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COMANCHE PEAK STEAM ELECTRIC STATION

ENVIRONMENTAL REPORT

VOLUME I

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0032

TEXAS UTILITIES GENERATING COMPANY

COMANCHE PEAK STEAM ELECTRIC STATION

ENVIRONMENTAL REPORT - AMENDMENT 1

AEC QUESTIONS & APPLICANT'S RESPONSES

AEC Question A.1

What is the expected contribution to growth in electrical demand due to the construction of the Dallas-Fort Worth Regional Airport? Is this effect considered in Table 1.1-1, (Section 1.1)?

Response

Refer to page 1.1-1.

AEC Question A.2

Since peak hour demands in Tables 1.1-2 and 1.1-3 are presented as non-diversified demand, supply the appropriate diversity factors or diversified demand. Are peak hour demands given in Table 1.1-1 diversified? If not, supply diversity factors.

Response

Diversified demands are provided as follows:

	TIS Diversified Demands, MW	
1971	17,149	
1972	18,973	
1973	20,138	2

Note: Above demands exclude interruptible load. Sufficient records are not available to determine diversified demands for ERCOT, or for TIS prior to 1971.

Peak hour demands given in Table 1.1-1 for TUCS are diversified.

AEC Question A.3

Provide a complete description of TIS, include membership obligations, reserve requirements and any other implications. Provide similar information for ERCOT. (Section 1.0)

Response

Refer to page ii.

AEC Question A.4

How is interruptible load handled during peak hours? If left on line, does it reduce the reserve margin? (Section 1.1.1b)

Response

Refer to page 1.1-8.

AEC Question A.5

What is the interconnection capacity planned for 1980-82? How much is needed for reliability? How much is left over? Describe TUCS ability to import major amounts of bulk power from 1973 to 1984. (Section 1.1.3)

Response

Refer to page 1.1-15. 2

AEC Question A.6

Provide dates and duration of any emergency load reductions and voltage reductions from 1963 to present.

Response

None occurred.

COMANCHE PEAK NUCLEAR STEAM ELECTRIC STATION ENVIRONMENTAL REPORT

PREFACE

In response to the requirements of Appendix D of 10CFR50, this Environmental Report is hereby submitted to the Atomic Energy Commission by Texas Utilities Generating Company (TUG) of Dallas, Texas, for the proposed Comanche Peak Steam Electric Station, a two-unit nuclear fueled electric generation station to be located near Glen Rose, Texas. Texas Utilities Generating Company is a corporate affiliate of the joint owners and is acting in behalf of the joint owners of the project in submission of this report, and will operate the proposed station as agent for the joint owners.

The Nuclear Steam Supply System (NSSS) for the proposed plant will incorporate two Westinghouse pressurized water reactors (PWR) with a nominal rating of 1150 MWe each. Unit No. 1 is scheduled for commercial operation on January 1, 1980, with Unit No. 2 scheduled for January 1, 1982.

The three joint owners, each with 33 1/3 percent ownership, are Dallas Power & Light Company (DPL), Texas Electric Service Company (TES), and Texas Power & Light Company (TPL). These owners are electric utility subsidiaries of Texas Utilities Company of Dallas, Texas. Other subsidiaries of Texas Utilities Company are Texas Utilities Generating Company which will operate the proposed generating station (see above); Texas Utilities Services, Inc., which furnishes engineering, financial, fuel, and other services at cost to other affiliated companies; Texas Utilities Fuel Company, which acquires and transports fuel gas for the three electric utility subsidiaries for the generation of electric energy. Old Ocean Fuel Company and Bi-Stone Fuel Company are subsidiaries of, and provide fuel services for, TES and TPL respectively. The above named companies, each of which is incorporated under the laws of the State of Texas, comprise the Texas Utilities Company System (TUCS).

Each of the three electric utility subsidiaries is a corporate entity and each is responsible for providing adequate facilities to serve its own customers; however, planning for generation and major transmission facilities is carried out on a TUCS coordinated basis. Capabilities, demands and other data pertaining to justification for the subject facility are reported on a TUCS consolidated basis in appropriate later sections of this report.

DPL, TES and TPL are members of the Texas Interconnected System (TIS), a group of nine interconnected electric systems of which six are privately owned and three are publicly owned. The members of the TIS are as follows:

Central Power and Light Company
City of Austin
City Public Service (San Antonio)
Dallas Power & Light Company
Houston Lighting & Power Company
Lower Colorado River Authority
Texas Electric Service Company
Texas Power & Light Company
West Texas Utilities Company

There are no membership obligations. Each company is obligated to its own customers to provide reliable electric service. Nothing in the TIS Coordination Agreement can be construed as limiting or interfering with in any way the power or right of each member to control the use and operation of its own facilities. Nothing in the Agreement can be construed to create an association, joint venture, trust or partnership or impose a trust or partnership duty, obligation or liability on any member of TIS.

Reserve requirements are at least 15% above expected peak load. On the average, each company is expected to comply with this minimum reserve requirement. 1

Each member of TIS is also a member of the Electric Reliability Council of Texas (ERCOT), which is one of nine regional reliability councils comprising the National Electric Reliability Council (NERC). ERCOT is comprised of 28 municipalities, 47 cooperatives, 8 investor-owned companies and one state agency. ERCOT is a voluntary association and there are no legal obligations on any member. Each member retains sole control of its own facilities and the use thereof. Nothing in the ERCOT agreement impairs the ability of or right of any member to take such actions or to fail to act, as it deems necessary or desirable, with respect to the management, extension, construction, maintenance and operation of its own facilities, present 2

1/21/74 Amendment 2

9/28/73 Amendment 1

Municipalities

Austin
Boerne
Brady
Brenham
Bryan
Coleman
Crosbyton
Cuero
Denton
Garland
Giddings
Goldthwaite
Gonzales
Greenville
Hearne
Hemphill
Hondo
La Grange
Livingston
Lockhart
Luling
New Braunfels
Robstown
San Antonio
Schulenburg
Seguin
Tulia
Weimar

Cooperatives

B - K
Bartlett
Belfalls
Bluebonnet
Brazos
Cap Rock
Comanche County
Deep East Texas
Denton County
De Witt County
Dickens County
Fannin County
Farmers
Fayette
Grayson-Collin
Guadalupe Valley
Hamilton County
Hill County
Hunt-Collin
J-A-C
Jackson
Jasper-Newton
Johnson County
Kaufman County
Kimble County
Lamar County
Limestone
Lone Wolf
Magic Valley
McCulloch
McLennan County
Medina
Mid-South
Midwest
Navarro County
New Era
Pedernales
Robertson
Sam Houston
San Bernard
San Patricio
South Texas
Southwest Texas
Stamford
Tri-County
Victoria County
Wise

Investor-Owned

Central Power & Light Company
Community Public Service Company
Dallas Power & Light Company
Houston Lighting & Power Company
Southwestern Electric Service Company
Texas Electric Service Company
Texas Power & Light Company
West Texas Utilities Company

State Agencies

Lower Colorado River Authority

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1.0 PURPOSE OF THE PROPOSED FACILITY

The purpose of the proposed facility is to supply the following needs:

1. To provide additional generating capacity to meet the projected increases in demand and energy requirements of the three joint owners.
2. To assure an adequate reserve margin and to maintain reliability of the bulk power supply system of TUCS.
3. To initiate the timely utilization of nuclear fuel by the owners as part of their broad base of energy resources.

1.1 NEED FOR POWER

The subject facility is a major and integral part of planned supply facilities for TUCS for both capacity and energy. The combined service area of the three joint owners covers approximately 75,000 square miles and has a population estimated at more than 3,700,000. DPL serves the City of Dallas and three incorporated communities surrounded by Dallas, all in Dallas County. TES serves customers in 47 counties in North Central and West Texas; and TPL serves customers in 51 counties in North Central and East Texas. The new Dallas - Ft. Worth Regional Airport is expected to increase the importance of this area in national and international air transportation, and give additional impetus to commercial enterprises. It is expected that during early operations, peak demand of the Airport will be 56,000 kw. This demand is expected to increase as the Airport expands and matures.

The Dallas-Fort Worth metropolitan area has benefited from excellent air transportation facilities for many years. Growth in air transportation has contributed substantially to the dynamic growth history of the area. While the complete impact 1
of the new airport, if it could be precisely defined, is substantial, it is not expected to change the area growth trend in electrical energy demand. The new airport will make possible a continuation of the dynamic growth pattern established in the past. The effect of the new airport on electrical demand and energy requirements is included in the data supplied in Table 1.1-1 (Section 1.1).

Until 1972, essentially all fuel for generating stations was natural gas with oil as a stand-by fuel. During 1971 and 1972 the first lignite-fueled units, jointly owned by the three subsidiary companies, were placed in service. The third and fourth lignite units are under construction, the fifth and sixth are in the advanced planning stage, and still other lignite deposits are being considered for use. The subject nuclear facility represents the next logical step in energy source development. Base-load nuclear generation, in proper mix with other types, is necessary for projected demand and energy requirements, at the present and projected annual load factor of slightly more than 51%.

Need for the subject units is based only on the expected load growth of the Texas Utilities Company System. Historic and projected demand and energy data for TUCS are given in Table 1.1-1.

2 The three joint owners of the subject facility are members of TIS and ERCOT as indicated in the Preface. Although neither of these two organizations has consolidated generation and transmission planning responsibilities, data pertaining to historic and projected demands for them are presented in Tables 1.1-2 and 1.1-3 respectively, based on the best information available as of April 1, 1973 (original filing) and the dates of the amendments thereafter.

The historical data not shown in Tables 1.1-2 and 1.1-3 is not presently available in the records of the Texas Interconnected System (TIS) and the Electric Reliability Council of Texas (ERCOT).

As a regional council of the National Electric Reliability Council, ERCOT was not formally organized until 1970, therefore the data omitted from Table 1.1-3 does not exist. Collection of the remainder of the data for both TIS and ERCOT is not within the capability of the Applicant.

1 There is no Public Utilities Commission in the State of Texas having jurisdiction over electric utilities. Regulation of electric utilities is accomplished by the local communities in which service is provided. Therefore, there are no commission forecasts of load and resources for the State. Forecasts of load and resources for the State are not available from the many local communities involved in electric utility regulation.

Service area of TIS, which is virtually the same as that of ERCOT, is shown in Figure 1.1-1. Currently, ERCOT members provide approximately 80 percent of the electric service in Texas.

1.1.1 LOAD CHARACTERISTICS

TUCS, TIS, and ERCOT are summer peaking areas with very little diversity between individual systems. In 1980 and 1982, the annual load factor of TUCS is estimated at approximately 53%, with that of TIS and ERCOT somewhat higher.

Demand and energy projection methodology is based on past load patterns and rates of growth that have been experienced by the three electric utility subsidiaries of the Texas Utilities Company System. Demand and energy forecasts are extrapolations of historical trends with recognition, primarily in the near term, of anticipated variations due to economic conditions and growth patterns.

1 Demand and energy forecasts are made in two increments - the short term which covers a period of five years, and the long term which extends to twenty years. A discussion of local

forecasting practice for each electric utility subsidiary follows.

1.1.1.1 Load Forecasting

Dallas Power & Light Company 2

Short-term energy forecasts (up to five years) are prepared on two bases -- sales to customers and system input requirements. Energy sales to customers are derived from correlations of numbers of customers, use per customer, and specific information concerning significant load changes; the estimate is made on two bases -- by rates and by major groupings of the Standard Industrial Classification Code. Separate projections are made of system input energy requirements and maximum hour demands, and these are compared with the results of the customer sales forecast. The independent projections are compared and, if necessary, the differences reconciled. 1

In preparing a forecast both demand and system input energy are always projected and the resulting load factor calculated. Demand Versus Energy plotted on logarithmic graph paper results in a straight line relationship for a constant load factor. This is an excellent tool for trend appraisal and is utilized to evaluate the projections.

Long-term forecasts (extending from five to twenty years) are based on separate projections of demand and energy. Regular use is made of least squares curve fitting and multiple regression programs.

Texas Electric Service Company

Forecasts of energy requirements are based on individual estimates for each revenue class. For those classes with consistent growth patterns in usage per customer, the energy sales to customers of each class are derived from correlations of numbers of customers, kilowatt-hour use per customer, and specific information concerning significant load changes. Energy sales to customers for all other classes are estimated directly from historical trends, again, adjusted for known or anticipated changes.

System input energy requirements are calculated by applying line losses to the total customer sales. System line losses are estimated using historical trends.

The load factor is estimated from historical trends and the maximum hour demand forecast obtained by applying the load factor to the corresponding system input energy. The values calculated are checked against separate projections of historical demand data.

Texas Power & Light Company

Load forecasting of necessity includes a forecast of three elements - demand, energy and how the two related contribute to affect load factor. The overall process of forecasting might be described as an iterative process since the influence of many factors and projections from many operational units within the organization must be reflected in the final fore-
2 cast. This can only be achieved by successive trials at forecasting until an overall best fit is achieved.

Projections of total company customers, kwh sales per customer and kwh sales by customer classes are made and compared to projections of total kwh sales. Energy use per customer (based on total company analysis) coupled with population and associated customer growth provide an additional check on reasonableness of total energy forecasts.

1 System energy losses are estimated based on trend of historical data. Net consumed system input projections are then obtained by summing total company projections of kwh sales and losses. Separate projections are made of annual peak demand using various curve fitting techniques. Load factor is then calculated using separate projections of energy and demand and checked for reasonableness.

All short and long term forecasts of energy and demand are adjusted to provide correlating data and reflect anticipated changes not represented by trends of historical data.

General

Temperature-sensitive loads represent the predominant source of variation of experienced peak demands and energy requirements about the growth trend. Therefore, load versus weather analyses are undertaken in order to adjust experience to normal conditions.

Various curve-fitting and estimating techniques are used, including least squares and multiple regression. Other forms, such as Gompertz and logistic curves, exponential smoothing, and the statistical theory of extreme values, are periodically reviewed as to their applicability in forecasting. Forecasts are reviewed and compared with experience on an annual basis.

(a) TUCS peak hour demands for the period 1963-1984 are shown in Table 1.1-1. Load estimates are based upon a summation of demand schedules for each of the three electric utility subsidiaries taking into account situations unique to each subsidiary.

Load forecasts are prepared by each of the three operating utilities of TUCS. The TUCS load forecast consists of the sum of these three load forecasts. Situations influencing load forecasts which are unique to each operating utility are:

(1) DPL - metropolitan area exclusively - limited service area

(2) TPL - combination of rapidly-developing suburban communities and rural areas

(3) TES - Ft. Worth and West Texas service area - some irrigation pumping

(b) Interruptible load is excluded from power planning studies and is not used to reduce either annual peak demand or energy requirements, but is used only for contingency purposes.

Interruptible load is normally left on line during peak hours, but may be interrupted any time if operating conditions warrant. Being on line, it does reduce reserve margin. (Interruptible load is automatically tripped by underfrequency relays when an unusual frequency drop occurs, so that the reduction of reserve by the amount of the interruptible load does not increase risk to the load of other customers.)

Load forecasts are prepared with interruptible load excluded. Capacity installation plans are made and reserve margins are planned, also omitting the interruptible load. The contract for interruptible load provides for interruption when system conditions warrant. In actual day-to-day practice, however, all system load, including interruptible, is supplied when sufficient capability and energy are available. A type of contingency which might result in elimination of interruptible load any time during the year is the loss of an unusual amount of generation, say equalling or exceeding the spinning reserve in the TUCS area. The interruptible load in a situation like this would remain off till additional generating capability could be brought on line.

(c) Power transactions in the form of sales to and purchases from other utilities are not taken into consideration during demand forecasting, since each utility is responsible for meeting its own power demand. The net of power purchases and sales, applicable at time of annual peak, and accounted in capability, is shown in Table 1.1-4.

Two options appear reasonable for the treatment of firm purchases or sales. One is to treat them as a part of the load, with sales being positive, and purchases negative. This treatment would require consideration of net purchases in the process of load forecasting.

Texas Utilities Company System, however, has a practice of considering sales as a part of capability (with sales being negative and purchases positive). This technique removes completely from consideration those sales to other electric utilities when considering the preparation of load forecasts.

(d) Monthly peak and energy loads, interruptible peak and energy loads, and firm power peak and energy purchases for TUCS for 1980 and 1982 are shown in Table 1.1-7.

(e) A TUCS load duration curve is shown by Figure 1.1-2 for the year 1980, and by Figure 1.1-3 for 1982. The assumptions upon which these curves are derived are as follows:

FOR 1980 OPERATION (PEAK LOAD OF 17,100 MW)

Fuel	Capability (MWe)	Capacity Factor (%)
Nuclear	1,150	63
Lignite	6,800	64
Gas/Oil	12,233	32
Purchases	140	20

FOR 1982 OPERATION (PEAK LOAD OF 20,074 MW)

Fuel	Capability (MWe)	Capacity Factor (%)
Nuclear	2,300	68
Lignite	8,600	67
Gas/Oil	12,233	27
Purchases	140	20

DPL, TES and TPL are not members of any coordination group other than TUCS, TIS and ERCOT. As noted previously under "Need for Power", TIS and ERCOT do not have consolidated generation and transmission planning responsibilities. However, historic and projected demand and energy data for these groups was presented in that section.

1.1.1.2 Energy Conservation

Anticipated demand and energy growth are expected to be substantially more than the effect of possible reductions due to efforts to conserve electric energy. Because anticipated growth is large, and possible reductions are expected to be small, the latter are not discernible in the projected growth trend. Each of the subsidiaries have programs for energy conservation, which are discussed below.

Dallas Power & Light Company

Educational and informational programs have been a part of Dallas Power & Light Company's customer service activities since its earliest days. For many decades the company has conducted cooking schools, demonstrated the proper use of appliances, and assisted commercial and industrial customers with the efficient utilization of electric service. Programs in the school system have helped thousands of young women learn the efficient use of electric appliances.

Currently the company is conducting a program entitled "Helpful Hints on Using Your Electric Service." This program is designed to inform the customer of energy savings and economical ways to use electricity. It informs the customer of ways to use electric appliances in the most efficient manner possible. The program is totally oriented to encouraging the wise and efficient use of electricity. It is not promotional and it does not in any way encourage unnecessary use of electricity. Rather, it directly advises the customer of ways to use less electricity and to save money. 1

The program is published in newspaper, magazine, television and radio advertising. The consumer booklet on conservation information has been published and widely distributed.

The program takes the form of educating the customer within specific areas. Foremost among these is air conditioning. The use of air conditioning is approximately 80% saturated in Dallas. The Company has long experienced summer peaks due to the use of air conditioning. For many years the company has encouraged customers to keep such equipment in proper operating condition and to use it economically by selecting reasonable thermostat settings. 2

The present program strongly encourages customers to observe conservation measures by setting thermostats to insure only reasonable comfort, by cleaning and servicing equipment properly, and by the use of insulation materials in the home. The use of home insulation has been encouraged for many years to provide the customer efficient use of electric service. 2

The current program also offers information on how to select the most efficient air conditioning equipment. Educational messages explain the relationship of BTU output and wattage and offer specific examples of operating costs of air conditioning units.

The "Helpful Hints" program also covers home heating in a way comparable to the information provided on air conditioning.

Other educational information in the program explains the wise and efficient use of electric ranges, clothes dryers and dishwashers. Another segment provides information on the efficient use of lighting in the home and answers commonly asked questions concerning the performance of lighting equipment.

A consumer booklet containing the information discussed above is offered to the public upon request through the mail and at company facilities. The publication has stimulated the interest of retail appliance dealers who are using copies to distribute to appliance buyers in their stores.

Company representatives work directly with various customer groups in the following ways:

A. Home builders are encouraged to use construction methods and equipment that enable the buyer to conserve energy.

B. Commercial and industrial customers are counseled on the efficient use of air conditioning.

C. Commercial and industrial customers are counseled on efficient use of both interior and exterior lighting.

D. Institutional and commercial cooking customers are counseled on the efficient use of cooking and kitchen equipment.

E. Printed material is distributed to commercial and industrial customers to encourage the wise and efficient use of electric service.

Texas Electric Service Company

Texas Electric Service Company has throughout its history encouraged the efficient use of electricity by providing specialized assistance to its customers. This effort takes many forms, but includes counseling services of residential, commercial and industrial specialists which often includes engineering assistance.

Its advertising and information programs encourage energy conservation through efficient use. Beginning in 1972 these efforts were intensified and will continue to be dominant in the future.

Further, the company is demonstrating conservation internally 2
through new programs which reduce energy consumption. These
steps include lower lighting levels where practical, reduced
sign lighting, reduction of vehicles and the use of smaller
vehicles where practical.

Energy conservation through efficient use of electricity is a
continuing Company practice and objective. 2

Texas Power & Light Company

For over thirty years Texas Power & Light Company has main-
tained a technical service group which offers assistance to 1
customers in an attempt to reduce the customer's overall
energy use and bill.

The Company has recently strengthened its program to solicit
its customers to conserve electrical energy. This is part of
a continuing program carried on through the years to keep
customers aware of the problems and needs of the electric 2
utility industry.

