.	0.	0.	0.	21472.	2169.9	1056.
5	467.	1698.	360.	1162.	0.	0.	0.	19667.	2167.9	1081.
6	609.	1644.	1950.	845.	0.	0.	0.	19364.	2167.6	1091.
7	354.	1698.	6040.	682.	0.	0.	0.	23352.	2171.5	1005.
8	630.	1704.	5390.	697.	0.	0.	0.	26408.	2174.1	967.
9	334.	1644.	8160.	644.	0.	0.	0.	32590.	2179.3	898.
10	727.	2123.	10.	5938.	0.	0.	0.	29750.	2176.9	921.
11	331.	1644.	570.	1066.	0.	0.	0.	28345.	2175.7	934.
12	284.	1698.	10.	5938.	0.	0.	0.	26373.	2174.1	946.
	5068.	20425.	22570.		0.	0.	0.			

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DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	-------END OF MONTH------- CONTENT *AC-FT*	ELEV. *FT*	QUALITY *MG/L*
1976										
1	454.	1698.	20.	5672.	0.	0.	0.	24241.	2172.3	966.
2	500.	1532.	0.	0.	0.	0.	0.	22209.	2170.6	987.
3	567.	1698.	0.	0.	0.	0.	0.	19944.	2168.2	1014.
4	-61.	1644.	3070.	775.	0.	0.	0.	21431.	2169.9	979.
5	596.	1698.	260.	1236.	0.	0.	0.	19397.	2167.6	1011.
6	784.	1644.	180.	1543.	0.	0.	0.	17149.	2165.1	1060.
7	225.	1698.	9170.	630.	0.	0.	0.	24396.	2172.4	913.
8	406.	1704.	700.	1025.	0.	0.	0.	22986.	2171.2	932.
9	204.	1644.	1390.	900.	0.	0.	0.	22528.	2170.8	938.
10	127.	1698.	830.	993.	0.	0.	0.	21533.	2170.0	946.
11	295.	1644.	30.	4962.	0.	0.	0.	19624.	2167.9	965.
12	287.	1698.	0.	0.	0.	0.	0.	17639.	2165.7	980.
	4384.	20000.	15650.		0.	0.	0.			
1977										
1	99.	1698.	0.	0.	0.	0.	0.	15842.	2163.7	986.
2	194.	1532.	0.	0.	0.	0.	0.	14116.	2161.8	999.
3	368.	1698.	0.	0.	0.	0.	0.	12050.	2159.3	1027.
4	186.	1644.	1660.	871.	0.	0.	0.	11880.	2159.0	1022.
5	-75.	1698.	7360.	657.	0.	0.	0.	17617.	2165.6	872.
6	625.	1644.	2870.	785.	0.	0.	0.	18218.	2166.3	888.
7	849.	1698.	0.	0.	0.	0.	0.	15671.	2163.5	933.
8	276.	1704.	3800.	745.	0.	0.	0.	17491.	2165.5	908.
9	716.	1644.	20.	5672.	0.	0.	0.	15151.	2162.9	955.
10	440.	1698.	30.	4962.	0.	0.	0.	13043.	2160.6	994.
11	343.	1644.	0.	0.	0.	0.	0.	11056.	2157.7	1022.
12	306.	1698.	0.	0.	0.	0.	0.	9052.	2154.5	1054.
	4327.	20000.	15740.		0.	0.	0.			
1978										
1	100.	1698.	0.	0.	0.	0.	0.	7254.	2151.7	1066.
2	52.	1532.	0.	0.	0.	0.	0.	5670.	2148.6	1075.
3	188.	1698.	0.	0.	0.	0.	0.	3784.	2143.6	1118.
4	210.	1644.	0.	0.	0.	0.	0.	1930.	2137.8	1203.
5	163.	1698.	12130.	598.	0.	0.	0.	12199.	2159.5	656.
6	487.	1644.	4100.	734.	0.	0.	0.	14168.	2161.8	698.
7	793.	1698.	970.	964.	0.	0.	0.	12647.	2160.1	758.
8	583.	1704.	270.	1227.	0.	0.	0.	10630.	2157.0	808.
9	130.	1644.	5640.	691.	0.	0.	0.	14496.	2162.2	772.
10	408.	1698.	400.	1140.	0.	0.	0.	12790.	2160.3	805.
11	15.	1644.	250.	1245.	0.	0.	0.	11381.	2158.2	815.
12	170.	1698.	30.	4962.	0.	0.	0.	9543.	2155.3	841.
	3299.	20000.	23790.		0.	0.	0.			