Specifically, the following active steps have been taken:

1. All sales promotion advertising has been discontinued.

2. Current newspaper advertising concerns conservation of energy in the use of air conditioners, and will be published in 132 newspapers in Company's service area. 2 Similar matter will be contained in "bill stuffers" and in handouts to customers.

3. All promotional incentive payments have been eliminated, or are being phased out.

4. Guidelines for conservation of energy at Company facilities have been issued. Lighting and air conditioning practices at all Company offices, storerooms, warehourses, loading docks and power plants have been revised to conserve energy.

5. Customer service personnel activities are principally devoted to educating and influencing all classes of customers, dealers and manufacturers of electric appliances and equipment toward the goal of wise and efficient use of electricity and its conservation.

6. Wholesale power customers of TPL are being apprised of its efforts and are being urged to do likewise.

1.1.2 POWER SUPPLY

The bulk power supply planning for TUCS is based on the TUCS area only and is keyed to the development of fuel resources of the area to meet the requirements of increasing demand.

Since three basic fuel resources - gas, oil, and lignite - are located in the service area, plans are currently being implemented to use each of these to the best advantage, with due consideration for economics and fuel supply. The use of nuclear energy is the next logical step in development of major energy sources for the area.

Information on TUCS capacity resources is as follows:

(a) The capability assigned to each category of generation for the year 1963 is shown by Table 1.1-5, and changes in capability by type and by years is given in Table 1.1-6.

(b) There are no actual or projected sales affecting capacity resources of TUCS during the subject period.

(c) Capacity purchases for 1963 are shown in Table 1.1-5, and changes by years through 1984 are given in Table 1.1-6.

(d) New generating units and their projected capabilities are shown in Table 1.1-6.

(e) Retirements of generating units are shown in Table 1.1-6.

A summary of generating capacity by type (base, intermediate, and peaking) for the year 1963 and installations by type and by years thereafter is given in Tables 1.1-5 and 1.1-6. The generating capacity additions are indicated to be base, intermediate, or peaking according to the type of service expected for the first few years. Purchases, which are included in these Tables, are indicated to be a very minor part of the power supply of TUCS. 2

A curve for the peak day of 1972, giving the hourly integrated loads of TUCS and depicting the use of base, intermediate, and peaking capacity, is provided in Figure 1.1-5. 1

In the past, when natural gas was virtually the only fuel used by TUCS, and when each new unit was more efficient than its predecessors, each new unit would experience a relatively high annual capacity factor for the first few years, and then would gradually decline as other capacity came on line. More recently solid fuel has been utilized, and the cost differential between solid fuel and natural gas has altered this pattern. Certain units (indicated in Table 1.1-6) now have a low annual capacity factor from the date of installation, and other units, installed as base or intermediate, will be relegated to peaking service as additional lignite-fueled or nuclear-fueled capacity comes on line, and as natural gas use decreases. The key to the type of service which a unit will experience depends fundamentally on availability and economics of the fuel which it utilizes.

A forecast indicating proportions of expected fuel use, and indicating the transition from natural gas to other forms of energy, which will affect the usage of all generating units, is given in Table 1.1-12.

1.1.3 CAPACITY REQUIREMENT

Criteria used by TUCS in determining reserve margin and in planning the bulk power system are as follows:

1. System generating capability is planned to meet estimated load requirements under reasonably predictable operating conditions and with the assumption that construction schedules are met. The planned minimum generating capability reserve will be the greater of:

   a. 15% of forecast maximum hour demand or
   b. that required to insure a likelihood of insufficient generating capability no greater than once in ten years, with due consideration given to unit size, expected forced outage rates, interconnection capacity, installed reserve of neighbors, and the eventuality of loads greater than forecast.

2. Projected Texas Utilities Company System planning will include simulated testing to insure that the system will not experience cascading break-up and collapse initiated by the occurrence of contingencies such as:

   a. loss of all generating capacity at any generating station,
   b. loss of any two generating units,
   c. outage of any circuit or generating unit during scheduled maintenance on any other transmission line or generating unit,
   d. outage of any single or double circuit transmission line, generating unit, transformer, or bus,
   e. simultaneous outage of overhead transmission lines parallel to each other for a substantial distance having a spacing between circuits of less than the height of the structures,
   f. any fault cleared by normal operation of backup relays,
   g. loss of any large load or concentrated load area.

Factors considered in establishing the reserve criteria are:

1. Accuracy of load forecasts
    - a. Temperature variations (from normal)
    - b. Lead time (extent into the future)
    - c. Economic changes
    - d. Load characteristics, new or special loads (from technological change), load factor, and seasonal characteristics

2. Expected operating conditions
    - a. Equipment failure (number, size, rate)
    - b. Fuel supply
    - c. Time of repair
    - d. Transmission limitations
    - e. Interconnections
    - f. Maintenance scheduling
    - g. Reserve of interconnected neighboring utilities

The minimum reserve criteria do not include an amount for serving interruptible load. Also, the minimum reserve criteria do not include an amount for long term construction delay. Plans vary from the reserve criteria to the extent that construction schedules are considered. Where long term construction delays are possible plans may reflect higher than 15% reserve due to use of present "best estimate" of completion dates without unusual unexpected delays.

Although TUCS uses probability analysis to examine reserve margin, the 15% minimum, tempered with judgment, normally controls. The established criteria have proven reliable through the years, as have the methods employed in developing estimates of future demands.

The probability analysis employed makes use of a calculation of the mathematical expectation of insufficient capacity, or "loss-of-load" for each year of the study period. This method is employed over a ten-year period and makes use of forced outage rates developed from industry experience compiled and published by the Edison Electric Institute.

The operation of the proposed Comanche Peak Steam Electric Station is not expected to have any significant effect on the TUCS reserve criteria as presented above. In addition, present and planned interconnections are not expected to affect these criteria.

TIS and ERCOT members install generating capacity to maintain at least 15% reserve above expected peak load. This is stated in the Planning Criteria as follows:

> "Sufficient generating capacity will be provided, as nearly as practicable, to insure a reserve of at least 15% of the forecasted maximum hour demand of the Interconnected System."

Each company is expected, on the average, to provide its proportionate share of this generating capacity. Inasmuch as there is little or no diversity between load demands of the various companies, and similar fuel costs throughout the area, there is little occasion or incentive for interchange of power under normal conditions.

Interchange of power between companies is viewed as a prime avenue for increasing reliability through mutual assistance in emergencies, and to this end the substantial part of intercompany transmission tie capacity is reserved for emergency use, and generating capacity is maintained and operated so as to be in a constant state of readiness to assist in any emergency which may arise throughout the system.

Spinning reserve is distributed both among units and geographically so that maximum benefit is available to all parts of the isolated interconnected system when emergencies arise. Distribution of spinning reserve among units controls frequency most effectively during emergencies and returns frequency to normal in the shortest time after loss of generation.

Power interchange policy is such as to encourage this mutual emergency assistance, with energy so delivered to be paid back in kind when the emergency is past. Should an occasion for economy interchange arise of a more extended duration, such interchange would be subject to operating rules governing minimum spinning reserves to be in service by areas, and to mutual agreement between the parties.

Interconnection capacity of TUCS planned for 1980-82 is approximately 900 MW. This amount of power could be imported with the transmission system normal, and could be sustained with the further loss of any one major transmission circuit.

2 The interconnection capacity of 900 MW is needed in its entirety
1 for system reliability. As stated above, interconnections are
normally operated lightly loaded. It is necessary to operate
in this manner so as to be able to withstand other severe
2 contingencies, such as loss of an entire plant (See Page 1.1-12
for planning criteria).

TUCS ability to import bulk power is limited to about 600 MW at present, grows to about 900 MW by 1977, and remains at that level through 1984. It is of course subject to availability of generating reserves in other parts of ERCOT, and energy transfers would also be subject to energy availability. Any sustained transfer would be subject to contingencies in the transmission network. Reliability would be compromised by any sustained large transfer, as compared with the present practice of operation with lightly loaded ties. 1

1.1.4 STATEMENT ON AREA NEED

As stated previously, the minimum installed reserve criterion for TUCS, TIS, and ERCOT is 15% above forecast maximum demand.

The following information is shown in the accompanying Table 1.1-8 which shows need for the subject facility:

1. TUCS capability resources with the proposed project.
2. TUCS capability resources without the proposed project.
3. TUCS annual system peak demand

As can be noted from Table 1.1-4, the small quantities of purchased power range from 2.3% to 0.5% of total capability resources for the period 1968-1984. For this reason, the generating capability of the TUCS is essentially identical to the capability resources. Although need for the subject facility is based on reserves and capacity requirements of TUCS only, a study of projected capacity additions and reserve margin for ERCOT for the years 1980-1984 is shown in Table 1.1-9, with and without the subject project. 2

The latest dates the proposed nuclear units can be placed in service without endangering the adequacy and reliability of the projected bulk power supply are:

Unit 1 - January 1, 1980

Unit 2 - January 1, 1982

TABLE 1.1-1

TUCS PEAK-HOUR DEMAND AND ANNUAL ENERGY (1)

YEAR	PEAK-HOUR DEMAND, MW	INCREASE MW	INCREASE %	ANNUAL ENERGY 10^6KWH	INCREASE 10^6KWH	INCREASE %	ANNUAL LOAD FACTOR (%)
ACTUAL							
1963	3,770.6	388.7	11.5	16,644	1,946	13.2	50.38
1964	4,181.9	411.3	10.9	17,818	1,174	7.1	48.50
1965	4,330.7	148.8	3.6	19,361	1,543	8.7	51.04
1966	4,891.1	560.4	12.9	21,401	2,040	10.5	49.95
1967	5,410.0	518.9	10.6	23,627	2,226	10.4	49.85
1968	5,699	289	5.3	25,879	2,252	9.5	51.70
1969	6,828	1,129	19.8	29,828	3,949	15.3	49.87
1970	7,188	360	5.3	32,134	2,306	7.7	51.03

TABLE 1.1-1
CONTINUED

TUCS PEAK-HOUR DEMAND AND ANNUAL ENERGY (1)

YEAR	PEAK-HOUR DEMAND, MW	INCREASE MW	INCREASE %	ANNUAL ENERGY 10^6KWH	INCREASE 10^6KWH	INCREASE %	ANNUAL LOAD FACTOR (%)
ACTUAL							
1971	7,679	491	6.8	34,336	2,202	6.9	51.04
1972	8,285	606	7.9	38,888	4,552	13.3	53.44
1973	8,670	385	4.6				
PROJECTED							
1973				41,344	2,456	6.3	
1974	10,286	1,616	18.6	46,159	4,815	11.6	51.23
1975	11,218	932	9.1	50,837	4,678	10.1	51.73
1976	12,224	1,006	9.0	55,706	4,869	9.6	51.88
1977	13,310	1,086	8.9	60,868	5,162	9.3	52.20
1978	14,489	1,179	8.9	66,479	5,611	9.2	52.37

TABLE 1.1-1
CONTINUED

TUCS PEAK-HOUR DEMAND AND ANNUAL ENERGY (1)

YEAR	PEAK-HOUR DEMAND,MW	INCREASE MW	INCREASE %	ANNUAL ENERGY 10^6KWH	INCREASE 10^6KWH	INCREASE %	ANNUAL LOAD FACTOR (%)
PROJECTED							
1979	15,752	1,263	8.7	72,556	6,077	9.1	52.58
1980	17,100	1,348	8.6	78,987	6,431	8.9	52.59
1981	18,536	1,436	8.4	85,810	6,823	8.6	52.84
1982	20,074	1,538	8.3	93,117	7,307	8.5	52.95
1983	21,722	1,648	8.2	100,929	7,812	8.4	53.04
1984	23,484	1,762	8.1	109,340	8,411	8.3	53.00

(1) Excluding interruptible demand and energy supplied to a large industrial customer.

TABLE 1.1-2

TIS PEAK HOUR DEMAND AND ANNUAL ENERGY (1)

YEAR	PEAK-HOUR DEMAND,MW	INCREASE MW	INCREASE %	ANNUAL ENERGY 10^6KWH	INCREASE 10^6KWH	INCREASE %	ANNUAL LOAD FACTOR (%)
ACTUAL							
1963	8,501						
1964	9,367	866	10.2				
1965	9,895	528	5.6				
1966	11,087	1,192	12.1				
1967	12,302	1,215	11.0				
1968	13,257	955	7.8	65,888 (3)			
1969	15,580	2,323	17.5	75,907 (3)	10,019	15.2	55.62
1970	16,410	830	5.3	81,765 (3)	5,858	7.7	56.88
1971	17,614	1,204	7.3	89,047 (3)	7,282	8.9	57.71
1972	19,366	1,752	9.9	99,295 (3)	10,248	11.5	58.37
1973	20,481	1,115	5.8				

TABLE 1.1-2
CONTINUED

TIS PEAK HOUR DEMAND AND ANNUAL ENERGY (1)

YEAR	PEAK-HOUR DEMAND, MW	INCREASE MW	INCREASE %	ANNUAL ENERGY 10^6KWH	INCREASE 10^6KWH	INCREASE %	ANNUAL LOAD FACTOR (%)
PROJECTED (2)							
1973				106,604	7,309	7.4	
1974	23,718	3,237	15.8	116,673	10,069	9.4	56.15
1975	26,035	2,317	9.8	128,485	11,812	10.1	56.34
1976	28,527	2,492	9.6	141,434	12,949	10.1	56.44
1977	31,073	2,546	8.9	153,760	12,326	8.7	56.49
1978	33,751	2,678	8.6	166,592	12,832	8.3	56.35
1979	36,612	2,861	8.5	180,552	13,960	8.4	56.30
1980	39,636	3,024	8.3	195,255	14,703	8.1	56.08
1981	42,852	3,216	8.1	210,688	15,433	7.9	56.13
1982	46,292	3,440	8.0	227,011	16,323	7.7	55.98

TABLE 1.1-2
CONTINUED

TIS PEAK HOUR DEMAND AND ANNUAL ENERGY (1)

YEAR	PEAK-HOUR DEMAND,MW	INCREASE MW	INCREASE %	ANNUAL ENERGY 10^6KWH	INCREASE 10^6KWH	INCREASE %	ANNUAL LOAD FACTOR (%)
PROJECTED (2) (4)							
1983	49,985	3,693	8.0	244,779	17,768	7.8	55.90
1984	53,955	3,970	7.9	263.720	18,941	7.7	55.64

(1) Excluding interruptible demand

(2) Undiversified

(3) Source: FPC Form 12 Reports

(4) Excluding energy delivered to interruptible load

TABLE 1.1-3

ERCOT PEAK HOUR DEMAND AND ANNUAL ENERGY (1) (2)

YEAR	PEAK-HOUR DEMAND,MW	INCREASE MW	INCREASE %	ANNUAL ENERGY 10^6KWH	INCREASE 10^6KWH	INCREASE %	ANNUAL LOAD FACTOR (%)
ACTUAL							
1968							
1969							
1970	17,101	1,703	10.0				
1972	20,648	1,844	9.8				
PROJECTED							
1973	22,568	1,920	9.3	110,504			55.90
1974	24,785	2,217	9.8	120,970	10,466	9.5	55.72
1975	27,255	2,470	10.0	133,414	12,444	10.3	55.88
1976	29,911	2,656	9.7	146,931	13,517	10.1	55.92
1977	32,663	2,752	9.2	159,964	13,033	8.9	55.91
1978	35,583	2,920	8.9	173,858	13,894	8.7	55.78

2

TABLE 1.1-3
CONTINUED

ERCOT PEAK HOUR DEMAND AND ANNUAL ENERGY (1) (2)

YEAR	PEAK-HOUR DEMAND, MW	INCREASE MW	INCREASE %	ANNUAL ENERGY 10^6KWH	INCREASE 10^6KWH	INCREASE %	ANNUAL LOAD FACTOR (%)	
PROJECTED								
1979	38,735	3,152	8.9	189,318	15,460	8.9	55.79	
1980	42,105	3,370	8.7	205,580	16,262	8.6	55.58	
1981	45,733	3,628	8.6	221,018	15,438	7.5	55.17	2
1982	49,666	3,933	8.6	237,478	16,460	7.4	54.58	
1983	53,985	4,319	8.7	257,547	20,069	8.5	54.46	
1984	58,574	4,589	8.5	278,416	20,869	8.1	54.11	

(1) Excluding interruptible demand and energy

(2) Undiversified

Source for data for Amendment 2: ERCOT response to FPC Order 383-3, Docket R-362, dated Sept. 1, 1973.

TABLE 1.1-4

TUCS GENERATION CAPACITY RESOURCES (MW) AT TIME OF ANNUAL PEAK

1968 - 1984

YEAR	GAS/OIL	LIGNITE/ COAL	NUCLEAR	PURCHASES	TOTAL
ACTUAL					
1968	6,865.3	0	0	162.5	7,027.8
1969	7,240.3	0	0	162.5	7,402.8
1970	8,152.3	0	0	162.5	8,314.8
1971	8,900.0	0	0	162.5	9,062.5
1972	9,617.0	575.0	0	162.5	10,354.5
PROJECTED					
1973	9,662.0	1,150.0	0	162.5	10,974.5
1974	10,717.0	1,150.0	0	140.0	12,007.0
1975	11,492.0	1,725.0	0	140.0	13,357.0
1976	11,797.7	2,300.0	0	140.0	14,237.7
1977	12,282.7	3,050.0	0	140.0	15,472.7
1978	12,282.7	4,550.0	0	140.0	16,972.7
1979	12,282.7	6,050.0	0	140.0	18,472.7
1980	12,233.2	6,800.0	1,150.0	140.0	20,323.2
1981	12,233.2	8,075.0	1,150.0	177.5	21,635.7
1982	12,233.2	8,600.0	2,300.0	215.0	23,348.2
1983	12,198.7	10,850.0	2,300.0	215.0	25,563.7
1984	12,198.7	11,600.0	3,450.0	215.0	27,463.7

TABLE 1.1-4 (Continued)

TUCS GENERATION CAPACITY RESOURCES DETAIL BY UNITS

1968

Unit	Capability by Energy Source, MW			Purchases,MW	Type (Base, Intermediate, or Peaking)
	Gas/Oil	Lignite	Nuclear		
Eagle Mountain 1	115				B
Eagle Mountain 2	175				B
Graham 1	240				B
Handley 1	45				P
Handley 2	80				P
Handley 3	400				B
Morgan Creek 1	22				P
Morgan Creek 2	22				P
Morgan Creek 3	44				P
Morgan Creek 4	70				I
Morgan Creek 5	175				I
Morgan Creek 6	500				B

TABLE 1.1-4 (Continued)

TUCS GENERATION CAPACITY RESOURCES DETAIL BY UNITS

Unit	Energy Source, MW Gas/Oil	Lignite	Nuclear	Purchases,MW	Type (Base, Intermediate, or Peaking)
North Main 0	23.8				P
North Main 1	17				P
North Main 4	80				B
Permain Basin 1	13				P
Permain Basin 2	13				P
Permain Basin 3	13				P
Permain Basin 4	13				P
Permain Basin 5	115				B
Wichita Falls 6	13				P
Wichita Falls 7	13				P
Collin	153				I
Lake Creek 1	87				I
Lake Creek 2	230				B
River Crest	110				P

TABLE 1.1-4
TUCS GENERATION CAPACITY RESOURCES (MW)
AT TIME OF ANNUAL PEAK
1963 - 1984

YEAR	GAS/OIL	LIGNITE/ COAL	NUCLEAR	PURCHASES	TOTAL
ACTUAL					
1963	4,085.1	0	0	187.5	4,272.6
1964	4,472.9	0	0	187.5	4,660.4
1965	4,812.9	0	0	187.5	5,000.4
1966	5,496.1	0	0	162.5	5,658.6
1967	6,330.9	0	0	162.5	6,493.4
1968	6,865.3	0	0	162.5	7,027.8
1969	7,240.3	0	0	162.5	7,402.8
1970	8,152.3	0	0	162.5	8,314.8
1971	8,900.0	0	0	162.5	9,062.5
1972	9,617.0	575.0	0	162.5	10,354.5
1973	9,617.0	1,150.0	0	162.5	10,929.5
PROJECTED					
1974	10,717.0	1,150.0	0	140.0	12,007.0
1975	11,492.0	1,725.0	0	140.0	13,357.0
1976	11,797.7	2,300.0	0	140.0	14,237.7
1977	12,282.7	3,050.0	0	140.0	15,472.7
1978	12,282.7	4,550.0	0	140.0	16,972.7
1979	12,282.7	6,050.0	0	140.0	18,472.7
1980	12,233.2	6,800.0	1,150.0	140.0	20,323.2
1981	12,233.2	8,112.5	1,150.0	140.0	21,635.7
1982	12,233.2	8,675.0	2,300.0	140.0	23,348.2
1983	12,198.7	10,925.0	2,300.0	140.0	25,563.7
1984	12,198.7	11,675.0	3,450.0	140.0	27,463.7

2

TABLE 1.1-4 (Continued)

TUCS GENERATION CAPACITY RESOURCES DETAIL BY UNITS

Unit	Energy Source, MW			Purchases,MW	Type (Base, Intermediate, or Peaking)
	Gas/Oil	Lignite	Nuclear		
Mountain Creek 1	34.5				P
Mountain Creek 2	33				P
Mountain Creek 3	70				P
Mountain Creek 4	14				P
Mountain Creek 5	14				P
Mountain Creek 6	115				I
Mountain Creek 7	125				I
Mountain Creek 8	550				B
North Lake 1	175				I
North Lake 2	175				I
North Lake 3	350				B
Parkdale 1	87				P
Parkdale 2	115				I
Parkdale 3	125				I

TABLE 1.1-4 (Continued)

TUCS GENERATION CAPACITY RESOURCES
DETAIL BY UNITS

	Energy Source, MW				
Unit	Gas/Oil	Lignite	Nuclear	Purchases,MW	Type (Base, Intermediate, or Peaking)
Purchases				162.5	-
All other	37.9				P
Total	6,865.3			162.5	

TABLE 1.14- (Continued)

TUCS GENERATION CAPACITY RESOURCES
DETAIL OF CAPABILITY CHANGES
1969-1984

Unit & Year	Energy Source, MW			Purchases, MW	Type (Base, Intermediate, or Peaking) (1)
	Gas/Oil	Lignite	Nuclear		
1969					
Graham 2	+375				P
1970					
Trading-house Creek 1	+565				B
Lake Hubbard 1	+375				P
Mountain Creek 4	- 14				P
Mountain Creek 5	- 14				P
1971					
Terrell	- 2.3				P
Valley 3	+375				P
Eagle Mountain 3	+375				P
1972					
Big Brown 1		+575			B
Waco 3	- 13				P
Trading-house Creek 2	+730				B

(1) At time of installation

TABLE 1.1-4 (Continued)

TUCS GENERATION CAPACITY RESOURCES
DETAIL OF CAPABILITY CHANGES
1969-1984

Unit & Year	Energy Source, MW			Purchases,MW	Type (Base, Intermediate or Peaking)(1)
	Gas/Oil	Lignite/ Coal	Nuclear		
1973					
					B
Big Brown 2		+575			B
1974					
Lake Hubbard 2	+515				B
Permian Basin 6	+540				B
Purchases				-22.5	-
Trading-house 2 (Adj.)	+ 45				

(1) At time of installation

TABLE 1.1-4 (Continued)

TUCS GENERATION CAPACITY RESOURCES
DETAIL OF CAPABILITY CHANGES
1969-1984

Unit & Year	Energy Source, MW			Purchases,MW	Type (Base, Intermediate, or Peaking)(1)
	Gas/Oil	Lignite/ Coal	Nuclear		
1975					
Monticello 1		+575			B
DeCordova 1	+775				B
1976					
Monticello 2		+575			B
Handley 4	+425				P
Unannounced Retirements	-119.3				P
1977					
Martin Lake 1		+750			B
Martin Lake CT	+ 60				P
Handley 5	+425				P
1978					
Martin Lake 2		+750			B
Monticello 3		+750			B

TABLE 1.1-4 (Continued)

TUCS GENERATION CAPACITY RESOURCES
DETAIL OF CAPABILITY CHANGES
1969-1984

Unit & Year	Energy Source, MW			Purchases, MW	Type (Base, Intermediate, or Peaking) (1)
	Gas/Oil	Lignite/ Coal	Nuclear		
1979					
Martin Lake 3		+750			B
Unassigned		+750			B
1980					
Comanche Peak 1			+1150		B
Martin Lake 4		+750			B
Unannounced Retirements	-49.5				P
1981					
Unassigned		+750			B
Unassigned		+525		+37.5	B

(1) At time of installation

TABLE 1.1-4 (Continued)

TUCS GENERATION CAPACITY RESOURCES
DETAIL OF CAPABILITY CHANGES
1969-1984

Unit & Year	Energy Source, MW Gas/Oil	 Lignite/ Coal	 Nuclear	Purchases,MW	Type (Base, Intermediate or Peaking)(1)
1982					
Comanche Peak 2			+1150		B
Unassigned		+525		+37.5	B
1983					
Unassigned		+750			B
Unassigned		+750			B
Unassigned		+750			B
Unannounced Retirements	-34.5				P
1984					
Unassigned		+750			B
Unassigned			+1150		

(1) At time of installation

TABLE 1.1-5

TUCS MONTHLY DEMAND AND ENERGY FORECASTS
1980 AND 1982

	Firm Load		Interruptible Load		Purchases	
	MW	Energy, 10^6KWH	MW	Energy, 10^6KWH	Capacity MW	Energy, 10^6KWH
1980						
January	10,090	5,627	451	287	140	33
February	10,009	5,130	451	286	140	31
March	9,550	5,455	451	287	140	33
April	10,635	5,560	511	288	80	(17)
May	13,387	6,389	511	288	80	(16)
June	16,010	7,801	451	287	140	38
July	16,736	8,997	451	287	140	38
August	17,100	9,021	451	287	140	38
Sept.	16,208	7,526	451	287	140	31
October	13,187	6,099	511	288	80	(20)
Nov.	10,566	5,565	511	288	80	(20)
Dec.	10,734	5,817	451	287	140	31
		78,987		3,447		200
1982						
January	11,906	6,635	261	121	215	23
February	11,817	6,043	261	119	215	29
March	11,216	6,426	321	121	155	(33)
April	12,454	6,542	261	121	140	33
May	15,740	7,525	321	121	155	(32)
June	18,817	9,210	261	121	215	38
July	19,664	10,616	261	121	215	38
August	20,074	10,642	261	121	215	38
Sept.	19,053	8,875	261	121	215	31
October	15,460	7,189	261	121	140	30
November	12,408	6,562	321	121	155	(36)
December	12,610	6,852	261	121	215	31
		93,117		1,450		200

TABLE 1.1-6

TUCS GENERATING CAPABILITY ADDITIONS (MW) (1)
FROM ANNUAL PEAK TO ANNUAL PEAK
1968-1984

YEAR	GAS/OIL	LIGNITE/ COAL	NUCLEAR	PURCHASES	TOTAL
ACTUAL					
1968	550	0	0	0	550
1969	375	0	0	0	375
1970	940	0	0	0	940
1971	750	0	0	0	750
1972	730	575	0	0	1,305
PROJECTED					
1973		575	0	0	575
1974	1,100	0	0	0	1,100
1975	775	575	0	0	1,350
1976	425	575	0	0	1,000
1977	485	750	0	0	1,235
1978		1,500	0	0	1,500
1979		1,500	0	0	1,500
1980	0	750	1,150	0	1,900
1981		1,275	0	37.5	1,312.5
1982	0	525	1,150	37.5	1,712.5
1983		2,250	0	0	2,250
1984	0	750	1,150	0	1,900

(1) Gross additions only; retirements are shown in Table 1.1-7.

TABLE 1.1-7

TUCS GENERATING CAPABILITY DELETIONS (MW) FROM ANNUAL PEAK TO ANNUAL PEAK
1968-1984

YEAR	GAS/OIL	PURCHASES	TOTAL
ACTUAL			
1968	15.6	0	15.6
1969	0	0	0
1970	28.0	0	28.0
1971	2.3	0	2.3
1972	13.0	0	13.0
PROJECTED			
1973	0	0	0
1974	0	22.5	22.5
1975	0	0	0
1976	119.3	0	119.3
1977	0	0	0
1978	0	0	0
1979	0	0	0
1980	49.5	0	49.5
1981	0	0	0
1982	0	0	0
1983	34.5	0	34.5
1984	0	0	0

TABLE 1.1-6 (Continued)
TUCS GENERATION CAPACITY RESOURCES
DETAIL OF CAPABILITY CHANGES
FROM ANNUAL PEAK TO ANNUAL PEAK
1963 - 1984

Unit and Year	Capability By Energy Source, MW			Purchases, MW	Type (Base, Intermediate Or Peaking) (1)	
	Gas/Oil	Lignite/ Coal	Nuclear			
1974						
Lake Hubbard 2	+515				B (DPL)	
Permian Basin 6	+540				B (TES)	
Purchases				-22.5	-	
Tradinghouse 2 (Adjustm't.)	+45				B (TPL)	
1975						
Monticello 1		+575			B (JOINT)	
DeCordova 1	+775				B (TPL)	
1976						
Monticello 2		+575			B (JOINT)	
Handley 4	+425				P (TES)	
Unannounced Retirements	-119.3				P	2
1977						
Martin Lake 1		+750			B (JOINT)	
Martin Lake CT	+60				P (JOINT)	
Handley 5	+425				P (TES)	
1978						
Martin Lake 2		+750			B (JOINT)	
Monticello 3		+750			B (JOINT)	
1979						
Martin Lake 3		+750			B (JOINT)	
Unassigned		+750			B (TPL)	
1980						
Comanche Peak 1			+1150		B (JOINT)	

(1) At time of installation

TABLE 1.1-6 (Continued)
TUCS GENERATION CAPACITY RESOURCES
DETAIL OF CAPABILITY CHANGES
FROM ANNUAL PEAK TO ANNUAL PEAK
1963 - 1984

	Capability By Energy Source, MW					
Unit and Year	Gas/Oil	Lignite/ Coal	Nuclear	Pur- chases, MW	Type (Base, Intermediate Or Peaking) (1)	
1980 (Cont.)						
Martin Lake 4		+750			B (JOINT)	
Unannounced Retirements	-49.5				P	2
1981						
Unassigned		+750			B (JOINT)	
Unassigned		+562.5			B -	
1982						
Comanche Peak 2			+1150		B (JOINT)	
Unassigned		+562.5			B -	
1983						
Unassigned		+750			B (JOINT)	
Unassigned		+750			B (JOINT)	
Unassigned		+750			B (JOINT)	
Unannounced Retirements	-34.5				P -	
1984						
Unassigned		+750			B (JOINT)	
Unassigned			+1150		B (JOINT)	

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(1) At time of installation

TABLE 1.1-8

TUCS CAPACITY RESOURCES, DEMAND, AND RESERVE MARGIN AT TIME OF ANNUAL PEAK

YEAR	CAPACITY RESOURCES (MW)	PEAK-HOUR DEMAND (MW) (1)	RESERVE MARGIN (MW)	RESERVE MARGIN %
ACTUAL				
1968	7,027.8	5,699	1,328.8	23.3
1969	7,402.8	6,828	574.8	8.4
1970	8,314.8	7,188	1,126.8	15.7
1971	9,062.5	7,679	1,383.5	18.0
1972	10,354.5	8,285	2,069.5	25.0
PROJECTED - with Comanche Peak				
1973	10,929.5	9,399	1,530.5	16.3
1974	12,007.0	10,286	1,721.0	16.7
1975	13,357.0	11,218	2,139.0	19.1
1976	14,237.7	12,224	2,013.7	16.5
1977	15,472.7	13,310	2,162.7	16.2
1978	16,972.7	14,489	2,483.7	17.1
1979	18,427.7	15,752	2,720.7	17.3
1980	20,323.2	17,100	3,223.2	18.8
1981	21,635.7	18,536	3,099.7	16.7
1982	23,348.2	20,074	3,274.2	16.3
1983	25,563.7	21,722	3,841.7	17.7
1984	27,463.7	23,484	3,979.7	16.9

TABLE 1.1-8
CONTINUED

TUCS CAPACITY RESOURCES, DEMAND, AND RESERVE MARGIN AT TIME OF ANNUAL PEAK

YEAR	CAPACITY RESOURCES (MW)	PEAK-HOUR DEMAND (MW) (1)	RESERVE MARGIN (MW)	RESERVE MARGIN %
PROJECTED - without Comanche Peak				
1980	19,173.2	17,100	2,073.2	12.1
1981	20,485.7	18,536	1,949.7	10.5
1982	21,048.2	20,074	974.2	4.9
1983	23,263.7	21,722	1,541.7	7.1
1984	25,163.7	23,484	1,679.7	7.2

(1) Excluding interruptible demand of a large industrial customer.

TABLE 1.1-8 (Continued)
TEXAS UTILITIES COMPANY SYSTEM
CAPABILITIES, DEMANDS AND RESERVES BY COMPANIES
1963 - 1984

KILOWATTS

(ASSUMED ANNUAL PEAK IN AUGUST)

	DPL	TES	TPL*	TUCS*
HISTORIC				
1973*				
Added Capability	191,667	191,667	191,667	575,000
Total Capability	2,936,334	3,349,792	4,643,384	10,929,508
Demand	2,231,000	2,870,000	3,638,000	8,670,000
Reserve	705,334	479,792	1,005,384	2,259,508
% Reserve	31.6	16.7	27.6	26.1
Time of Peak	Aug. 14	Aug. 23	Aug. 21	Aug. 21

2

	DPL	TES	TPL*	TUCS*
PROJECTED				
1974*				
Added Capability	515,000	528,750	33,750	1,077,500
Total Capability	3,451,334	3,878,542	4,677,134	12,007,008
Demand	2,665,000	3,421,000	4,200,000	10,286,000
Reserve	786,334	457,542	477,134	1,721,008
% Reserve	29.5	13.4	11.4	16.7
1975*				
Added Capability	115,000	172,500	1,062,500	1,350,000
Total Capability	3,566,334	4,051,042	5,739,634	13,357,008
Demand	2,850,000	3,678,000	4,690,000	11,218,000
Reserve	716,334	373,042	1,049,634	2,139,008
% Reserve	25.1	10.1	22.4	19.1
1976*				
Added Capability	36,500	556,700	287,500	880,700
Total Capability	3,602,834	4,607,742	6,027,134	14,237,708
Demand	3,050,000	3,954,000	5,220,000	12,224,000
Reserve	552,834	653,742	807,134	2,013,708
% Reserve	18.1	16.5	15.5	16.5
1977*				
Added Capability	162,000	587,000	486,000	1,235,000
Total Capability	3,764,834	5,194,742	6,513,134	15,472,708
Demand	3,260,000	4,250,000	5,800,000	13,310,000
Reserve	504,834	944,742	713,134	2,162,708
% Reserve	15.5	22.2	12.3	16.2
1978*				
Added Capability	300,000	375,000	825,000	1,500,000
Total Capability	4,064,834	5,569,742	7,338,134	16,972,708
Demand	3,480,000	4,569,000	6,440,000	14,489,000
Reserve	584,834	1,000,742	898,134	2,483,708
% Reserve	16.8	21.9	13.9	17.1

* Excluding Alcoa Interruptible Demand

TABLE 1.1-8 (Continued)
TEXAS UTILITIES COMPANY SYSTEM
CAPABILITIES, DEMANDS AND RESERVES BY COMPANIES
1963 - 1984

KILOWATTS

(ASSUMED ANNUAL PEAK IN AUGUST)

	DPL	TES	TPL*	TUCS*
PROJECTED				
1979*				
Added Capability	150,000	150,000	1,200,000	1,500,000
Total Capability	4,214,834	5,719,742	8,538,134	18,472,708
Demand	3,710,000	4,912,000	7,130,000	15,752,000
Reserve	504,834	807,742	1,408,134	2,720,708
% Reserve	13.6	16.4	19.7	17.3
PROJECTED WITH COMANCHE PEAK 2				
1980*				
Added Capability	533,333	533,333	783,833	1,850,500
Total Capability	4,748,167	6,253,075	9,321,967	20,323,208
Demand	3,930,000	5,280,000	7,890,000	17,100,000
Reserve	818,167	973,075	1,431,967	3,223,208
% Reserve	20.8	18.4	18.1	18.8
1981*				
Added Capability	75,000	337,500	900,000	1,312,500
Total Capability	4,823,167	6,590,575	10,221,967	21,635,708
Demand	4,150,000	5,676,000	8,710,000	18,536,000
Reserve	673,167	914,575	1,511,967	3,099,708
% Reserve	16.2	16.1	17.4	16.7
1982*				
Added Capability	383,333	383,333	945,833	1,712,500
Total Capabiltiy	5,206,500	6,973,908	11,167,800	23,348,208
Demand	4,370,000	6,104,000	9,600,000	20,074,000
Reserve	836,500	869,908	1,567,800	3,274,208
% Reserve	19.1	14.3	16.3	16.3
1983*				
Added Capability				2,215,500
Total Capability	Allocations of the capacity of Joint Units to the respective companies have not been determined for 1983 and later.			25,563,708
Demand				21,722,000
Reserve				3,841,708
% Reserve				17.7
1984*				
Added Capability				1,900,000
Total Capability				27,463,708
Demand				23,484,000
Reserve				3,979,708
% Reserve				16.9

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* Excluding Alcoa Interruptible Demand

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TABLE 1.1-8 (Continued)
TEXAS UTILITIES COMPANY SYSTEM
CAPABILITIES, DEMANDS AND RESERVES BY COMPANIES
1980 - 1984 PROJECTED

KILOWATTS

WITHOUT COMANCHE PEAK

(ASSUMED ANNUAL PEAK IN AUGUST)

	DPL	TES	TPL*	TUCS*
1980*				
Added Capability	150,000	150,000	400,500	700,500
Total Capability	4,364,834	5,869,742	8,938,634	19,173,208
Demand	3,930,000	5,280,000	7,890,000	17,100,000
Reserve	434,834	589,742	1,048,634	2,073,208
% Reserve	11.1	11.2	13.3	12.1
1981*				
Added Capability	75,000	337,500	900,000	1,312,500
Total Capability	4,439,834	6,207,242	9,838,634	20,485,708
Demand	4,150,000	5,676,000	8,710,000	18,536,000
Reserve	289,834	531,242	1,128,634	1,949,708
% Reserve	7.0	9.4	13.0	10.5
1982*				
Added Capability	0	0	562,500	562,500
Total Capability	4,439,834	6,207,242	10,401,134	21,048,208
Demand	4,370,000	6,104,000	9,600,000	20,074,000
Reserve	69,834	103,242	801,134	974,208
% Reserve	1.6	1.7	8.4	4.9
1983*				
Added Capability	Allocations of the capacity of Joint Units to the respective companies have not been determined for 1983 and later.			2,215,500
Total Capability				23,263,708
Demand				21,722,000
Reserve				1,541,708
% Reserve				7.1
1984*				
Added Capability				1,900,000
Total Capability				25,163,708
Demand				23,484,000
Reserve				1,679,708
% Reserve				7.2

* Excluding Alcoa Interruptible Demand

TABLE 1.1-9

PROJECTED ERCOT CAPACITY RESOURCES, PEAK-HOUR DEMANDS, AND RESERVE MARGINS

WITH COMANCHE PEAK

YEAR	RESOURCES (MW)	PEAK-HOUR DEMANDS (MW) (1) (2)	RESERVE MARGIN (MW)	RESERVE MARGIN (%)
1980	50,649	42,105	8,544	20.3
1981	56,535	45,733	10,802	23.6
1982	61,109	49,666	11,443	23.0
1983	65,654	53,985	11,669	21.6
1984	70,214	58,574	11,640	19.9

WITHOUT COMANCHE PEAK

YEAR	RESOURCES (MW)	PEAK-HOUR DEMANDS (MW) (1) (2)	RESERVE MARGIN (MW)	RESERVE MARGIN (%)
1980	49,499	42,105	7,394	17.5
1981	55,385	45,733	9,652	21.1
1982	58,809	49,666	9,143	18.4
1983	63,354	53,985	9,369	17.4
1984	67,914	58,574	9,340	15.9

(1) Excluding interruptible demands

(2) Undiversified

Source: National Power Survey Data, February 1973

TABLE 1.1-10
TEXAS UTILITIES COMPANY SYSTEM
ELECTRIC ENERGY SALES BY CUSTOMER CLASS
1963-1972 (HISTORICAL)

2

	1963		1964		1965	
	MWH	%	MWH	%	MWH	%
Residential	4,558,869	30	4,871,843	29	5,321,418	29
Commercial	4,193,598	27	4,429,626	27	4,835,472	27
Industrial*	4,831,514	32	5,433,984	33	5,946,933	33
Government and Municipal	585,053	4	640,427	4	689,845	4
Other Electric Utilities	1,028,253	7	1,133,834	7	1,178,004	7
TOTAL	15,197,287	100	16,509,719	100	17,971,672	100
*Includes interruptible service to a large industrial customer	-		226,265		228,901	

	1966		1967		1968	
	MWH	%	MWH	%	MWH	%
Residential	5,716,174	29	6,415,514	29	7,281,535	30
Commercial	5,218,604	26	5,739,264	26	6,226,452	25
Industrial*	7,032,983	35	7,934,421	35	8,597,143	35
Government and Municipal	740,902	4	817,445	4	845,171	4
Other Electric Utilities	1,246,332	6	1,371,243	6	1,584,018	6
TOTAL	19,954,995	100	22,277,887	100	24,534,319	100
*Includes interruptible service to a large industrial customer	411,742		595,674		551,333	

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TABLE 1.1-12

RELATIVE PROPORTIONS OF TUCS ACTUAL AND PROJECTED FUEL USE 1970-1982

Year	Gas/Oil %	Lignite/Coal %	Nuclear %	Total %
1970 (Actual)	100.0	0.		100.0
1971 (Actual)	100.0	0.		100.0
1972 (Actual)	94.0	6.0		100.0
1973	85.4	14.6		100.0
1974	85.7	14.3		100.0
1975	80.7	19.3		100.0
1976	76.6	23.4		100.0
1977	71.5	28.5		100.0
1978	61.6	38.4		100.0
1979	53.2	46.8		100.0
1980	43.3	48.7	8.0	100.0
1981	32.2	59.8	8.0	100.0
1982	28.2	56.8	15.0	100.0