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DATE	EVAP. LOSS *AC-FT*	DEMAND *AC-FT*	INFLOW *AC-FT*	INFLOW QUALITY *MG/L*	SHORT-AGE *AC-FT*	D/S RELEASE *AC-FT*	SPILLS *AC-FT*	--------END OF MONTH------- CONTENT *AC-FT*	ELEV. *FT*	QUALITY *MG/L*
1979										
1	79.	1698.	40.	4113.	0.	0.	0.	7806.	2152.6	863.
2	135.	1532.	20.	5672.	0.	0.	0.	6159.	2149.9	894.
3	125.	1698.	90.	2424.	0.	0.	0.	4426.	2145.3	941.
4	158.	1644.	20.	5672.	0.	0.	0.	2644.	2140.6	1011.
5	120.	1698.	1420.	897.	0.	0.	0.	2246.	2139.3	997.
6	416.	1644.	25890.	518.	0.	0.	0.	26076.	2173.8	551.
7	837.	1698.	24740.	523.	0.	0.	0.	48281.	2189.9	546.
8	1277.	2130.	5860.	686.	0.	0.	0.	50734.	2191.3	576.
9	1270.	2055.	0.	0.	0.	0.	0.	47409.	2189.3	591.
10	1214.	2123.	90.	2424.	0.	0.	0.	44162.	2187.1	610.
11	435.	2055.	0.	0.	0.	0.	0.	41672.	2185.5	616.
12	180.	2120.	90.	2424.	0.	0.	0.	39462.	2184.0	623.
	6246.	22095.	58260.		0.	0.	0.			
1980										
1	274.	2123.	0.	0.	0.	0.	0.	37065.	2182.4	628.
2	292.	1915.	0.	0.	0.	0.	0.	34858.	2181.0	633.
3	626.	2123.	0.	0.	0.	0.	0.	32109.	2178.9	645.
4	746.	2055.	0.	0.	0.	0.	0.	29308.	2176.5	660.
5	164.	1698.	4280.	728.	0.	0.	0.	31726.	2178.6	673.
6	970.	2055.	4810.	712.	0.	0.	0.	33511.	2180.1	697.
7	1673.	2123.	0.	0.	0.	0.	0.	29715.	2176.9	735.
8	1259.	1704.	420.	1129.	0.	0.	0.	27172.	2174.7	774.
9	246.	1644.	24190.	525.	0.	0.	0.	49472.	2190.6	658.
10	969.	2123.	150.	1737.	0.	0.	0.	46530.	2188.7	675.
11	514.	2055.	70.	2856.	0.	0.	0.	44031.	2187.0	686.
12	298.	2120.	1470.	891.	0.	0.	0.	43083.	2186.4	697.
	8031.	23738.	35390.		0.	0.	0.			
1981										
1	260.	2123.	10.	5938.	0.	0.	0.	40710.	2184.8	703.
2	119.	1915.	1340.	907.	0.	0.	0.	40016.	2184.4	711.
3	336.	2123.	460.	1110.	0.	0.	0.	38017.	2183.1	722.
4	86.	2055.	1100.	941.	0.	0.	0.	36976.	2182.4	730.
5	389.	2123.	620.	1049.	0.	0.	0.	35084.	2181.1	743.
6	525.	2055.	730.	1017.	0.	0.	0.	33234.	2179.8	761.
7	979.	2123.	0.	0.	0.	0.	0.	30132.	2177.2	784.
8	446.	2130.	1550.	882.	0.	0.	0.	29106.	2176.4	801.
9	536.	1644.	1480.	890.	0.	0.	0.	28406.	2175.8	820.
10	-515.	1698.	26920.	514.	0.	0.	0.	54143.	2193.2	663.
11	548.	2055.	70.	2856.	0.	0.	0.	51610.	2191.8	673.
12	498.	2120.	20.	5672.	0.	0.	0.	49012.	2190.3	681.
	4207.	24164.	34300.		0.	0.	0.			

CRITICAL PERIOD IS FROM 7/1963 THROUGH 4/1978. MINIMUM CONTENT = 1930.

APPENDIX B

Wildlife Habitat Appraisal Procedures

JUSTICEBERG - WHAP

LOSSES DUE TO RESERVOIR CONSTRUCTION (NORMAL POOL - ELEVATION 2220'):

HABITAT TYPE	RESOURCE CATEGORY	ACRES IMPACTED	HSI	HU'S LOST
Riparian	2	26	.66	15.6
Rangeland	3	484	.40	193.6
Mesquite/Lotebush Shrubland	3	396	.41	162.4
Mesquite/Juniper Shrubland	3	1411	.58	818.4
Other: Crop, Sand, Oil Field	4	567		
TOTAL:		2884		

LOSSES DUE TO RESERVOIR CONSTRUCTION (PMF - ELEVATION 2257.5)

HABITAT TYPE	RESOURCE CATEGORY	ACRES IMPACTED	HSI	HU'S LOST
Riparian	2	32	.66	21.1
Rangeland	3	2514	.40	1005.6
Mesquite/Lotebush Shrubland	3	523	.41	214.4
Mesquite/Juniper Shrubland	3	4084	.58	2368.7
Other: Crop, Sand, Oil Field	4	1302		

DOWNSTREAM TRACT

HABITAT VALUE OF POTENTIAL COMPENSATION AREAS (SITE #1)
(Based on minimal management - 25% of potential for improvement)

HABITAT TYPE	RESOURCE CATEGORY	AVG. HSI	INCREASE IN HABITAT VALUE	ACRES NEEDED FOR IN-KIND COMPENSATION
Riparian	2	.60	.10	156
Rangeland	3	.41	.15	1291
Mesquite/Lotebush Shrubland	3	.46	.14	1160
Mesquite/Juniper Shrubland	3	.47	.13	6292
Other: Crop, Sand, Oil Field	4			
TOTAL:				8899