2

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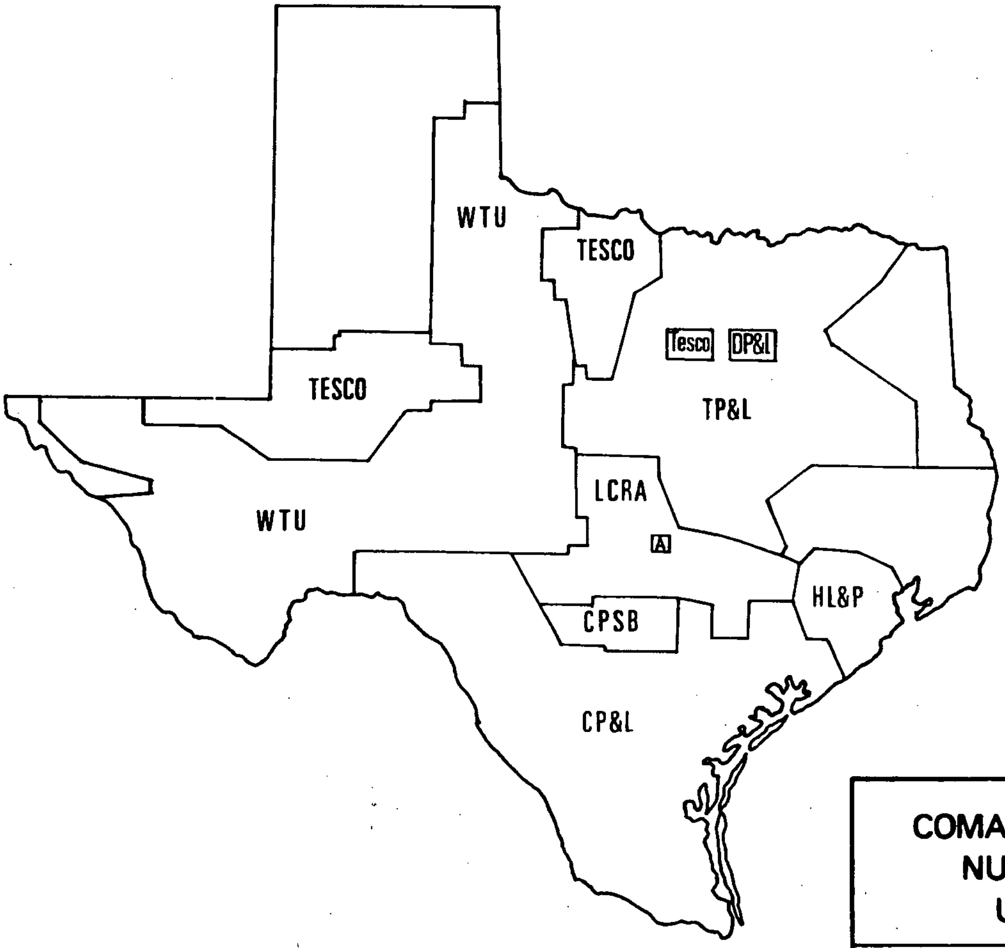
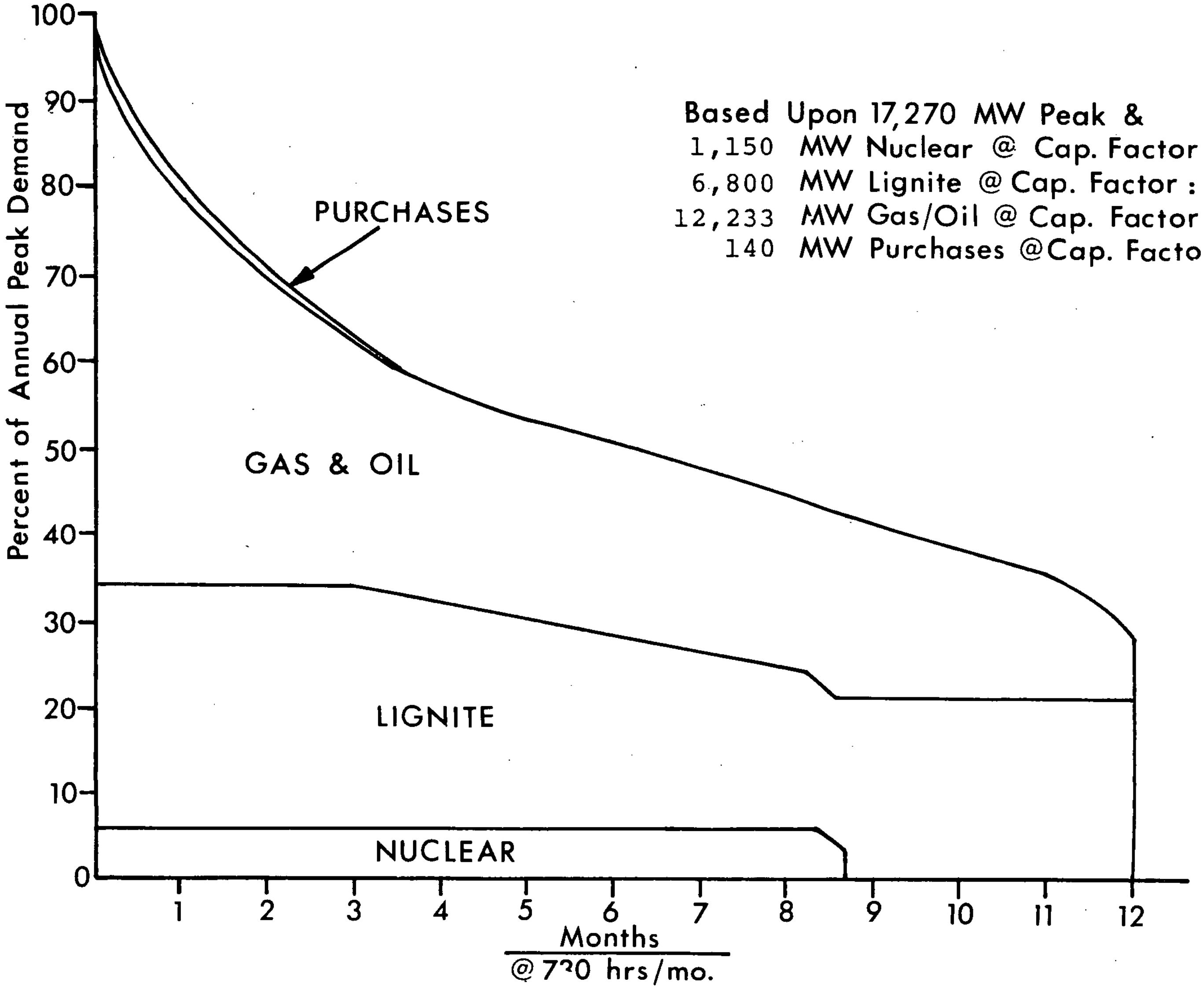
TEXAS INTERCONNECTED SYSTEM



COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

TEXAS
INTERCONNECTED SYSTEM

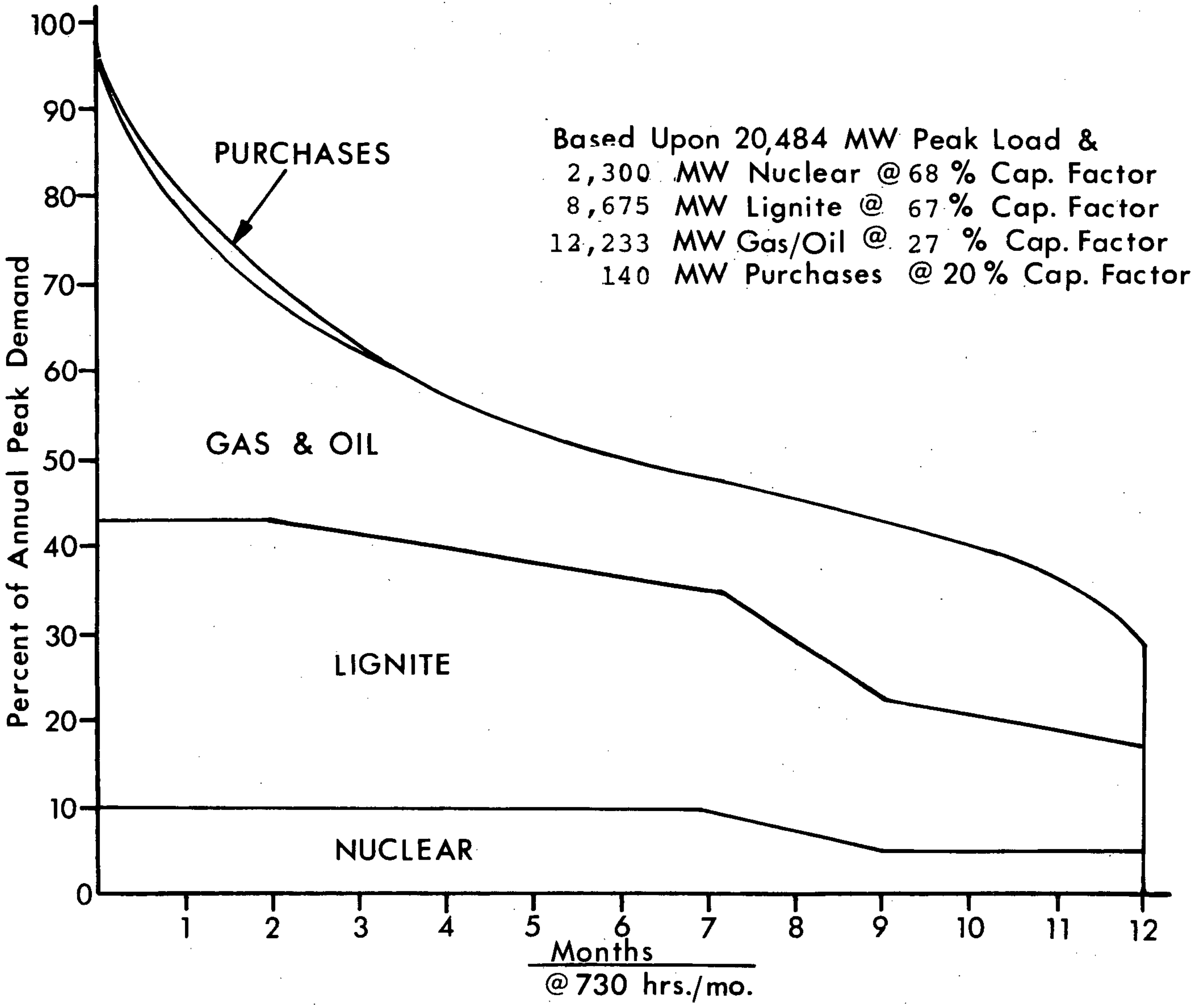
FIGURE 1.1-1



Based Upon 17,270 MW Peak &
1,150 MW Nuclear @ Cap. Factor: 63%
6,800 MW Lignite @ Cap. Factor: 64%
12,233 MW Gas/Oil @ Cap. Factor: 32%
140 MW Purchases @ Cap. Factor: 20%

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2
TUCS LOAD DURATION CURVE
1980 OPERATION

FIGURE 1.1-2



COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

TUCS LOAD DURATION CURVE
1982 OPERATION

FIGURE 1.1-3

1.2 OTHER PRIMARY OBJECTIVES

No other primary objectives exist at this time.

1.3 CONSEQUENCES OF DELAY

The reserve for the Texas Utilities Company System would be sub-normal beginning in 1980 without the subject unit. Of course, the actual location and timing of a power shortage would depend on many factors, with varying probabilities and within the companies' control in varying degrees. Examples are:

1. the bringing of other capacity into commercial service as scheduled in 1980 and prior years

2. actual load developments greater or less than planned, due to increased or decreased economic activity, and depending in an increasing degree on summer temperatures

3. generating unit forced outages

4. storms and other natual disasters which can affect the power system

The normal planned reserve, and prudent design of the bulk power system, are intended to guard against these and other contingencies. When reserve is depressed, the probability of power shortage begins to increase, and continues to increase as reserve is further depressed, until at some point contingencies begin to control and a power shortage results. The power shortage would in all likelihood cover the entire Texas Utilities Company System, including the Dallas-Ft.Worth metropolitan area, and many other communities in North, Central and West Texas.

As public utilities, the three joint owners have a general legal obligation to supply electric energy in the areas which they serve. All municipalities in Texas are empowered by statute to regulate rates and to prescribe rules and regulations under which service is rendered by electric utility corporations; and in some areas such rules and regulations, and franchises granted by municipalities, provide specifically for such an obligation to render service. As discussed in more detail under 1.1.3, System Demand and Resource Capability Comparison, the proposed facility will contribute to TUCS generating capacity, and enable the three electric utility subsidiaries to meet their obligations to supply service.

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2.0 THE SITE

3

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LIST OF FIGURES (Continued)

2.0 THE SITE

2.1 SITE LOCATION & LAYOUT

2.1.1 SITE LOCATION

The site is located in Hood and Somervell Counties, Texas, about 65 miles southwest of Dallas-Fort Worth Metropolitan area. The site is defined as that area to be occupied by the Comanche Peak Steam Electric Station (CPSES), Squaw Creek Reservoir (SCR), the visitor facilities and the adjacent areas owned by the applicant. The site covers approximately 8876 acres and is jointly owned by Dallas Power & Light Company, Texas Electric Service Company, and Texas Power & Light Company.

CPSES will be located on a small ridge immediately west of Squaw Creek, about five miles north-northwest of Glen Rose, and ten miles south of Granbury. The location and coordinates of CPSES are presented on Figure 2.1-1. Figure 2.1-2 provides a more definitive view of the region and Figure 2.1-3 shows the plant boundary and other significant features of the proposed facility. Figure 2.1-4 shows the plant perimeter and exclusion area and delineates the land uses within the exclusion area.

A cooling water impoundment of approximately 3200 surface acres will be formed by damming Squaw Creek, a small tributary stream which enters the Paluxy River near the Paluxy-Brazos River confluence, as shown in Figure 2.1-3.

Although specific design details for a Visitor's Center had not been developed at the time this Report was published, some general guidelines have been formulated. It is felt that this facility will be a modest and permanent structure whose architecture will be compatible with the historical and natural background of the site area.

The interior of the Center will include a number of visual displays pertaining to such aspects of nuclear power generation as historical development, operating principles, and safety. Also under consideration are a few visitor-participation demonstration type displays, plus an auditorium capable of seating some 75-100 persons for program presentations. More complete details regarding the location, design, and appearance of the Center will be appended to this Report when they are available.

2.1.2 SITE DESCRIPTION

Some of the more important characteristics of the site may be summarized as follows:

(a) Climate - sub-humid and temperate, with long summers and mild winters. The mean annual temperature is about 65°F; precipitation averages 31 inches per year and net lake evaporation reaches approximately 45 inches per year. Mean annual humidity ranges from about 80 percent in the morning to about 50 percent in the evening.[1]

(b) Topography - gently rolling to hilly, as shown on Figure 2.1-3. Elevations within the site boundaries range from about 640 feet to 860 feet. The topography is influenced by the underlying geology, with steeper slopes in areas underlain by limestone areas than in areas underlain by shale and sandstone.

(c) Drainage - provided by Squaw Creek, a small tributary to the Paluxy River, which in turn, is a tributary to the Brazos River, one of the principal rivers in the southwest.

(d) Soils - range from sandy to sandy loams.

(e) Natural Vegetation - consists primarily of blackland prairie, cross timbers vegetation, and juniper-oak savanna. Blackland prairies are characterized by medium-tall grasses, while cross timbers vegetation is typified by medium-tall grasses interspersed with groves of post and blackjack oaks. The juniper-oak savanna is largely composed of deciduous broad-leaf trees and small evergreens and shrubs as well as a variety of grasses.

(f) Land Usage - predominately agricultural. About two-
thirds of the 8876 acre site is presently used for
grazing, with range conditions varying from improved
3 pastures to dense juniper woodland range. About 13
percent of the area is planted in crops, including
peanuts, sorghum and cotton.

(g) Transportation - major highways in the site vicinity include U.S. Highways 377 and 67, State Highway 144, and Farm-to-Market Roads 51 and 201. Access to CPSES will be along a 2.1 mile access road extending from FM 201, as shown on Figure 2.1-3. Tracks of the AT & SF Railway approach from the northwest to within about 10 miles of the site; rail access will be provided by construction of a spur approximately 11 miles long. Major surface and air transportation routes, together with their amounts of traffic, are provided in Figures 2.1-5 and 2.1-6.

(h) Nearby Industrial & Public Facilities - include a number of schools, hospitals, county buildings and industrial structures; one fossil fuel power plant is under construction. The location of all major industrial and public facilities is provided in Figure 2.1-7, while Table 2.1-1 provides information concerning the sizes of the facilities.

2.1.3 REFERENCES

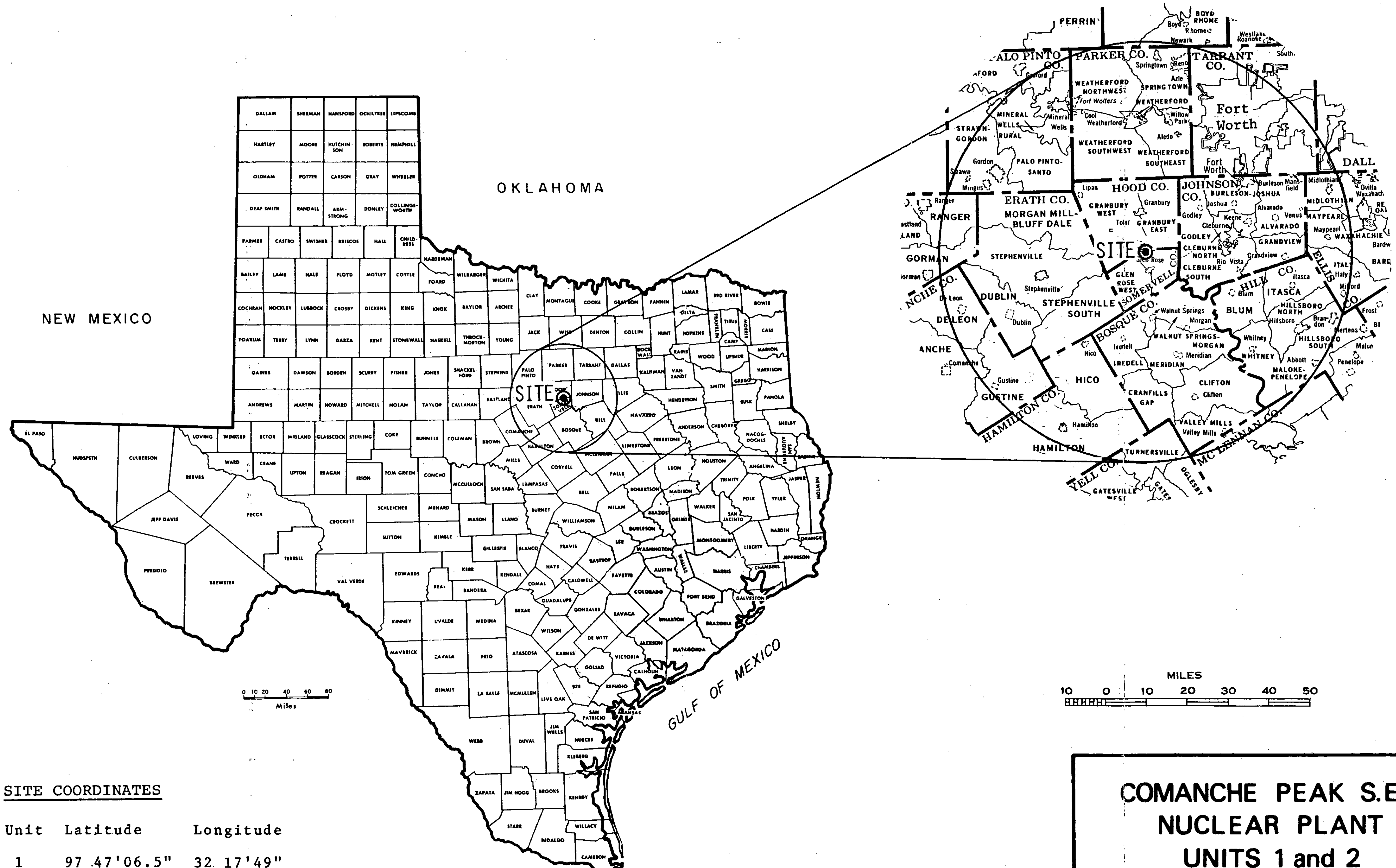
1. Arbingast, Stanley A., Kennamer, Lorrin G., Bonnie, Michael E., Atlas of Texas, Bureau of Business Research, University of Texas at Austin, 1967.

Table 2.1-1

PUBLIC FACILITIES, INSTITUTIONS AND INDUSTRIAL FACILITIES WITHIN TEN MILES OF CPSES

Facilities	Distance	Direction	Population	
*Glen Rose School District Grades 1-12	5-1/2 miles	SSE	610 students & staff	3
*Granbury School District Grades 1-12	10 miles	N	1,322 students & staff	
*Tolar School District Grades 1-12	10 miles	NW	295 students & staff	
Marks-English Hospital (includes hospital and nursing home)	5 miles	S	131 patients & staff	3
Granbury General Hospital	10 miles	N	22 patients	
Somervell County Jail	4-1/2 miles	SSE	5 (includes jailer)	
Dinosaur Valley State Park	4-1/2 miles	SW	See Section 2.2.1.1	
Cedar Brake (Girl Scout)	4-2/3 miles	SW	80 adults & children	
Camp Leonard (Boy Scout)	9-1/2 miles	NNE	800 children	
Camp Tres Rios (YWCA)	5 miles	SE	400 children	
Maybelle Sportswear Company	10 miles	N	62 employees	
Maryland Embroidery Company	10 miles	N	52 employees	
De Cordova Bend Steam Electric Station (under construction by TP & L)	8.7 miles	NE	30 employees (starting in 1975)	
Lake Granbury Recreation	8-10 miles	NE	Transient	

* Students are housed at one location



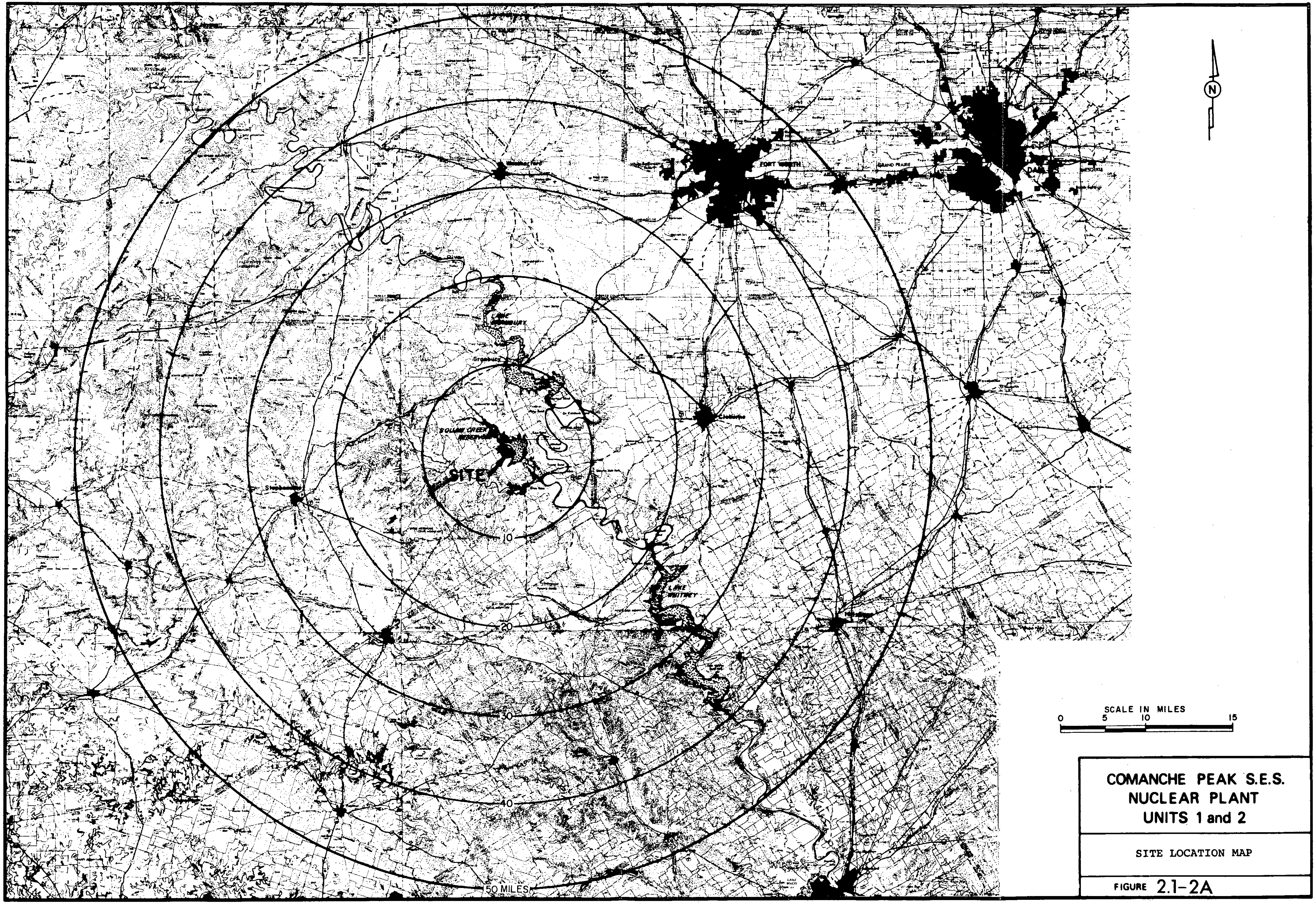
SITE COORDINATES

Unit	Latitude	Longitude
1	97 47'06.5"	32 17'49"
2	97 47'06"	32 17'52"

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

SITE LOCATION

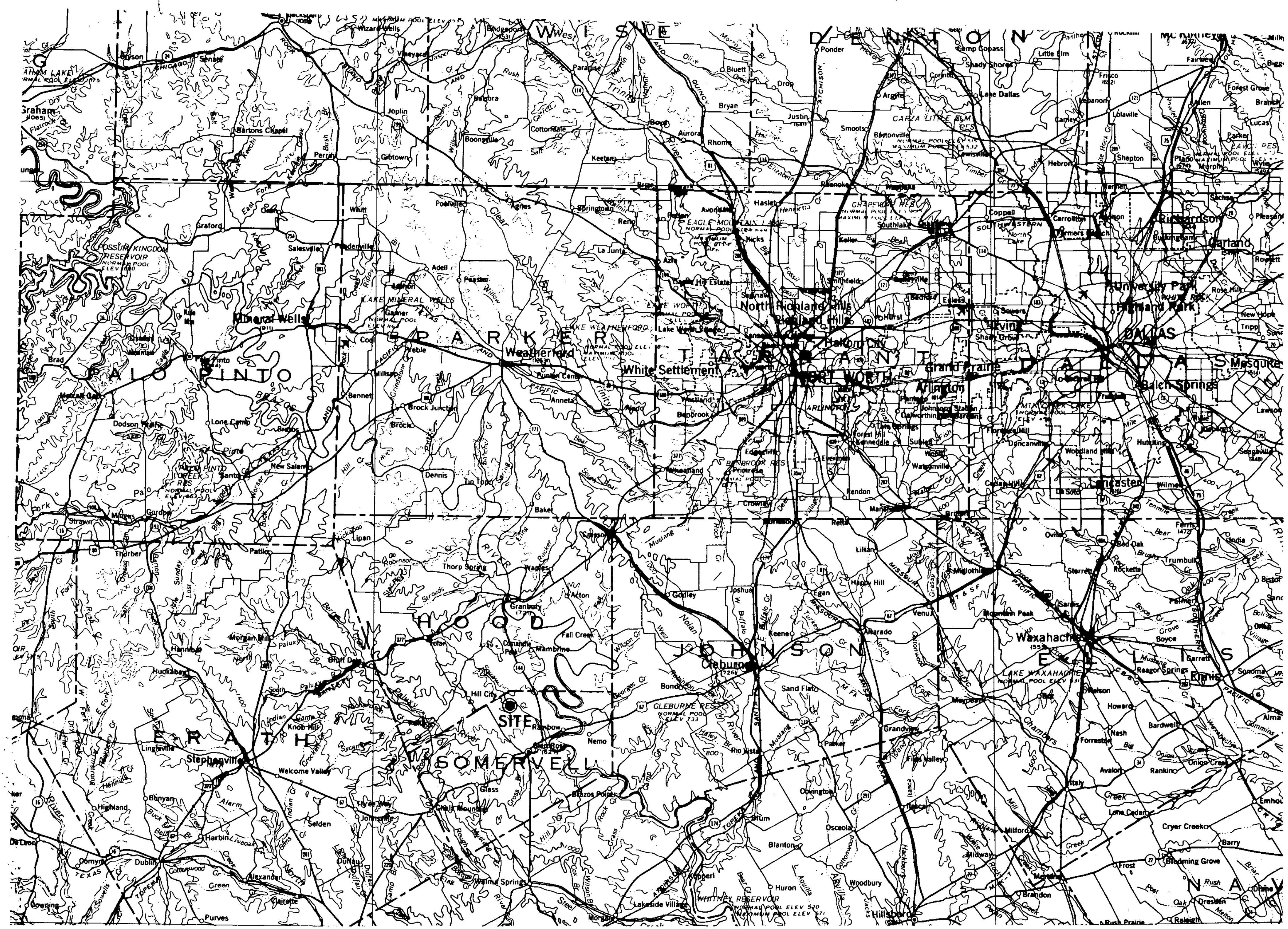
FIGURE 2.1-1



COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

SITE LOCATION MAP

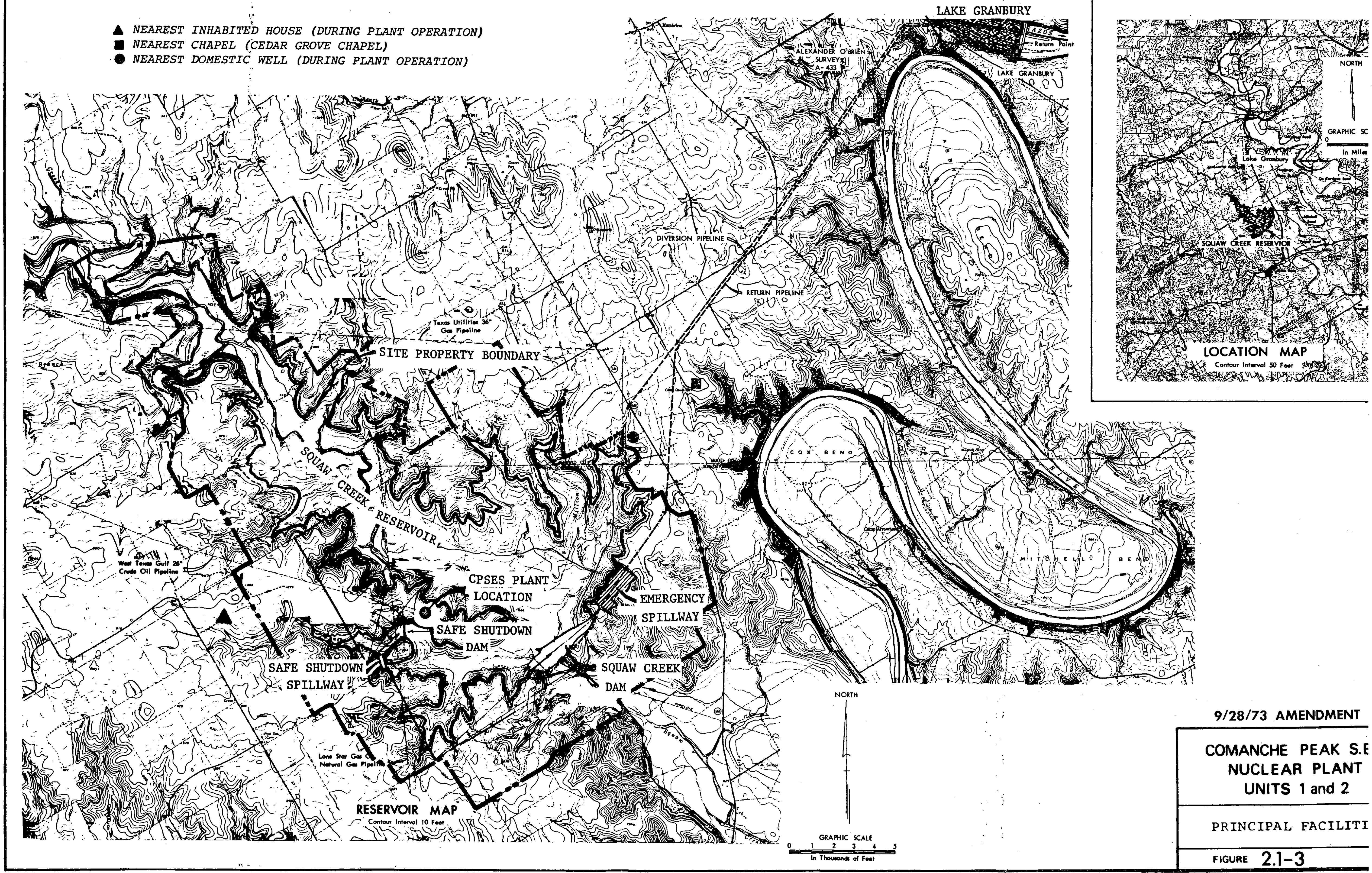
FIGURE 2.1-2A



COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

LOCATION MAP

FIGURE 2.1-2B



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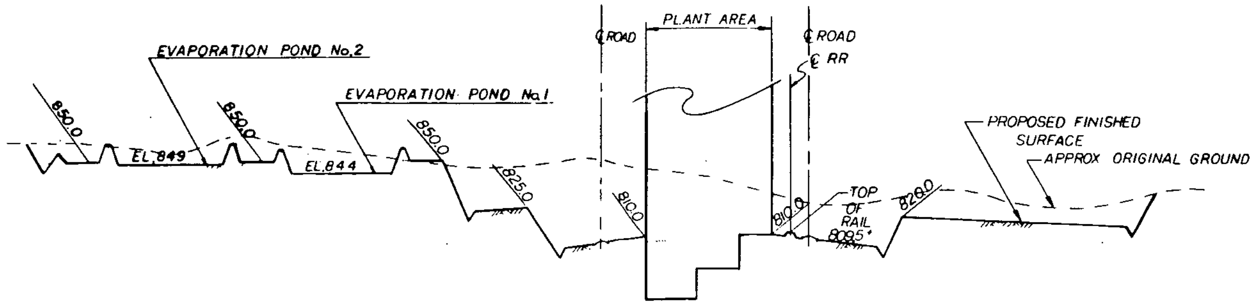
COMANCHE PEAK S.E
NUCLEAR PLANT
UNITS 1 and 2

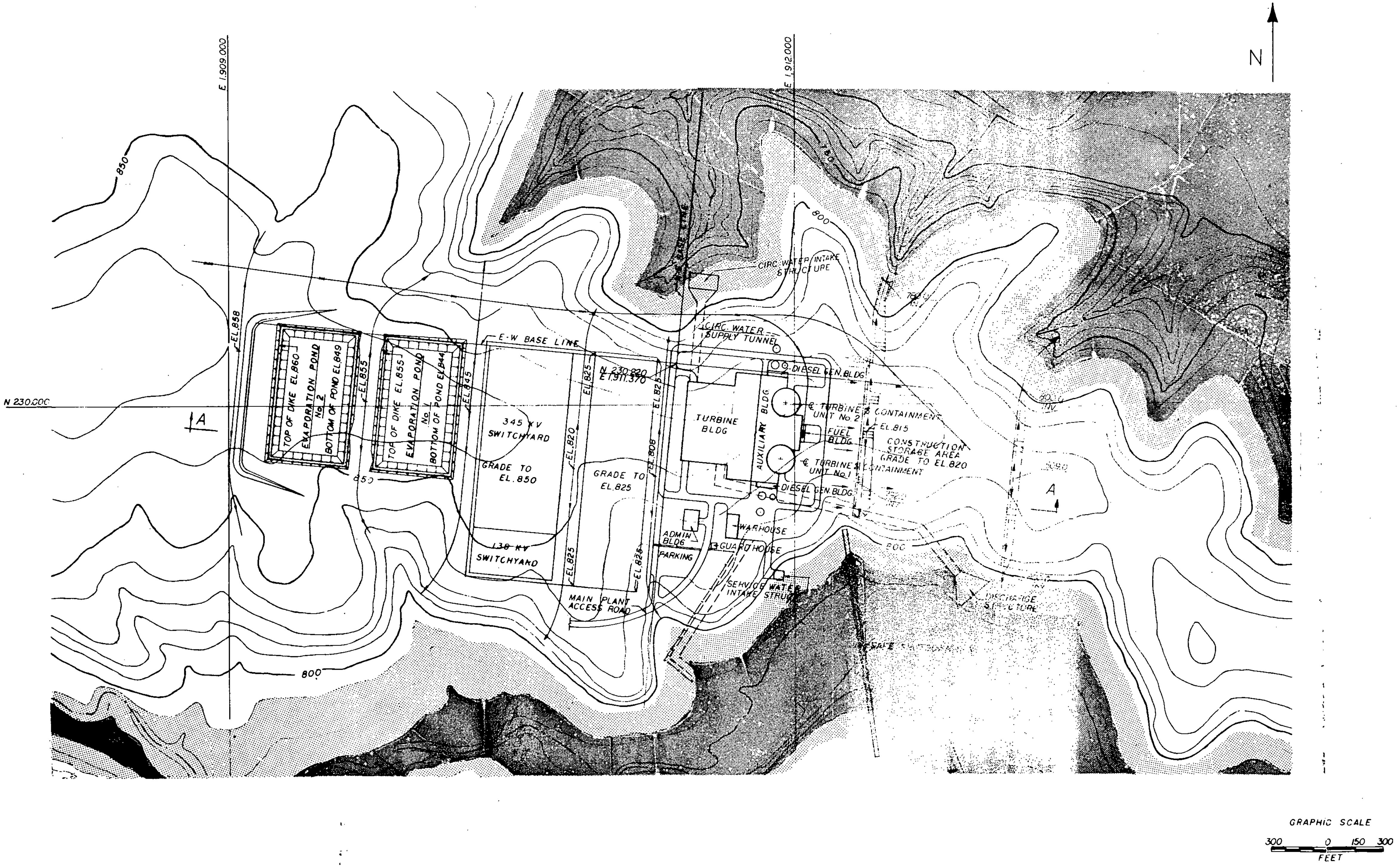
PRINCIPAL FACILITI

FIGURE 2.1-3



SECTION A-A

N.T.S.