HABITAT VALUE OF POTENTIAL COMPENSATION AREAS
(Based on moderate management - 50% of potential for improvement)

HABITAT TYPE	RESOURCE CATEGORY	AVG. HSI	INCREASE IN HABITAT VALUE	ACRES NEEDED FOR IN-KIND COMPENSATION
Riparian	2	.60	.20	78
Rangeland	3	.41	.30	645
Mesquite/Lotebush Shrubland	3	.46	.27	601
Mesquite/Juniper Shrubland	3	.47	.26	3148
Other: Crop, Sand, Oil Field	4			
TOTAL:				4472

DOWNSTREAM TRACT

HABITAT VALUE OF POTENTIAL COMPENSATION AREAS (SITE #1)
(Based on moderate management - 75% of potential for improvement)

HABITAT TYPE	RESOURCE CATEGORY	AVG. HSI	INCREASE IN HABITAT VALUE	ACRES NEEDED FOR IN-KIND COMPENSATION
Riparian	2	.60	.30	52
Rangeland	3	.41	.44	440
Mesquite/Lotebush Shrubland	3	.46	.40	406
Mesquite/Juniper Shrubland	3	.47	.40	2046
Other: Crop, Sand, Oil Field	4			
TOTAL:				2944

HABITAT VALUE OF POTENTIAL COMPENSATION AREAS
(Based on intensive management - 100% of potential for improvement)

HABITAT TYPE	RESOURCE CATEGORY	AVG. HSI	INCREASE IN HABITAT VALUE	ACRES NEEDED FOR IN-KIND COMPENSATION
Riparian	2	.60	.40	39
Rangeland	3	.41	.59	328
Mesquite/Lotebush Shrubland	3	.46	.54	328
Mesquite/Juniper Shrubland	3	.47	.53	1544
Other: Crop, Sand, Oil Field	4			
TOTAL:				2212

HABITAT VALUE OF POTENTIAL COMPENSATION AREA (SITE #2)
(Based on minimal management - 25% of potential for improvement)

HABITAT TYPE	RESOURCE CATEGORY	AVG. HSI	INCREASE IN HABITAT VALUE	ACRES NEEDED FOR IN-KIND COMPENSATION
Riparian	2	.58	.10	156
Rangeland	3	---	---	----
Mesquite/Lotebush Shrubland	3	.47	.13	1249
Mesquite/Juniper Shrubland	3	.475	.13	6292
Shin oak	3	.485	.13	----
		(plus relative replacement for rangeland)		1489
TOTAL:				9186

HABITAT VALUE OF POTENTIAL COMPENSATION AREA (SITE #2)
(Based on minimal management - 50% of potential for improvement)

HABITAT TYPE	RESOURCE CATEGORY	AVG. HSI	INCREASE IN HABITAT VALUE	ACRES NEEDED FOR IN-KIND COMPENSATION
Riparian	2	.58	.21	74
Rangeland	3	---	---	----
Mesquite/Lotebush Shrubland	3	.47	.26	625
Mesquite/Juniper Shrubland	3	.475	.26	3148
Shin oak	3	.485	.26	----
		(plus relative replacement for rangeland)		744
TOTAL:				4591

HABITAT VALUE OF POTENTIAL COMPENSATION AREA (SITE #2)
(Based on minimal management - 75% of potential for improvement)

HABITAT TYPE	RESOURCE CATEGORY	AVG. HSI	INCREASE IN HABITAT VALUE	ACRES NEEDED FOR IN-KIND COMPENSATION
Riparian	2	.58	.31	37
Rangeland	3	---	---	----
Mesquite/Lotebush Shrubland	3	.47	.40	406
Mesquite/Juniper Shrubland	3	.475	.39	2098
Shin oak	3	.485	.39	----
		(plus relative replacement for rangeland)		484
TOTAL:				3038

HABITAT VALUE OF POTENTIAL COMPENSATION AREA (SITE #2)
(Based on minimal management - 100% of potential for improvement)

HABITAT TYPE	RESOURCE CATEGORY	AVG. HSI	INCREASE IN HABITAT VALUE	ACRES NEEDED FOR IN-KIND COMPENSATION
Riparian	2	.58	.42	37
Rangeland	3	---	---	----
Mesquite/Lotebush Shrubland	3	.47	.53	306
Mesquite/Juniper Shrubland	3	.475	.52	1574
Shin oak	3	.485	.51	----
		(plus relative replacement for rangeland)		365
TOTAL:				2282

EXISTING SOURCES OF WATER SUPPLY FOR LUBBOCK

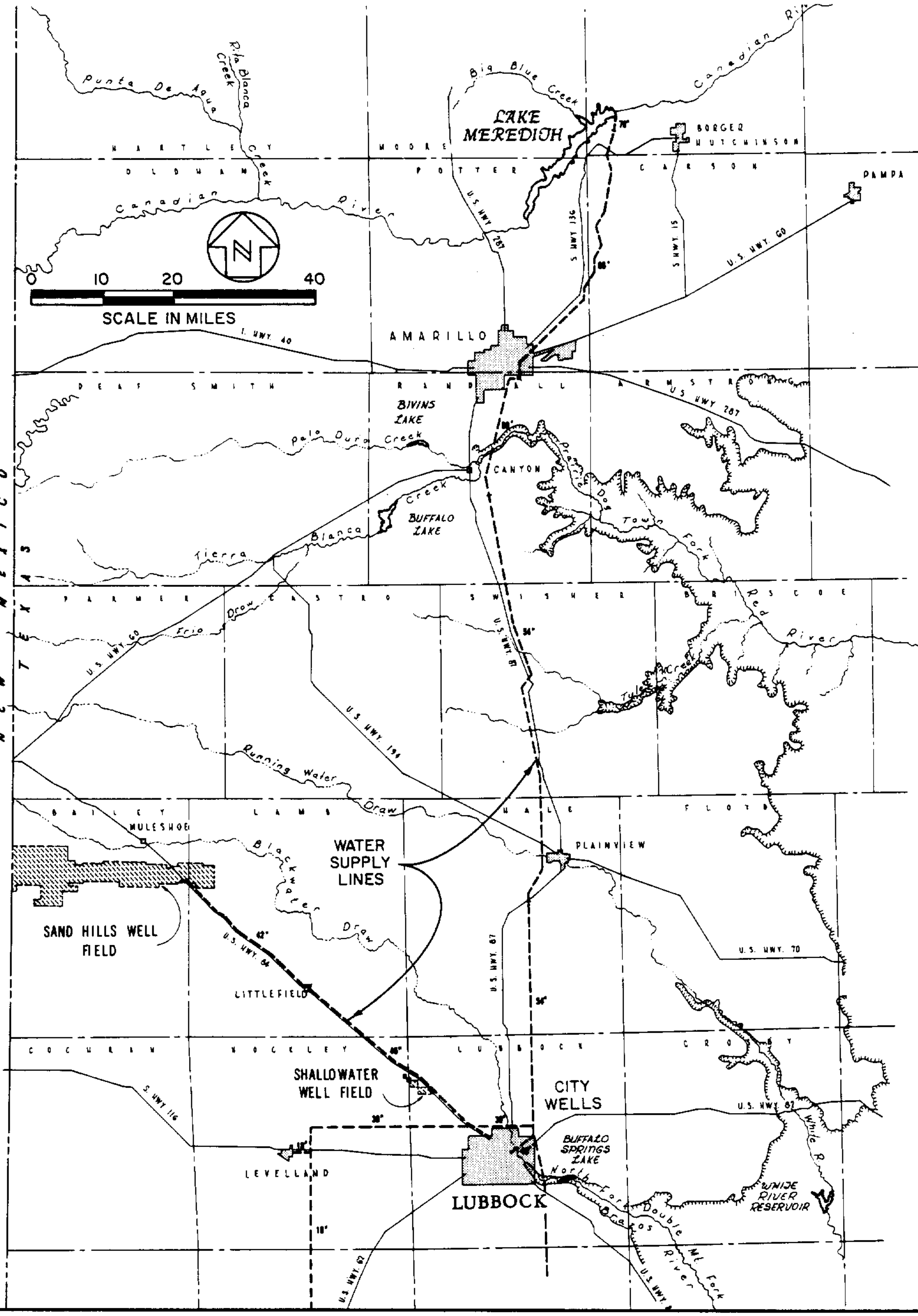
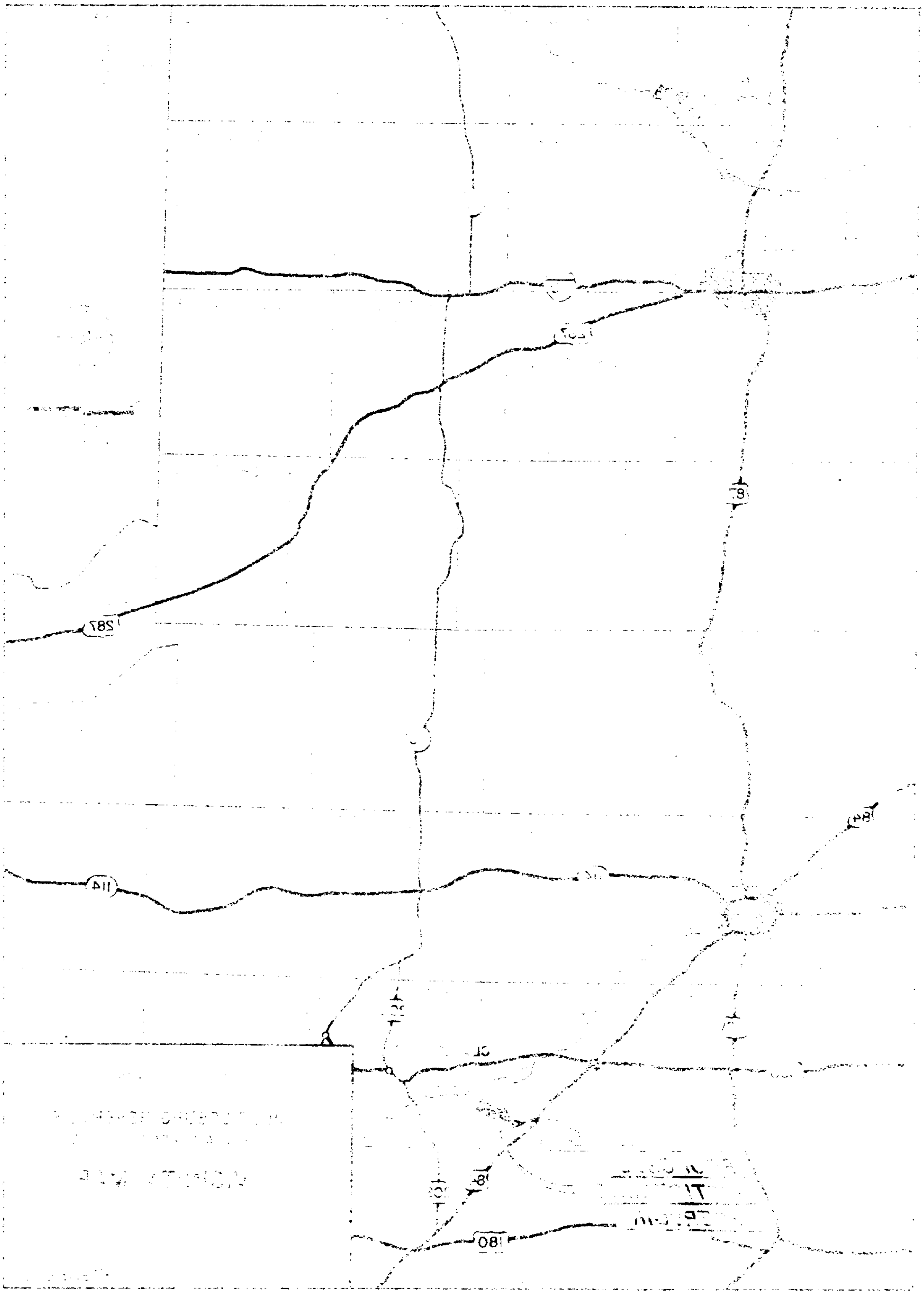