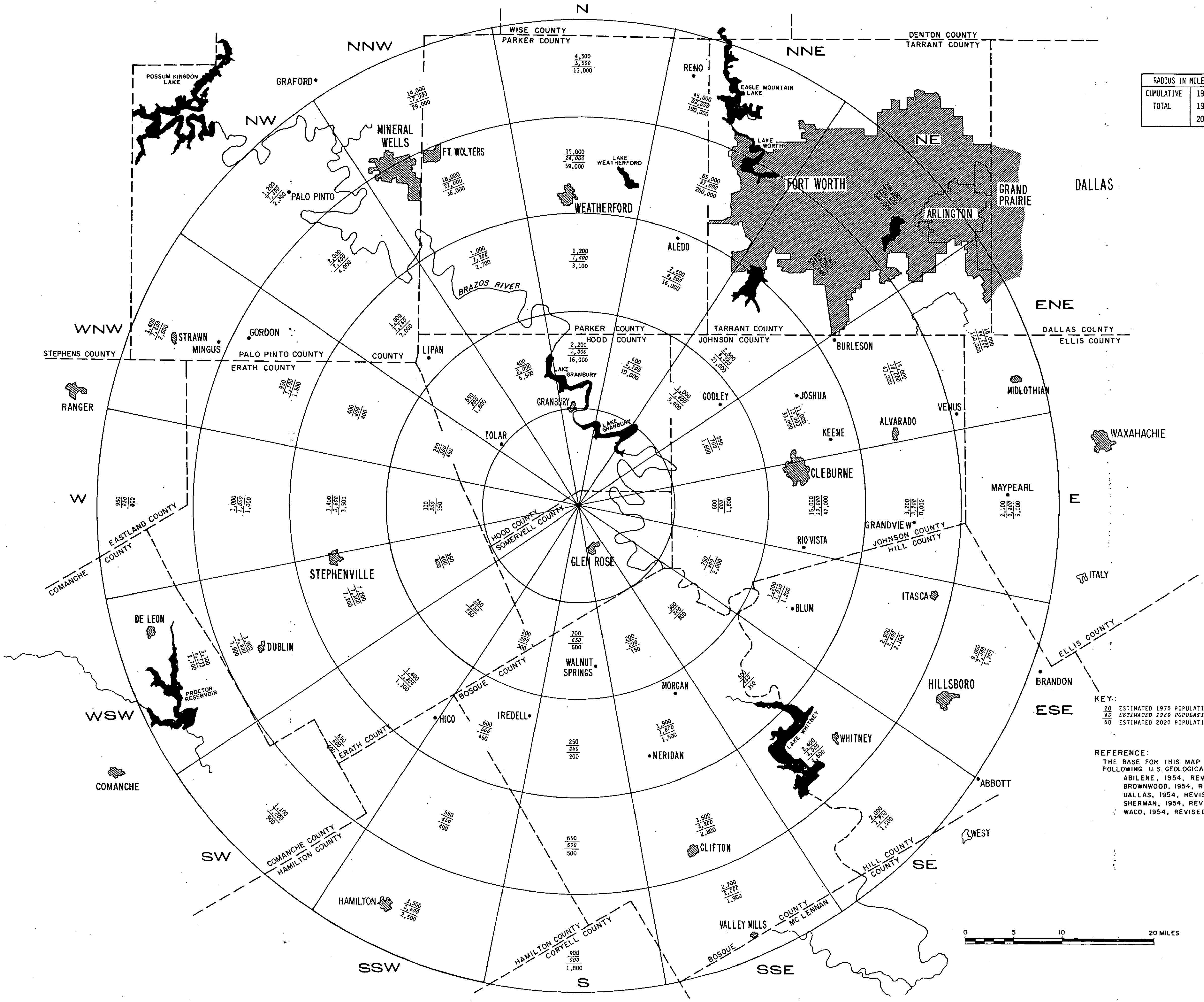


AMENDMENT No.2 1/21/74

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

TOPOGRAPHIC MAP OF SITE

FIGURE 2.1-3a



RADIUS IN MILES		10	20	30	40	50
CUMULATIVE	1970	6,554	15,854	67,004	419,704	816,854
TOTAL	1980	13,070	31,000	94,200	483,500	997,100
	2000	33,605	80,500	222,200	1,090,600	2,340,300

KEY:

20	ESTIMATED 1970 POPULATION
40	*ESTIMATED 1980 POPULATION*
60	ESTIMATED 2020 POPULATION

REFERENCE:
THE BASE FOR THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING U. S. GEOLOGICAL SURVEY 1 : 250,000 MAPS:
- ABILENE, 1954, REVISED 1965
- BROWNWOOD, 1954, REVISED 1964
- DALLAS, 1954, REVISED 1963
- SHERMAN, 1954, REVISED 1963
- WACO, 1954, REVISED 1963

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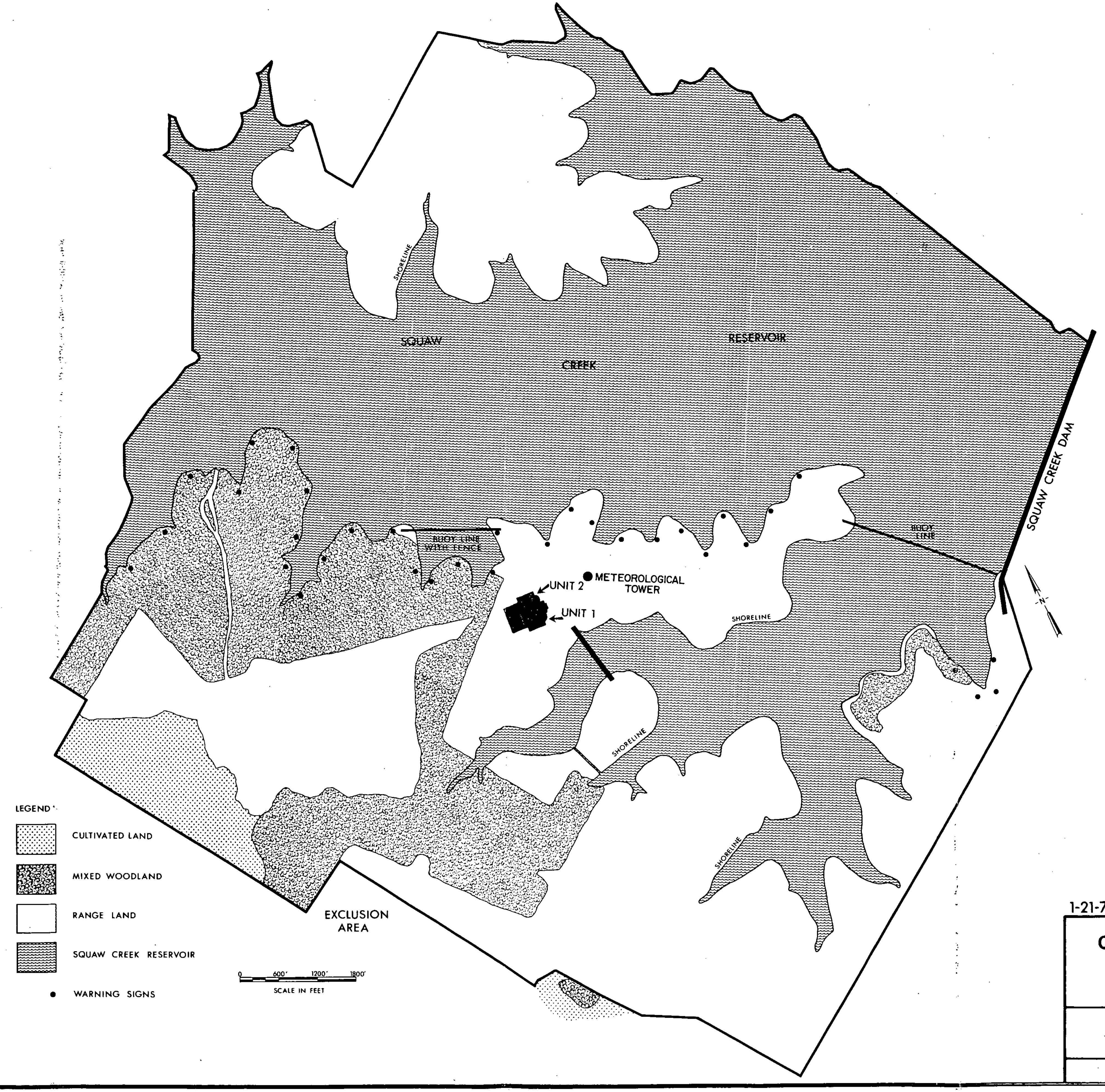
COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

REGIONAL MAP SHOWING PRESENT AND FUTURE POPULATION, 10 TO 50 MILES

FIGURE 2.1.3.2.1-1

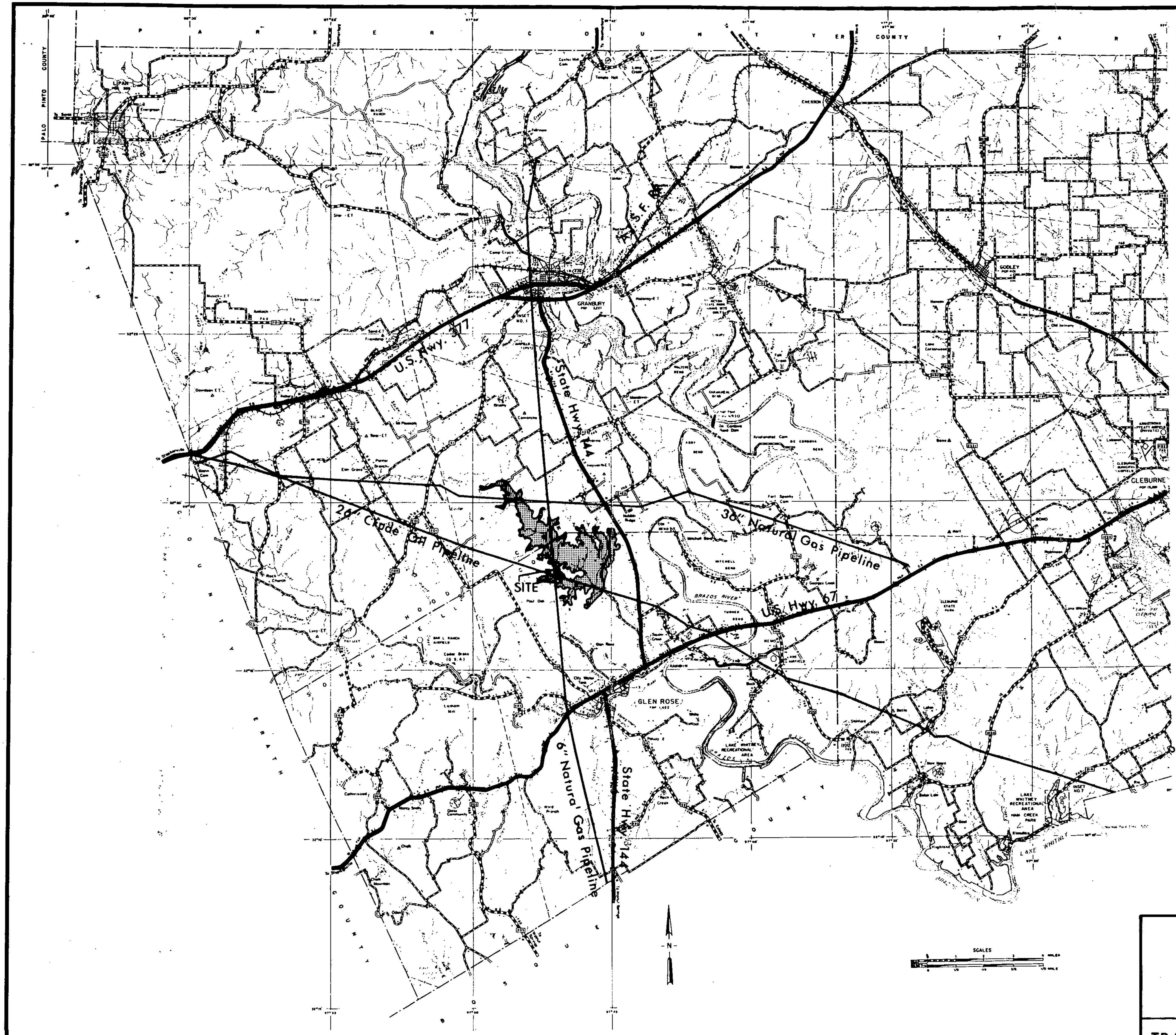


1-21-74 AMENDMENT 2

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

EXCLUSION BOUNDARY

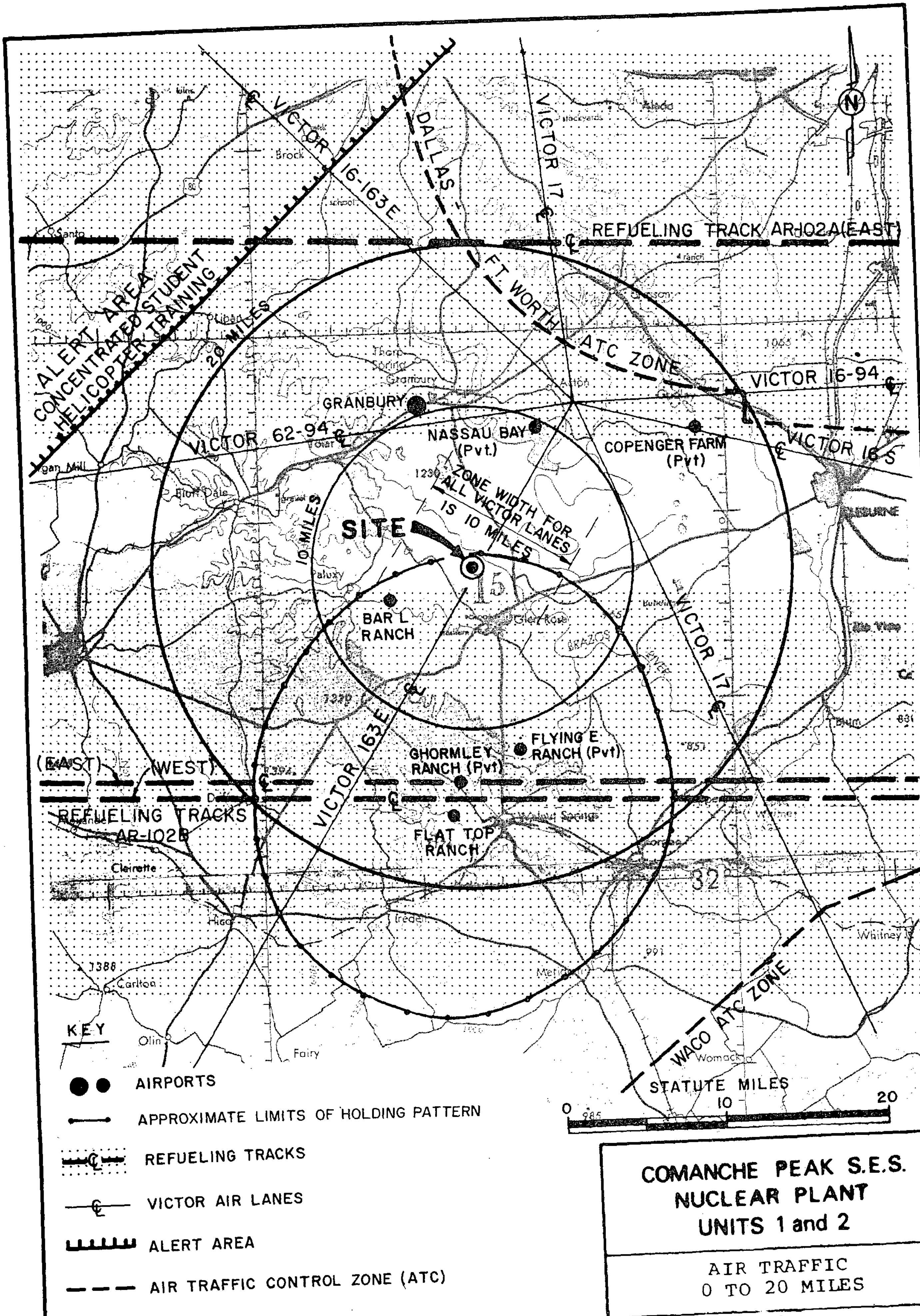
FIGURE 2.1-4



COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

TRANSPORTATION FACILITIES
0-10 MILES

FIGURE 2.1-5

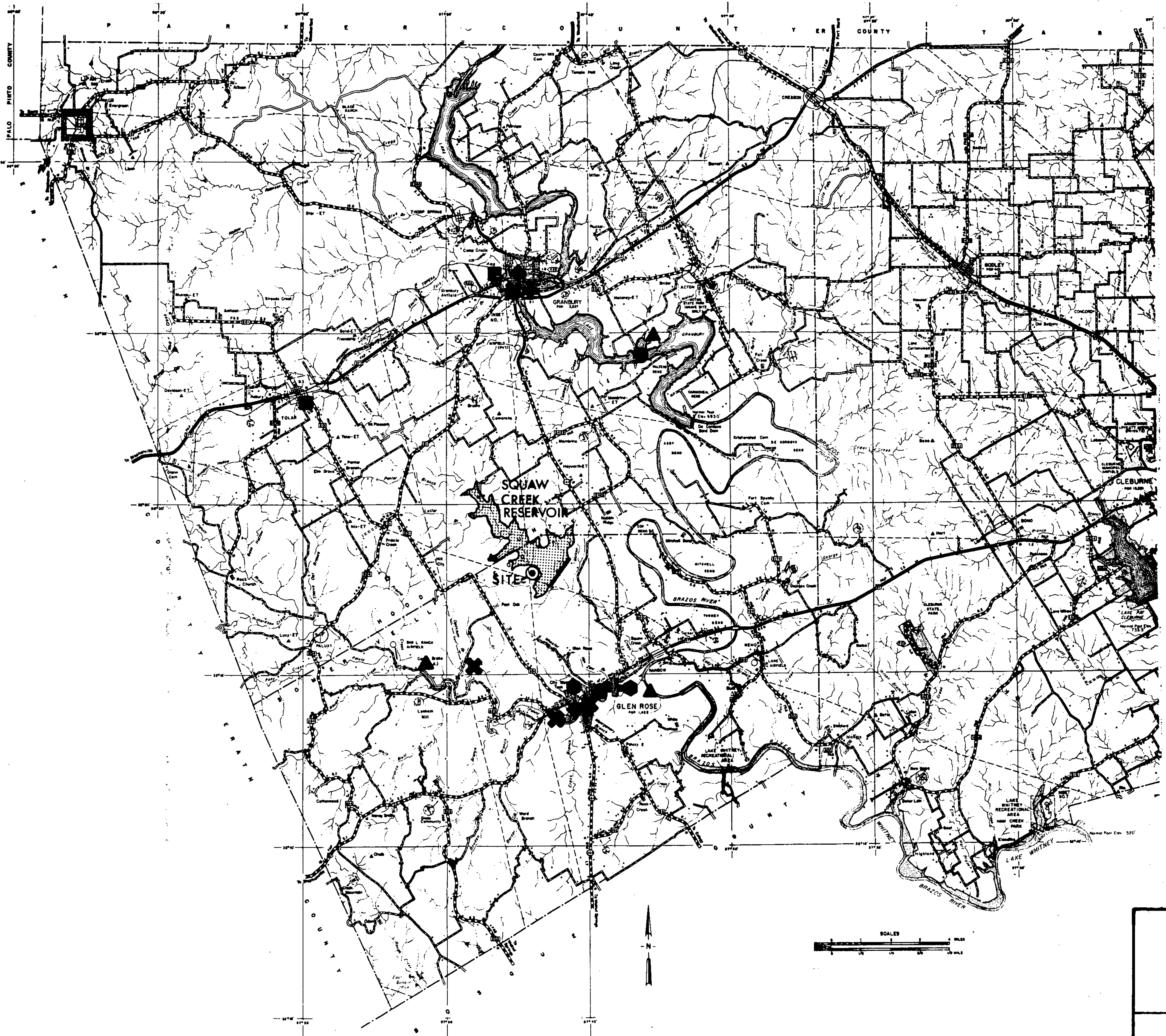


REFERENCE: This map was prepared from portions of sectional aeronautical charts, San Antonio & Ft.Worth.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

AIR TRAFFIC
0 TO 20 MILES

FIGURE 2.1-6



Key

✚ Hospital

■ School

▲ Organized Camp

◆ Jail

⬢ Nursing Home

● Water Recreation

✖ Park

COMANCHE PEAK S.E.S. NUCLEAR PLANT UNITS 1 and 2

PUBLIC FACILITIES
0-10 MILES

FIGURE 2.1-7

2.2 REGIONAL DEMOGRAPHY, LAND & WATER USE

2.2.1 POPULATION & POPULATION DISTRIBUTION

The Comanche Peak Steam Electric Station (CPSES) to be placed in operation in 1980, will have an estimated life of 40* years. Population studies were directed toward estimating the population distribution within fifty miles of the site for each decade from 1980 to 2020. Data from the 1970 U.S. Bureau of Census were used to determine a base-date distribution for comparison with projected populations.

2.2.1.1 1970 Population Within 10 Miles

Sparsely populated Hood and Somervell Counties have average population densities in 1970 of 14.9 and 14.2 persons per square mile respectively. The area is essentially rural; only three small communities, Glen Rose, Granbury, and Tolar have more than 100 residents each. The 1970 the population within 10 miles of the site was approximately 6600 residents.

Glen Rose, the nearest community, is about five miles south-southeast of CPSES and had a population of 1554 in 1970 [1]. Glen Rose has no industrial employers, and the only significant transient population is composed of staff and students of the Glen Rose School District and staff and patients of the Marks-English Hospital. There were approximately 66 students and staff in the school in 1972 [2], while the hospital, which also includes a small nursing home, had about 130 patients and staff [3]. Other commercial activities in Glen Rose are limited to small service-type facilities: cafes, retail outlets, gas stations, and several hotels and motels (which also provide sanitarium services).

Granbury, ten miles north of the site, is the largest community in the area, with a population of 2473 in 1970 [1]. Granbury's economy is partially supported by two dressmaking plants, which together employed 114 persons in 1971 [4]. The largest transient population in Granbury consists of the more than 1320 staff and students of the Granbury School District [5]. Other business activity is largely limited to a small hospital and several small service-oriented establishments, many of which have benefited economically from the impounding of Lake Granbury.

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* An estimated plant life of 30 years is used in computing cost-benefit relationships; however, the plant is expected to be in operation for 40 years.

Tolar, ten miles northwest of CPSES, is the only other community within ten miles. It had 312 residents in 1970 [1]. The Tolar School District, with 295 staff and students in 1972 [6], is the site of the area's only significant transient population, and is also probably the town's largest employer.

Three private camps and a state park also draw small transient populations. Dinosaur Valley State Park, consisting of 1274 acres is located about four and one-half miles southwest of CPSES. It was created by the State of Texas to protect dinosaur tracks in the Cretaceous limestone strata of the Glen Rose formation exposed by stream-bed erosion along the Paluxy River. The Paluxy and Brazos Rivers are the site of a number of organized camps including those of the Boy Scouts of America [8], Girl Scouts of America [9], and the Young Women's Christian Association [10], and a few smaller church camps.

Locations of the public, industrial, and institutional facilities mentioned above are shown in Figure 2.1-7, while the size of each is given in Table 2.1-1. They represent the only major concentrations of transient populations within 10 miles of the site. At present, no plans to increase the size or number of these facilities are known, except for a new steam electric station being constructed near the De Cordova Bend Dam, about 8.7 miles northeast of CPSES. It will employ approximately 30 persons when completed in 1975.

The development of recreational facilities on Lake Granbury is credited with an unknown transient population whose 1970 summer maximum is estimated to be 200. The rural character of the area within ten miles of the site accounts for the extremely small sector populations given in Figure 2.2-1, which shows that no one resides within one mile of CPSES, while only about 2000 people reside within five miles and only some 6600 reside within ten miles.

While the sector populations depicted in Figure 2.2-1 are based on 1970 census data, extensive refining of the census information was necessary to obtain the accurate, small-scale population distributions shown. This was accomplished through house counts in the rural areas and in communities too small to be recorded separately in census data. The number of houses in a given segment was estimated through interpretation of aerial photographs supplemented with field checks. The number of houses were then converted to a population estimate by multiplying the number of housing units by 2.8, the average number of persons per household within the appropriate census districts [11].

2.2.1.2 Future Populations Within 10 Miles

Hood and Somervell Counties both experienced small population gains in the decade between 1960 and 1970, after several decades of stagnant or decreasing populations.

The principal reason for this reversal was probably the impounding of nearby Lake Granbury, about seven to eight miles to the north and northeast of the CPSES site. A secondary reason may be Hood and Somervell Counties' proximity to the rapidly growing Dallas-Fort Worth Metropolitan Area, which approaches to within 35 miles of CPSES on the northeast. Although this is a fairly long commuting distance, considering the amount of open land immediately outside the metropolitan area, it is probable that a few local residents are willing to commute to Fort Worth, thus increasing immigration or at least partially stemming the emigration of young people so typical of most rural areas in the United States. Past emigration of young adults from the area is evident from Figure 2.2-2, which shows the age distributions of Hood and Somervell Counties in relation to the Texas averages. The area's median ages, 37.8 years in Hood County and 39.3 years in Somervell County are 11.4 years and 12.9 years older, respectively than the Texas median age of 26.4 years.

Population projections to 1990 for Hood and Somervell Counties have been published by the Population Research Center (PRC) at the University of Texas at Austin [12]. The basic method used in these projections was the ratio-correlation (multiple-regression) method which is commonly used for estimating current population. PRC extended the method by projecting five symptomatic variables using regression analysis. The five variables chosen were each county's proportion of the totals of births, deaths, automobile registrations, food sales, and retail sales in the state. The method provides estimates of each county's proportionate share of Texas' total population. PRC then multiplied the proportionate share by the Texas population as obtained from the U.S. Bureau of the Census, Series 1-C projections [13].

In extending projections to the year 2020, PRC first had to extend the Series 1-C Texas projections from 1990 to 2020. After assuming that the projected "change in proportion" between Texas and U.S. populations in the decade between 1980 and 1990 would be constant for each decade between 1990 and 2020, a projected Texas population was computed by adding the successive decile "changes in proportion" to the Texas proportion of the U.S. population in 1990, and multiplying by the Series C projections for the nation as provided by the U.S. Bureau of the Census [14]. This procedure used in arriving at the County projections shown below is explained in detail in Section 6.1.4.2. The actual and projected population figures for Hood and Somervell Counties are:

YEAR	HOOD COUNTY	SOMERVELL COUNTY
1930	6779	3016
1940	6674	3071
1950	5287	2542
1960	5443	2577
1970	6368	2793
1980	6700	3000
1990	7000	3200
2000	7000	3300
2010	7000	3400
2020	7000	3400

Since these projections indicate only a very small population growth, the projected population distributions within 10 miles of the site were assumed proportional to the population distributions of 1970. The results, by sector and decade, are shown in Table 2.2-1. Figure 2.2-1 shows present and future population, 0-10 miles.

Some circumspection is warranted when analyzing these projections. It should be recognized that published national, state, and county projections from 1990 to 2020, an additional degree of uncertainty was introduced. The uncertainty factor was further increased by proportioning county population projections into the extremely small sectors shown on Figure 2.2-1 (many of which contained no residents in 1970). Thus, the sector populations given should be viewed in a qualitative rather than in a purely quantitative sense. For example, the projected population for zero persons in 2020 in several sectors indicates that there is no reason, based on the best knowledge currently available, to expect that people should be located in those sectors in the future.

2.2.1.3 Present Population Between 10 and 50 Miles

The area within 50 miles of the site is also primarily rural, with the exception of the rapidly growing Dallas-Fort Worth Metropolitan Area, which is encountered about 35 miles northeast of CPSES. This pattern is reflected in the 1970 population distributions shown in Figure 2.2-3.

To calculate the 1970 population distributions for each sector within the 50 mile radius, the percentage of a census division within the sector was estimated and then multiplied by the division population. This procedure was repeated for all land areas within a sector, and the sum of these computations for each sector yielded its 1970 population.

The location and populations of cities and towns within 50 miles of the site are presented in Table 2.2-2.

The historical and projected populations of all counties within 50 miles of the site are presented in Table 2.2-3. The county projections were obtained from published PRC projections to 1990, with extensions performed in the manner described in Sections 2.2.1.2 and 6.1.4.2 for Hood and Somervell Counties. All counties within 50 miles of CPSES, except Coryell, Dallas, and Tarrant, have recently experienced less growth than Texas as a whole: the population in those counties, when compared with the state's population, is a consistently decreasing percentage. If the rate of percentage decrease in these counties, projected for the decade from 1980 to 1990 were to continue through the year 2020, several of the counties would theoretically have a 2020 population of zero, while others would suffer partial population reductions.

Rather than extend declining populations beyond 1990, it has been assumed that the rural population would continue at the 1990 level. This is shown in Table 2.2-3 by an arrow between the projected 1990 and 2020 populations.

Projections to 1990 for the Dallas-Fort Worth Metropolitan Area are also available from the North Central Texas Council of Governments (NCTCG) [15]. Comparison between NCTCG and PRC projections for the counties covered by NCTCG for the year 1990 are presented in Table 2.2-4.

The comparison shows that PRC projections indicate about a 61 percent population increase between 1970 and 1990 in the North Central Texas region, while the NCTCG projections indicate an 86 percent increase. The pattern of growth shown in both projections is much the same, with Dallas and Tarrant Counties sharing most of the growth in the region. Although the variance in percentile increase is significant, a comparison shows good correlation between the two, with regional population in 1990 projected as about 3.8 million by PRC and 4.4 million by NCTCG. Hood and Somervell Counties are not members of the NCTCG, so direct comparisons in the immediate site vicinity cannot be made. However, the NCTCG projections do reinforce the probability of small population changes in Hood and Somervell Counties, based on their projections of low-to-moderate population gains in the adjacent Johnson and Parker Counties.

PRC figures have been chosen as a basis for the population projections in this report because they are more recent (NCTCG projections were made prior to the 1970 census) and because they cover the entire region within 50 miles of the site.

Distribution of the county projections of Table 2.2-3 among the sectors shown on Figure 2.2-3 was accomplished in a manner similar to that described in Section 2.2.1.2. A comparison of 1970 and projected 2020 populations is shown in Figure 2.2-3, and results by decade and sector between 1970 and 2020 are listed in Table 2.2-5.

To gain a clearer perspective of the populations discussed above, it is helpful to compare the cumulative population within 50 miles of the CPSES site with that of some other nuclear power plants either completed or under construction. Figure 2.2-4 shows that the CPSES region is projected to have a much lower population in 2020 than most other nuclear power plant regions had when they were still in the planning stages.

2.2.2 LAND USE WITHIN THE SITE ENVIRONS

Most of land within 50 miles of CPSES is used for agricultural purposes, with the exception of the Fort Worth Metropolitan Area (FWMA). Although FWMA is expanding rapidly, it is not expected to reach the CPSES vicinity during the useful life of the plant. Therefore, the plant area is expected to retain its distinctly rural character.

2.2.2.1 Regional Land Use

The entire area within ten miles of CPSES lies within Hood and Somervell Counties. Agricultural practices in these counties will be discussed in the following paragraphs. (Although agricultural practices in the surrounding counties are not specifically mentioned, they are in general very similar to those described).

The area to the east and south of CPSES is generally devoted to cultivation, whereas the area to the north and west is devoted generally to livestock.

Land use data provided by the Soil Conservation Service [16] shows that over 96 percent of the land in Hood and Somervell Counties is used for agricultural purposes. A breakdown of land usage is shown below:

Land Use	Percent of Total Land Area in 1958	Percent of Total Land Area in 1967	Change in % of Total Land Area
Urban or built-up	2.3	2.3	0.0
Small water areas	1.0	1.1	+ 0.1
Cropland	20.8	15.0	- 5.8
Pasture	1.2	5.2	+ 4.0
Range	60.0	45.1	-14.9
Non-commercial forest	14.0	29.0	+15.0
Federal non-cropland	0.2	0.2	0.0
Miscellaneous	0.4	2.1	+ 1.7

The significant trend indicated by these data is the increasing acreage devoted to pasture and forest areas, largely at the expense of croplands and rangelands. Part of the increase in forests and decrease in rangelands is generally due to an invasion of the juniper and mesquite. A detailed listing of land uses for Hood and Somervell Counties is presented in Table 2.2-6. Another trend in local agriculture is the increased use of improved pasture for rotation-deferred grazing rather than for cultivation of hay crops.

Detailed agricultural statistics provided by the Texas Department of Agriculture [17] further delineate land use patterns, as shown in Tables 2.2-7 and 2.2-8. The data show that nearly two-thirds of the cash receipts from farm marketings come from livestock and livestock products, with cattle constituting the majority of livestock in the area. This is representative of an area dominated by rangelands. Field crops, including peanuts, sorghum, oats, hay and wheat, and peaches and pecans, together produce most of the remaining agricultural income. Government subsidy payments accounted for only about 3 percent of total farm receipts.

Inventories of irrigation presented by the Texas Water Development Board [18] show that irrigation does not play an important role in agricultural production in Hood and Somervell Counties, with only 1345 and 524 acres, respectively, under irrigation in 1969. A summary of these data is presented in Table 2.2-9.

Projections of future land use patterns vary only slightly from present patterns. The present trend toward pasture and non-commercial forest areas at the expense of cropland and rangeland areas is expected to continue. The trend to develop improved pasture through rotation-deferred grazing rather than the growing and harvesting of forage crops should also continue. At present, the most common method of fighting the invading juniper and mesquite trees on the rangelands is simply chain clearing. However, the juniper can revegetate a cleared field within three to five years. This conflict should thus continue until more practical means of range management are adopted. Although these are the most probable trends in future land use patterns, it should be recognized that future price structures, food supplies, and governmental policies are factors that will utimately determine the actual future land use patterns.

2.2.2.2 Land Use Classifications

Agriculture is the dominant land use within a five-mile radius of CPSES, consisting largely of livestock grazing and the cultivation of crops and orchards. The total percentage of land devoted to all types of agriculture is approximately 98.8 percent, or 49,600 acres.

The land within a five-mile radius of the proposed plant is divided into the following land use classifications: urban, parks, mixed woodland (deciduous and evergreen), cultivated land (cropland, improved pasture, and orchard), and range (grassland, mixed grassland-bushy land, savanna, and mesquite woodland). The factors for each classification are discussed in detail in the following sections. The acreage and percentage of the total for each individual classification is listed in Table 2.2-10.

2.2.2.2.1 Urban

Urban classification consists of built-up areas such as residential, commercial, industrial, sewerage facilities, etc. The only urban residential area within five miles of the proposed plant is in and around the town of Glen Rose. Clustered and individual rural residences and farm buildings are not included in this classification, but are absorbed by the land use classification within which they are located .

2.2.2.2.2 Parks

The parks classification includes any noticeable urban parks, athletic fields, playgrounds, and state parks. The Dinosaur Valley State Park is the most important park within the site area. It is also a Registered National Natural Landmark [19] (See Figure
3 2.2-5).

2.2.2.2.3 Mixed Woodland

The mixed woodland classification, as defined, is one consisting of dense stands of deciduous and evergreen trees. The major types of trees in the area are juniper and oak (several varieties of liveoak and oak). Riparian woodlands (trees along streams) are also included as mixed woodland. Areas within the site vicinity included in this classification were so classified after a study of aerial photographs.

2.2.2.2.4 Cultivated Land

The cultivated land within the area of the site consists basically of peanut fields and improved pasture, with some acreage in commercial vegetables, orchards, and cotton. The amount of land currently under cultivation within five miles of the site area is shown on Table 2.2-10.

2.2.2.2.5 Range

Range is a broad and diverse classification that has some of the characteristics of cultivated land and mixed woodland. Range generally can consist of grassland, mixed grassland-bushy land, savanna, or mesquite woodland. These vegetation types can appear quite similar to the cultivated land and mixed woodland classifications, especially in the black-and-white aerial photographs used for making the analysis.

The influence of man can greatly change the complexion of the range by deterioration and erosion and by modern range management techniques. Thus, the degree of range management practices, or lack thereof, can vary greatly from tract to tract thereby influencing the overall quality of rangeland. The areas classified as range are devoted generally to livestock raising near the plant site.

2.2.2.3 Food Products

Within the environs of CPSES, by far the greatest amount of land is devoted to livestock production, of which beef production is the most important. While no figures are available to estimate the number of beef cattle within a five-mile radius of the proposed plant, the total estimated number of beef cattle and calves available for slaughter in Hood and Somervell Counties is approximately 18,200 head [20].

In Hood County, beef cattle are grazed on almost all types of land, but it generally consists of improved pasture, range, mixed woodland, and cultivated land grazed after harvest. Livestock carrying capacity (productivity) varies greatly among these agricultural types. Range, for instance, can vary from good grassland to marginal mixed, bushy woodland. The best grazing land in the area is improved pasture, which is grassland that has been cleared, cultivated, fertilized, and planted with chosen species of grasses, and sometimes irrigated. Two acres of improved pasture can generally support one cow, while in rangeland the ratio may be as great as sixteen acres per cow. Juniper woodland of high density can crowd out the grasses, leaving bushy vegetation that is not suitable for grazing [21].

Hogs are another meat-producing animal raised in the area. The amount of hog production in Hood county for 1971 was placed at

2800 head [20]. There are no figures available for hog production in Somervell County.

Dairy production is a minor part of the total livestock production within a ten-mile radius of the proposed plant. Figure 2.2-6 shows an estimation of milk cow distribution within a ten-mile radius of CPSES. Of the 409 head total, four commercial dairy herds account for about 240 cows [22-23]. The closest dairy herd is five miles south-southeast and numbers approximately 80 cows. This operation is a feedlot, with cows confined to no more than two acres. The other three dairies have put cows into fields where they can graze. The total number of cows in these three dairies number approximately 140 head [22-23]. The remaining cows in the area are scattered about, and are used for local or family consumption. Dairy cows were observed on range, woodland, and improved pasture. Improved pasture would be the best location for grazing and the nearest improved pasture (exempting improved pasture within the proposed cooling lake) is about one and one-half miles east-southeast. The annual estimated value of milk (according to the 1970 average prices for these commercial dairies is $1,616,765. [24-25].

The final type of livestock activity prevalent in Hood County is egg production. Within a five mile radius of the proposed plant the amount of egg production is not accurately known. No chicken ranches were observed in the area though only a spot check was made. Hood County was reported to have had 14,000 hens and pullets, with a total egg production of 385,000 dozen in 1970. There was no mention of any broilers being raised in the county [20].

Peanuts are the dominant cash crop within a five-mile radius of the plant site. Table 2.2-11 shows the distance and direction from CPSES to the major peanut growing areas. There are no current estimates of the total acreage devoted to peanut production, but the 1971 Hood County estimates showed a total of 8100 acres harvested, yielding about 831 pounds of peanuts per acre, totaling 6,728,000 pounds. Somervell County harvested 2750 acres in 1971, with a yield of about 668 pounds per acre [26]. The total bi-county production was about 8,566,000 pounds [25]. The yield for both counties was well under the state average of1,235 lbs. per acre, and the total peanut production in both counties accounted for only .02 percent of the total Texas production.

Land in improved pasture and peanut fields amounts to a little over 15,000 acres within a five-mile radius of CPSES. The remaining cultivated land consists of a pecan orchard (200 acres), a cotton field (50 acres), and the sole reported commercial vegetable field, some 40-50 acres in extent.

There is one 200-acre pecan orchard located within a five-mile radius of the plant. The only known commercial vegetable operation is about four miles east of the plant site. The crops produced include squash, peas, okra, and possibly some tomatoes and cucumbers. The rest of the cropland surrounding the vegetable operation is devoted to peanuts.

2.2.2.4 Non-Food Agricultural Products

Some angora goats and sheep are raised within five miles of CPSES. Current figures are not available but the 1971 estimates for Hood County place the totals at 9000 angora goats and 3000 sheep. The same source estimates 2000 angora goats in Somervell County [20]. These animals are raised primarily for mohair and wool, rather than meat.

Equine livestock (horses, mules, asses) are also raised in the area. The 1971 estimates place 992 in Hood County and 423 in Somervell County [20]. It is not known how many are located within a five-mile radius of the proposed plant.

Finally, an exotic game farm is located in Somervell County 4.5 miles southeast of the plant site. Seven Mouflion sheep (Ovis sp.) were observed within the compound.

Cultivated grasses, oats, grain sorghum, cotton, and other small grains such as wheat and rye, are the main non-food agricultural products grown in the area. With the exception of cotton, they are produced for cattle feed or forage [21].

Oats and the other small grains like wheat and rye are listed in the agricultural estimates for the two counties. However, these small grain crops are used as ground cover to protect the forage on the peanut fields after harvest, and later serve as forage themselves for cattle grazing. They are not considered harvestable crops. Grain sorghum is used as feed. Improved pasture consists of cultivated grasslands that serve as pasture for cattle.

Cotton is a minor crop in the area. In 1970, only 700 acres were harvested in Somervell County. Hood County reported no cotton harvested or planted that year [26].

2.2.2.5 Military Facilities, Air & Surface Transportation Routes

Maps, aerial photographs and other documents pertaining to the vicinity of CPSES were examined in an attempt to locate all military bases and firing ranges, missile sites, airports, transportation routes (surface, air, and water), oil and gas pipelines, and tank farms within a 10-mile radius of the site (within a 20-mile radius for air routes, landing patterns, and airports). No military bases or firing ranges, missile sites, low level military air routes, or tank farms were found in the area. The nearest military bases to the site are Carswell Air Force Base, approximately 31 miles north-northeast; Fort Wolters, approximately 39 miles northwest; and Fort Hood, approximately 62 miles south.

Transportation routes within the area consist of two U.S. highways and one state highway, a railroad, nine air routes, two natural gas pipelines and a crude oil pipeline. Transportation routes are shown in Figures 2.1-5 and 2.1-6.

The closest highways to the CPSES are State Highway 144 (2.5 miles northeast), U.S. Highway 67 (4.5 miles south-southeast), U.S. Highway 377 (9 miles to the northeast), and Farm-to-Market Roads 51 and 201 (approximately 5 miles northwest and 2 miles west, respectively). The Atchison, Topeka and Santa Fe Railroad approaches within about 9.5 miles northwest of the site.

Two pipelines are located on or adjacent to the proposed facility. A third pipeline, 2.5 miles north of the site, crosses Squaw Creek where headwaters of the proposed cooling lake will be located. It is evident that the two pipelines located on or adjacent to the site will have to be relocated away from the plant site and cooling lake. The third pipeline, north of the site, will be weighted, protected, and allowed to remain on the bottom of the reservoir.

Seven airfields are located within 20 miles of the proposed facility, as shown in Figure 2.1-6. Granbury Municipal Airport (10 miles north-northwest) is the only one with a paved runway [27]. The runway is lighted to a length of 3000 feet. No commercial service is presently available at this airport [4].

The other six landing strips listed by the Federal Aviation Administration (FAA) [27] are:

1. Copenger Farm (Pvt.), 17 miles east-northeast
2. Flat Top Ranch, 16 miles south
3. Ghormley Ranch (Pvt.), 14 miles south
4. Flying E Ranch (Pvt.), 12 miles east-southeast
5. Nassau Bay (Pvt.), 10 miles north-northeast
6. Bar L Ranch, 5.5 miles west-southwest

These six airfield are sod strips serving only general aviation [27].

The FAA lists no restricted areas near the vicinity of the plant. Nine air corridors pass within a 20-mile radius of the site. Three of these routes are military and the other six are cleared for all types of aircraft. Eight of the routes pass within 10-miles of the site. Three are military refueling tracks (flight elevations 24,000 feet to 31,000 feet) 10 nautical-miles wide [28]. The others are Victor air lanes which have paths 10 statute miles wide and are cleared for general (small plane) aviation as well as for commercial and military aviation. Commercial and military flights in these lanes usually are at high altitudes, but can be cleared for elevations as low as 2100 feet to 2400 feet mean sea level datum. General aviation flights using these corridors can fly lower, but must be at least 500 feet above the ground.

None of the three military refueling tracks cross the CPSES site. The north edge of track AR-102B (East), approaches to within 1-3/4 miles south of the site. The north edge of track AR-102B (West) comes to within 2.5 miles south. The third track, AR-102A (East) runs 8.5 miles north of CPSES [28].

Victor 163E air lane is the only route which passes over the site (minimum flight elevation: 2400 feet). The limits of other Victor air lanes approach no closer than approximately five miles [27]. All air corridors are shown on Figure 2.1-6.