FIGURE 1.1



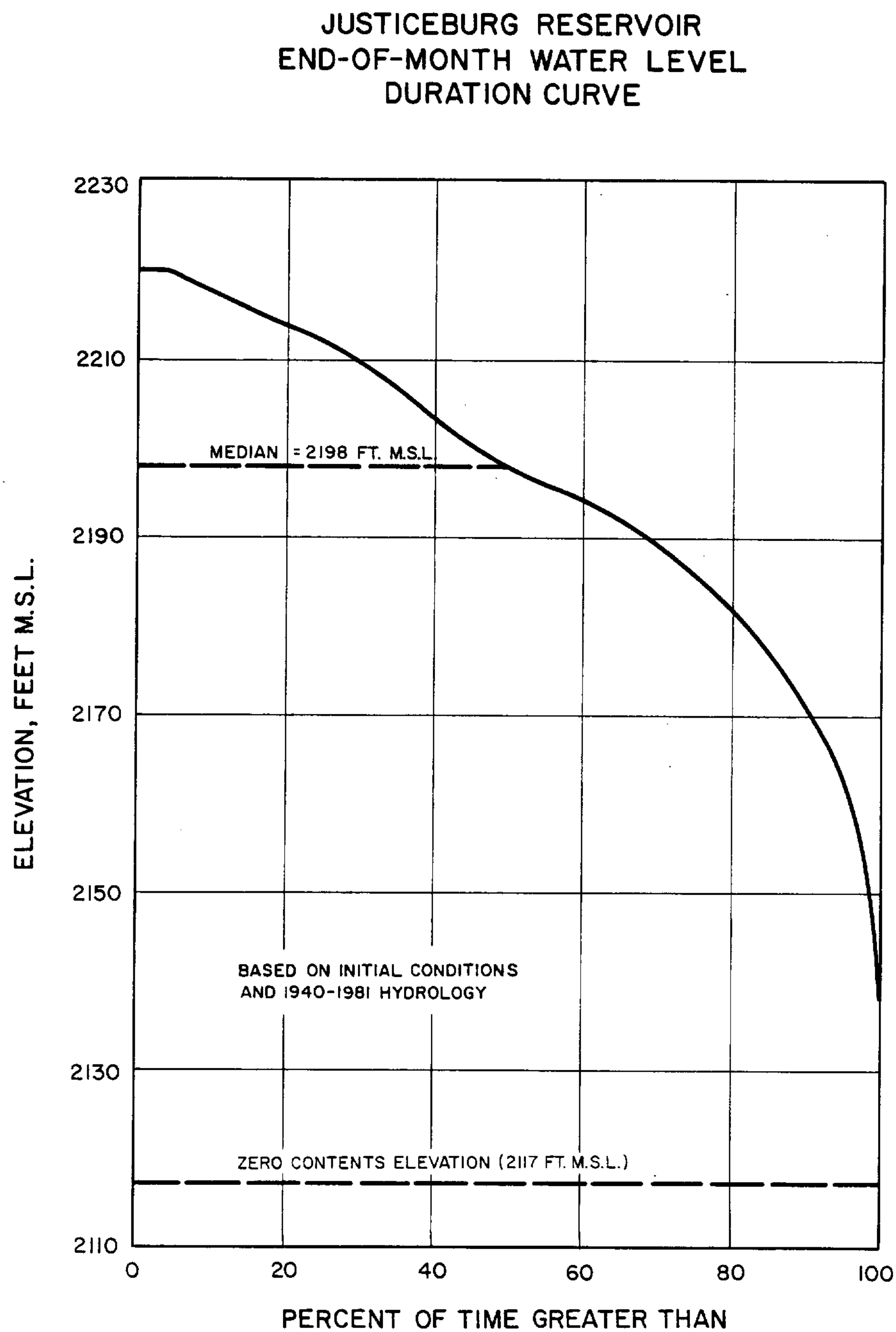

JUSTICEBURG RESERVOIR
END-OF-MONTH WATER LEVEL
DURATION CURVE
2230
2210
2190
2170
2150
2130
2110
ELEVATION, FEET M.S.L.
MEDIAN = 2198 FT. M.S.L.
BASED ON INITIAL CONDITIONS
AND 1940-1981 HYDROLOGY
ZERO CONTENTS ELEVATION (2117 FT. M.S.L.)
0
20
40
60
80
100
PERCENT OF TIME GREATER THAN

FIGURE 4.1

JUSTICEBURG RESERVOIR END OF MONTH WATER LEVELS

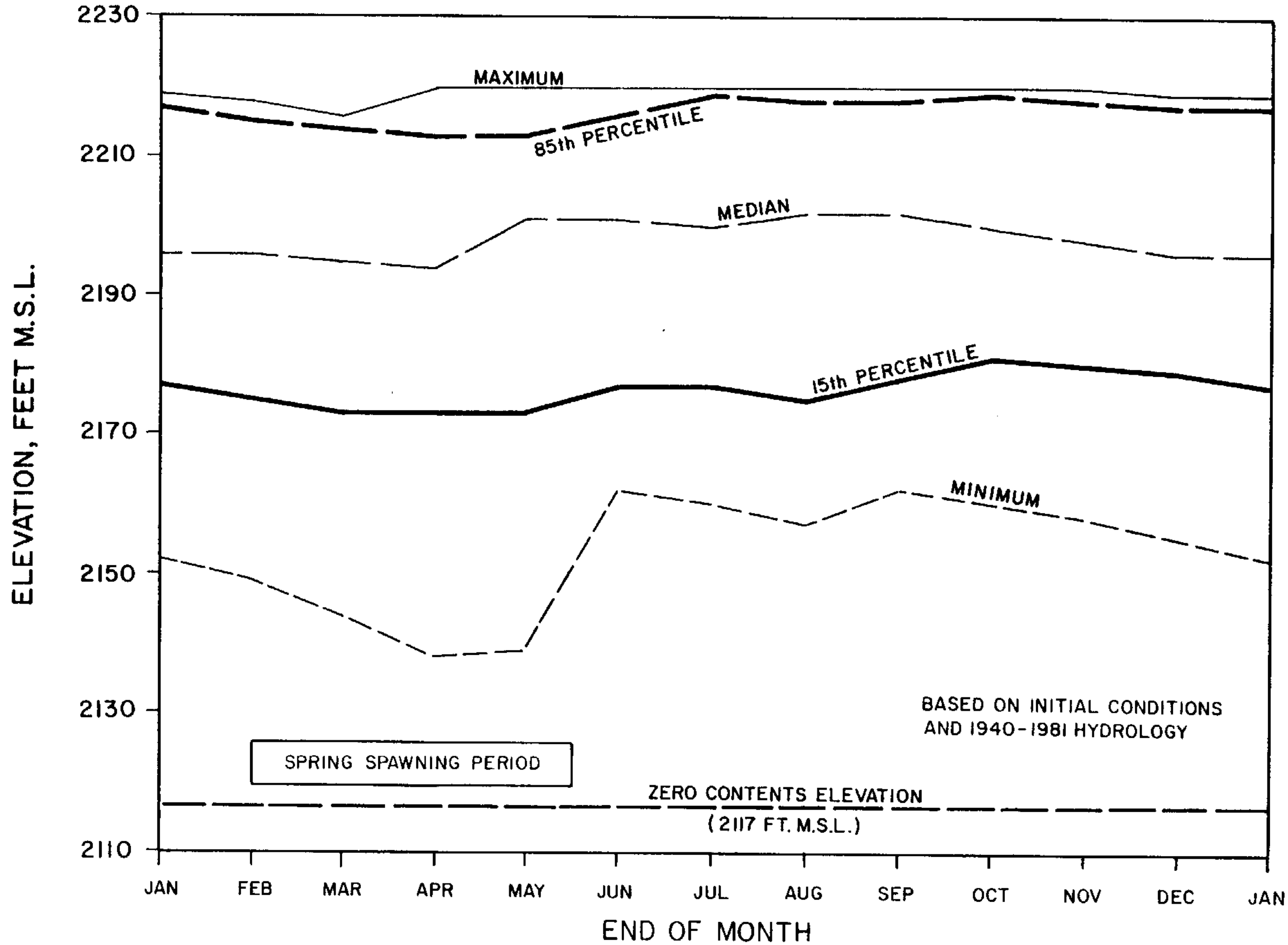


FIGURE 4.2

JUSTICEBURG RESERVOIR MONTHLY WATER LEVEL CHANGES

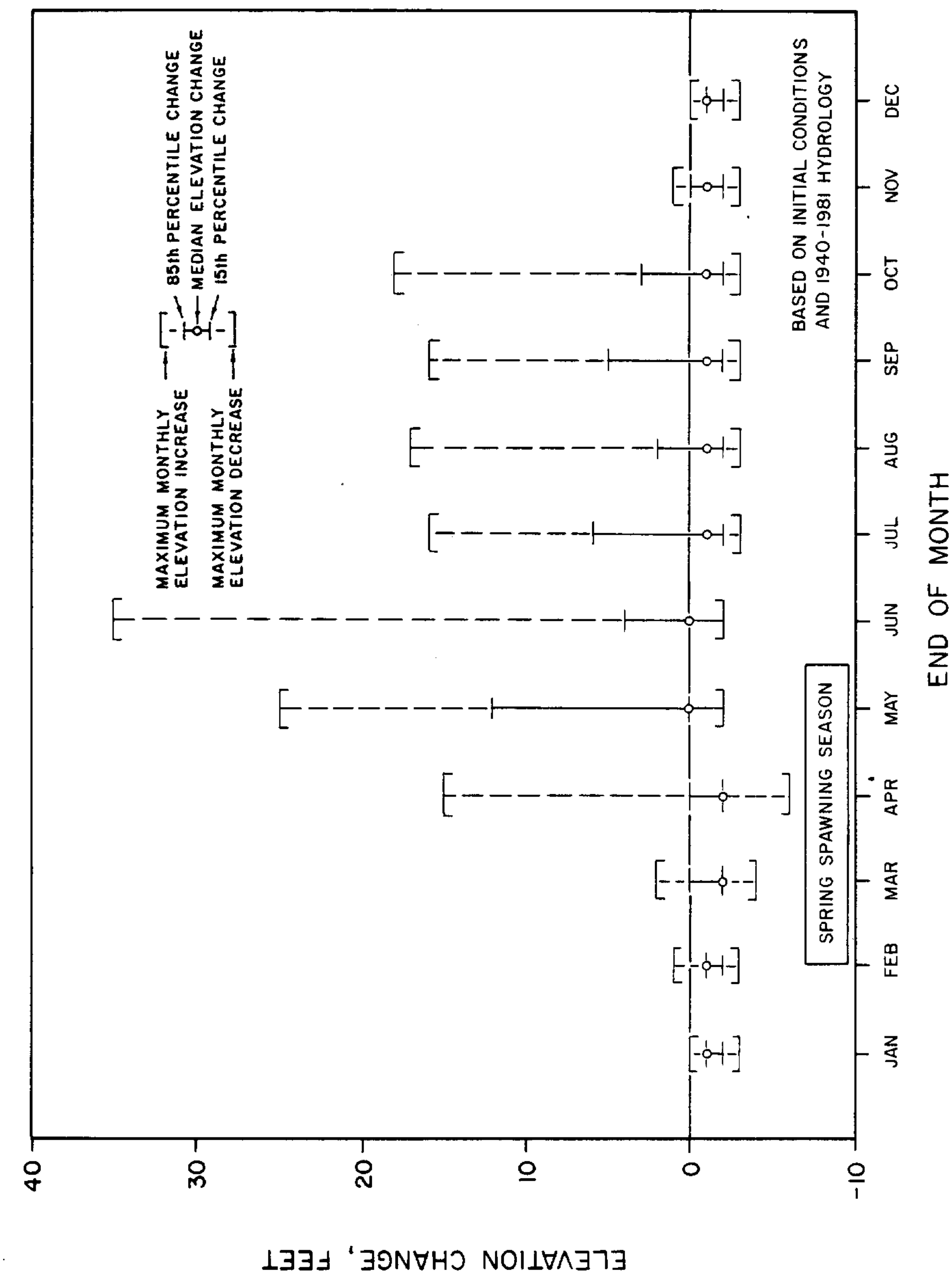
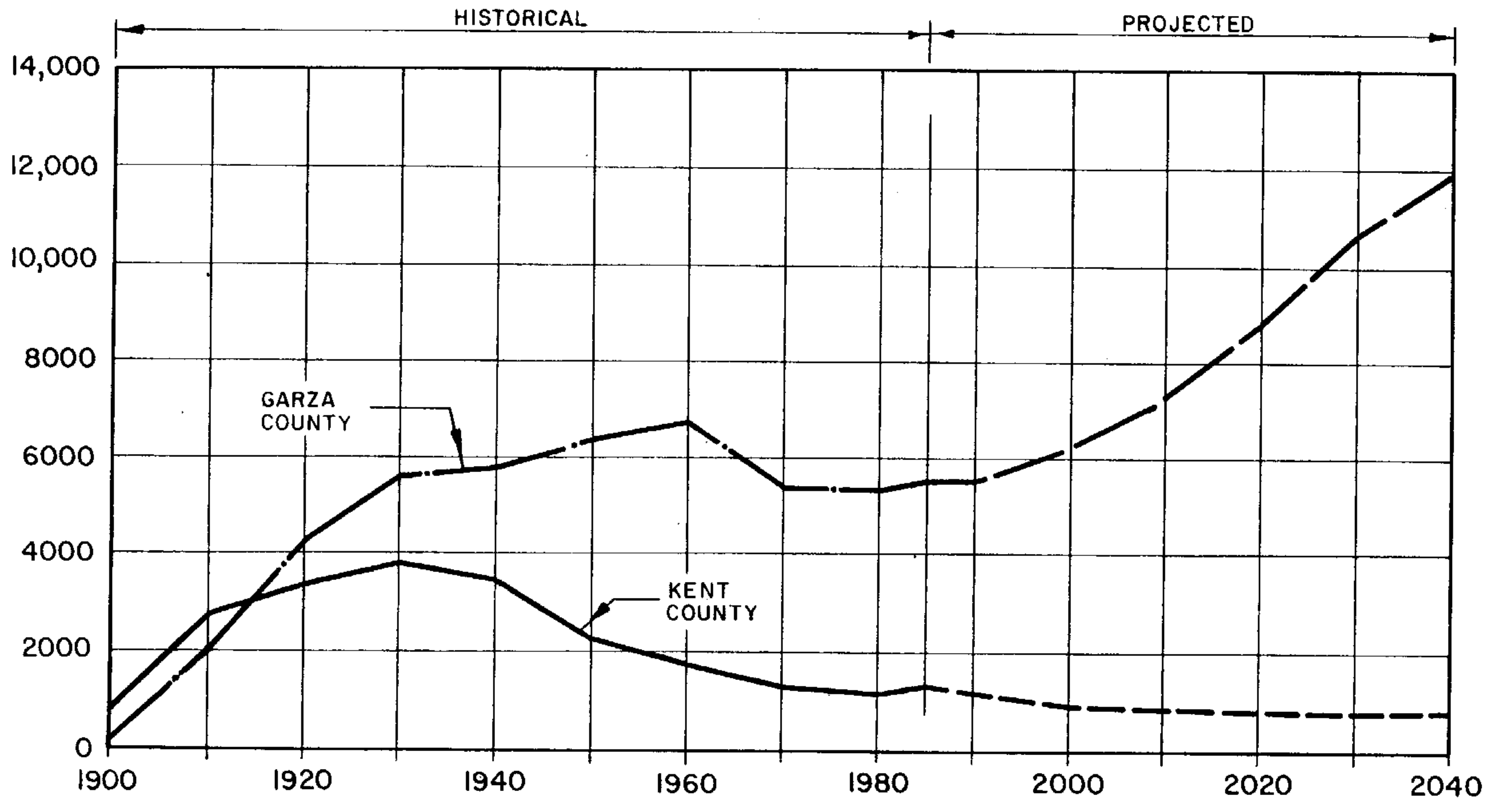


FIGURE 4.3

POPULATION TRENDS, GARZA AND KENT COUNTIES, 1900-2040



SOURCE : BUREAU OF CENSUS, 1902-1983 ; TEXAS WATER DEVELOPMENT BOARD, 1988

FIGURE 4.5

Table 2.4

Water Supply Alternatives Considered by the City of Lubbock

Alternatives	Evaluations
The Ogallala Aquifer in the Southern High Plains	Only small amounts of undeveloped water available; state policy discourages use
The Ogallala Aquifer in the Northern High Plains	Significant amounts available in Hartley and Ochiltree Counties; 164-190 mile pipeline distances; state policy discourages use
The Santa Rosa Formation	Unfavorable aquifer characteristics and water quality; state policy discourages use
The South Canadian River	Already fully developed
The North Canadian River	Yields less than Lubbock will need; 190 miles away
The Colorado River	Already fully developed
North Pease Reservoir site	Moderate yield; uncertain water quality
Middle Pease Reservoir site	Small yield; uncertain water quality
South Pease Reservoir site	Small yield; uncertain water quality
Aspermont Reservoir site on the Salt Fork Brazos River	Unsuitable water quality
Munday Reservoir site on the Salt Fork Brazos River	Unsuitable water quality
Post Reservoir site on the North Fork Double Mountain Fork Brazos River	Moderate yield; could be operated in coordination with Justiceburg site
Justiceburg Reservoir site on the Double Mountain Fork Brazos River	Significant yield; acceptable water quality; most economical alternative
Rotan Reservoir site on the Double Mountain Fork Brazos River	Unsuitable water quality

Flat Top Reservoir site on the Double Mountain Fork Brazos River	Unsuitable water quality
Reynolds Bend Reservoir site on the Clear Fork Brazos River	Significant yield; unsatisfactory water quality
Demineralization of saline waters	High costs
Importation under Texas Water Plan	Uncertain of realization
Reclamation of municipal wastewater	Wastewater already largely committed; not desirable at this time if other alternatives available
Water Conservation	Significant conservation measures already in effect

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