2.2.3 WATER USE WITHIN SITE ENVIRONS

Water use in the region is largely limited to domestic, irrigation, and livestock purposes, as would be expected in a rural area. In the immediate vicinity of CPSES, water usage is largely confined to a few low-producing domestic and livestock wells, most of which draw water from the Twin Mountains aquifer.

The following subsections provide information on the usage of ground and surface water in the area, while Section 2.5 describes the sources of the ground and surface water.

2.2.3.1 Groundwater

The locations and types of wells in the site vicinity are shown in Figure 2.2-7. Regional well capacity and user data are presented in Table 2.2-12. Nearly one-third of these wells are of small capacity and used to meet domestic and livestock requirements. Larger capacity wells account for most of the municipal, irrigation, and industrial groundwater supplies in the area. 2

All wells shown in Figure 2.2-7 and listed in Table 2.2-12 are completed in the Twin Mountains formation.

The Texas Water Development Board has completed a study [29], indicating that pumpage within 20 miles of the site totals

about 100 acre-feet per year. This yearly pumpage is expected
to increase to about 200 acre-feet by 2020. The rate of fluctua-
tion of piezometric surface is presented in Table 2.2-12; since
2 development of groundwater has increased rapidly in recent years
in most of the region, this surface has generally declined at a
similar rate.

2.2.3.2 Surface Water

CPSES station will affect two sources of surface water, Squaw Creek and the Brazos River. Squaw Creek will normally receive no blowdown water from SCR (during periods of heavy rainfall, some water from SCR may be discharged into lower Squaw Creek), but near normal flow will be maintained therein. The Brazos River will be affected since SCR will receive make-up water from, and discharge blowdown water into Lake Granbury, an impoundment on the Brazos River. No other surface water sources may be affected by plant effluents.

All potential surface water users in Texas must file with the
Texas Water Rights Commission; thus, a review of the "Water
Rights Master File" [30] reveals all surface water use within
Texas. A summary of the 1972 listing of applications, claims
and certified filings for surface water on Squaw Creek and the
1 Brazos River are presented in Table 2.2-14 and 2.2-15, respec-
tively. The approximate location of major withdrawals on the
Brazos River are shown on Figure 2.2-10.

1 As shown in Table 2.2-14, there are presently only two claims for surface water on Squaw Creek. Since both of these claims are located near the Hood-Somervell County line within the area to be inundated by SCR, it is probable that the claims will be dropped. The only users of Squaw Creek will then be cattle or other animals drinking from the stream.

Similarly, there are no known users of surface water on the Paluxy River, downstream of the Squaw Creek-Paluxy River confluence, and it is doubtful that cattle are watered from it.

1 A number of parties have applied for and/or received water allocations for use of Brazos River water, as shown in Table 2.2-15 and Figure 2.2-10. It is important to note that the nearest municipal use of Brazos River water is at Waco, nearly 140 miles downstream of Lake Granbury. The Brazos River Authority has an application for 10,000 acre-feet of water from Lake Granbury; at present, however, the City of Marlin (located 170 miles downstream of Lake Granbury) is the nearest municipal water user who has contracted to purchase water from the Brazos River Authority.

2.2.4 REFERENCES

1. U.S. Department of Commerce, Bureau of the Census, 1971, Number of Inhabitants, 1970 Census of Population, Texas.

2. Interview with Mr. J.M. McCroskey, Superintendent of Glen Rose School District.

3. Interview with Mr. Tom Voss, Glen Rose Hospital and Nursing Home.

4. "General Community Profile on Granbury, 7/24/71", City of Granbury, Texas.

5. Interview with Mr. John H. Brawner, Assistant Superintendent of Granbury School District.

6. Interview with Mr. Barry Cochran; son of Curtis Cochran, Superintendent of Tolar School District.

7. Interview with Mr. Johnny Buck, Texas Parks & Wildlife Dept.

8. Interview with Mr. Jeff Edwards, Camp Leonard Boy Scout Camp.

9. Interview with Jerry Smith, Circle T Ranch Girl Scout Ranch (Cedar Brake).

10. Interview with receptionist, Camp Tres Rios, YWCA Camp.

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18. Texas Water Development Board, May 1971, Report #127, Inventories of Irrigation in Texas, 1958, 1964 & 1969, Austin, Texas.

19. National Park Service, National Registry of Natural Landmarks, Additions, Federal Register, Vol. 37, No. 171, September 1, 1972, Washington, D.C.

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21. Interview with Mr. Zack (Buzz) Evans, Agent, Soil Conservation Service, Somervell County.

22. Interview with Mr. Doyle Cooper, County Farm Extension Serv.

23. Interview with Mr. Keith Hillman, County Farm Extension Serv. Agent, Hood County.

24. 1971 Texas Dairy Statistics , Texas Department of Agriculture, U.S. Department of Agriculture, Statistical Reporting Service.

25. Texas Prices Received and Prices Paid by Farmers , Texas Department of Agriculture, Statistical Reporting Service.

26. 1971 Texas Field Statistics , Texas Department of Agriculture, U.S. Department of Agriculture, Statistical Reporting Service.

27. "Sectional Aeronautical Chart", National Ocean Survey, U.S. Department of Commerce: Dallas-Fort Worth, San Antonio.

28. "Flight Information Publication Planning Military Training Routes", Effective 0901Z, 7 December 1972, The Aeronautical Chart and Information Center.

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TABLE 2.2-1

1970 AND PROJECTED FUTURE POPULATION FOR SECTORS WITHIN 10 MILES OF CPSES

1 to 2 Mile Zone

Sector	1970	1980	1990	2000	2010	2020
N	0	0	0	0	0	0
NNE	0	0	0	0	0	0
NE	0	0	0	0	0	0
ENE	6	0	0	0	0	0
E	0	0	0	0	0	0
ESE	3	5	5	5	5	5
SE	0	0	0	0	0	0
SSE	0	0	0	0	0	0
S	0	0	0	0	0	0
SSW	3	5	5	5	5	5
SW	11	10	10	10	10	10
WSW	9	10	10	10	10	10
W	6	10	10	10	10	10
WNW	3	5	5	5	5	5
NW	0	0	0	0	0	0
NNW	0	0	0	0	0	0
Total	41	45	45	45	45	45

2 to 3 Mile Zone

Sector	1970	1980	1990	2000	2010	2020
N	3	5	5	5	5	5
NNE	6	10	10	10	10	10
NE	3	5	5	5	5	5
ENE	6	10	10	10	10	10
E	0	0	0	0	0	0
ESE	6	10	10	10	10	10
SE	6	10	10	10	10	10
SSE	3	5	5	5	5	5
S	3	5	5	5	5	5
SSW	0	0	0	0	0	0
SW	3	5	5	5	5	5
WSW	3	5	5	5	5	5
W	9	10	10	10	10	10
WNW	3	5	5	5	5	5
NW	0	0	0	0	0	0
NNW	6	10	10	10	10	10
Total	60	95	95	95	95	95

TABLE 2.2-1 (Continued)

3 to 4 Mile Zone

Sector	1970	1980	1990	2000	2010	2020
N	6	10	10	10	10	10
NNE	27	30	30	30	30	30
NE	3	5	5	5	5	5
ENE	9	10	10	10	10	10
E	9	10	10	10	10	10
ESE	53	60	60	60	70	70
SE	9	10	10	10	10	10
SSE	0	0	0	0	0	0
S	3	5	5	5	5	5
SSW	3	5	5	5	5	5
SW	0	0	0	0	0	0
WSW	0	0	0	0	0	0
W	11	10	10	10	10	10
WNW	11	10	10	10	10	10
NW	0	0	0	0	0	0
NNW	0	0	0	0	0	0
Total	144	165	165	165	175	175

4 to 5 Mile Zone

Sector	1970	1980	1990	2000	2010	2020
N	11	10	10	10	10	10
NNE	9	10	10	10	10	10
NE	14	20	20	20	20	20
ENE	6	10	10	10	10	10
E	20	20	20	20	20	20
ESE	46	50	50	50	60	60
SE	33	40	40	40	40	40
SSE	1435	1540	1640	1700	1750	1750
S	60	60	70	70	70	70
SSW	36	40	40	40	40	40
SW	20	20	20	20	20	20
WSW	3	5	5	5	5	5
W	6	10	10	10	10	10
WNW	16	20	20	20	20	20
NW	3	5	5	5	5	5
NNW	20	20	20	20	20	20
Total	1738	1880	1990	2050	2110	2110

TABLE 2.2-1 (Continued)

5 to 10 Mile Zone

Sector	1970	1980	1990	2000	2010	2020
N	2150	2250	2360	2360	2360	2360
NNE	575	600	630	630	630	630
NE	157	170	170	170	170	170
ENE	38	40	40	40	40	40
E	80	80	90	90	90	90
ESE	242	250	270	270	270	270
SE	82	90	90	100	100	100
SSE	256	280	290	300	310	310
S	77	80	90	90	90	90
SSW	135	150	160	160	160	160
SW	58	60	70	70	70	70
WSW	91	100	100	100	100	100
W	69	70	80	80	80	80
WNW	130	140	140	140	140	140
NW	278	290	310	310	310	310
NNW	153	160	170	170	170	170
Total	4571	4820	5060	5080	5090	5090

Cumulative Populations

(Miles from Site)

Year	0-2	0-3	0-4	0-5	0-10
1970	41	101	245	1983	6554
1980	45	140	305	2185	7005
1990	45	140	305	2295	7355
2000	45	140	305	2355	7435
2010	45	140	315	2425	7515
2020	45	140	315	2425	7515

TABLE 2.2-2

CENTERS OF POPULATION IN REGION*

Community	Population	Distance From Site in Miles	Direction
0-10 Miles			
Glen Rose	1,554	4½-5½	SSE
Granbury	2,473	9 3/4-11	N
10-20 Miles			
Godley	533	18¼	NE
Tolar	312	10¼	NW
Walnut Springs	495	17	S
20-30 Miles			
Aledo	620	29	NNE
Benbrook	8,169	29-35	NNE & NE
Blum	382	25	ESE
Cleburne	16,015	22-25	ENE & E
Iredell	316	22½	SSW
Joshua	924	26	ENE
Hico	975	26½	SW
Keene	2,440	27½	ENE
Lipan	333	22	NW
Meridian	1,162	27	SSE
Morgan	415	22	SSE
Rio Vista	370	24	E
Stephenville	9,277	25-27	WSW & W

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* 1970 Population of all Unincorporated Communities Which Have 1,000 or more Inhabitants and All Incorporated Communities --- Within 50-Mile Radius of Site

TABLE 2.2-2 (Continued

Community	Population	Distance From Site in Miles	Direction
30-40 Miles			
Benbrook	8,169	32	NNE
Burelson	7,713	32	NE
Weatherford	11,750	32½	N
Grandview	935	35½	E
Alvarado	2,129	34½	ENE
Whitney	1,371	36	SE
Dublin	2,810	36	WSW
Clifton	2,578	37	SSE
Itasca	1,483	38	ESE
Mineral Wells	18,411	40	NNW
40-50 Miles			
Fort Worth	393,476	41	NE
Hillsboro	7,224	43	ESE
Mansfield	3,658	41½	ENE
Azle	4,493	44	NNE
Saginaw	2,382	45	NNE
Hamilton	2,760	45	SSW
De Leon	2,170	45½	WSW
Springtown	1,194	47	N
Valley Mills	1,022	47½	SSE
Midlothian	2,322	47½	ENE
Arlington	90,643	48½	NE
Hurst	27,215	50	NE

TABLE 2.2-3

HISTORICAL AND PROJECTED POPULATIONS FOR COUNTIES WITHIN 50 MILES OF CPSES

County	1930	1940	1950	1960	1970
Bosque	15,750	15,761	11,836	10,809	10,966
Comanche	18,430	19,215	15,516	11,865	11,898
Coryell	19,999	20,226	16,284	23,961	35,311
Dallas	325,691	398,564	614,799	951,527	1,327,321
Eastland	34,156	30,345	23,942	19,526	18,092
Ellis	53,936	47,733	45,645	43,395	46,638
Erath	20,804	20,760	18,434	16,236	18,141
Hamilton	13,523	13,303	10,660	8,488	7,198
Hill	13,523	38,355	31,282	23,650	22,596
Hood	6,779	6,674	5,287	5,443	6,368
Johnson	33,317	30,384	31,390	34,720	45,720
McLennan	98,682	101,898	130,194	150,091	147,553
Palo Pinto	17,576	18,456	17,154	20,516	28,962
Parker	18,759	20,482	21,528	22,880	33,888
Somervell	3,016	3,071	2,542	2,577	2,793
Tarrant	197,533	225,521	361,253	538,495	716,316
Wise		19,074	16,141	17,012	19,687

TABLE 2.2-3 (Continued)

County	1980	1990	2000	2010	2020
Bosque	10,000	8,800	→	→	8,800
Comanche	11,000	9,600	→	→	9,600
Coryell	42,600	53,100	64,800	79,900	97,200
Dallas	1,730,500	2,316,100	2,998,000	3,887,000	4,944,000
Eastland	16,000	13,500	→	→	13,500
Ellis	46,600	46,600	→	→	46,600
Erath	18,200	18,100	→	→	18,100
Hamilton	5,800	5,100	→	→	5,100
Hill	18,700	14,300	→	→	14,300
Hood	6,700	7,000	→	→	7,000
Johnson	51,900	57,600	62,500	68,300	73,500
McLennan	152,500	156,200	→	→	156,200
Palo Pinto	34,400	39,500	44,500	50,600	57,000
Parker	37,300	41,200	→	→	41,200
Somervell	3,000	3,200	3,300	3,400	3,400
Tarrant	860,000	1,071,000	1,304,000	1,604,000	1,949,000
Wise	21,400	23,000	24,000	25,000	25,400

TABLE 2.2-4

COMPARISON OF POPULATION PROJECTIONS FOR 1990

County	1970 Population	1990 Projections of the Population Research Council*	1990 Projections of the North Central Texas Council of Governments**
Collin	66,920	89,300	120,838
Dallas***	1,327,321	2,316,100	2,445,000
Denton	75,633	136,200	137,439
Ellis***	46,638	46,600	68,109
Johnson***	45,769	57,600	70,763
Kaufman	32,392	33,900	48,605
Parker***	33,888	41,200	48,899
Rockwell	7,046	9,700	17,753
Tarrant***	716,317	1,071,300	1,434,000
Wise***	19,687	23,000	23,812
Totals	2,371,611	3,824,900	4,415,218
Percent Increase from 1970 to 1990		61%	86%

* Reference [12]

** Reference [15]

*** Counties within 50 miles of CPSES

TABLE 2.2-5

1970 AND PROJECTED FUTURE POPULATION FOR SECTORS FROM 10 TO 50 MILES OF CPSES

10 to 20 Mile Zone

Sector	1970	1980	1990	2000	2010	2020
N	2160	2300	2400	2400	2400	2400
NNE	589	620	660	660	660	670
NE	981	1000	1200	1300	1400	1500
ENE	557	630	700	750	820	880
E	621	710	780	850	930	1000
ESE	1360	1400	1400	1500	1600	1700
SE	300	290	270	270	280	280
SSE	197	180	160	160	160	160
S	721	660	590	590	590	590
SSW	204	210	210	210	210	210
SW	245	250	250	250	250	250
WSW	374	380	380	380	380	380
W	293	300	300	300	300	300
WNW	265	270	280	280	280	280
NW	667	700	730	730	730	730
NNW	385	410	430	430	430	430
Total	9919	10310	10740	11060	11420	11760

20 to 30 Mile Zone

Sector	1970	1980	1990	2000	2010	2020
N	1164	1300	1400	1400	1400	1400
NNE	2556	2900	3300	3500	3800	4100
NE	2421	2900	3400	4000	4700	5400
ENE	10,448	11,900	13,000	14,000	16,000	17,000
E	14,626	17,000	18,000	20,000	22,000	24,000
ESE	1185	1050	880	900	930	950
SE	502	440	360	360	360	360
SSE	1919	1750	1540	1540	1540	1540
S	273	250	220	220	220	220
SSW	589	520	460	460	460	460
SW	1388	1200	1100	1100	1100	1100
WSW	7216	7200	7200	7200	7200	7200
W	3442	3500	3500	3500	3500	3500
WNW	371	380	380	380	390	390
NW	1008	1100	1200	1300	1300	1400
NNW	1015	1100	1200	1200	1200	1200
Total	50,123	54,490	57,140	61,060	66,100	70,220

TABLE 2.2-5 (Continued)

30 to 40 Mile Zone

Sector	1970	1980	1990	2000	2010	2020
N	13,716	15,000	17,000	17,000	17,000	7,000
NNE	64,536	77,000	96,000	117,000	143,000	174,000
NE	217,221	260,000	325,000	395,000	486,000	591,000
ENE	22,696	27,000	33,000	39,000	47,000	56,000
E	3,191	3,500	3,700	4,000	4,400	4,700
ESE	3,191	2,600	2,000	2,000	2,000	2,000
SE	2,442	2,000	1,600	1,600	1,600	1,600
SSE	3,489	3,200	2,800	2,800	2,800	2,800
S	672	600	500	500	500	500
SSW	534	400	400	400	400	400
SW	630	600	600	600	600	600
WSW	3,896	3,900	3,900	3,900	3,900	3,900
W	1,014	1,000	1,000	1,000	1,000	1,000
WNW	933	1,000	1,200	1,300	1,400	1,500
NW	2,034	2,400	2,800	3,100	3,600	4,000
NNW	17,915	21,000	24,000	27,000	31,000	34,000
Total	358,110	421,200	515,500	616,200	746,200	885,000

40 to 50 Mile Zone

Sector	1970	1980	1990	2000	2010	2020
N	4,482	4,900	5,400	5,500	5,500	5,500
NNE	45,418	54,000	67,000	82,000	100,000	121,000
NE	287,101	345,000	429,000	523,000	643,000	781,000
ENE	16,243	19,000	23,000	27,000	33,000	40,000
E	2,104	2,100	2,100	2,100	2,100	2,100
ESE	8,979	7,400	5,700	5,700	5,700	5,700
SE	1,967	1,700	1,500	1,500	1,500	1,500
SSE	2,161	2,000	1,900	1,900	1,900	1,900
S	886	900	1,100	1,300	1,500	1,800
SSW	3,511	2,800	2,500	2,500	2,500	2,500
SW	1,111	1,000	900	900	900	900
WSW	3,292	3,100	2,700	2,700	2,700	2,700
W	774	700	600	600	600	600
WNW	1,422	1,600	1,800	2,000	2,300	2,600
NW	1,160	1,400	1,600	1,800	2,000	2,300
NNW	12,652	15,000	17,000	19,000	21,000	23,000
Total	393,263	462,600	563,800	679,500	826,200	995,100

TABLE 2.2-5 (Continued)

CUMULATIVE POPULATIONS

	(Miles from Site)			
Year	0-20	0-30	0-40	0-50
1970	16,473	66,596	424,706	817,969
1980	17,300	71,800	493,000	955,600
1990	18,100	75,200	590,700	1,154,500
2000	18,500	79,600	695,800	1,375,300
2010	18,900	85,000	831,200	1,657,400
2020	19,300	89,500	974,500	1,969,600

TABLE 2.2-6

LAND USE IN HOOD AND SOMERVELL COUNTIES, 1958 AND 1967.

	Hood County		Somervell County	
	1958	1967	1958	1967
Cropland	60,000*	38,307	22,500	21,228
Pasture	4,900	18,365	--	2,348
Range	147,800	133,315	92,000	46,264
Forest	48,700	70,509	7,300	45,680
Other Land	1,500	1,969	200	6,358
Urban and Built-up	6,000	6,075	3,100	3,151
Small-Water	3,700	4,100	200	302
Federal Non-Cropland			800	749
Total	272,600	272,640	126,100	126,080

Source: Reference [26]

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* All numbers represent acreage.

TABLE 2.2-7

HOOD COUNTY 1971 AGRICULTURAL STATISTICS

1. CROPS

CROP		PLANTED ACRES	HARVESTED ACRES	YIELD PER HARVESTED ACRE	UNIT	PRODUCTION
UPLAND COTTON		*			Lb./Bale	
AMERICAN – PIMA COTTON		--			Lb./Bale	
WHEAT		2,500			Bushel	
OATS		15,500	1,600	11.9	Bushel	19,000
BARLEY		--			Bushel	
RYE		--			Bushel	
FLAXSEED		--			Bushel	
SORGHUMS	GRAIN	1/ 5,000	300	29.0	Bushel	8,700
	SILEAGE	--			Ton	
	HAY	--	2,400	1.8	Ton	4,400
CORN	GRAIN	1/ *			Bushel	
	SILAGE	--			Ton	
SOYBEANS		--			Bushel	
PEANUTS		8,200	8,100	831	Pound	5,728,000
RICE		--			Lb./Cwt.	
BROOMCORN		--			Lb./Ton	
CASTORBEANS		--			Pound	
SUGARBEETS		--			Ton	
GUAR		--			Pound	
ALFALFA HAY		--			Ton	
ALL HAY, EXCLUDING SORGHUM		--	10,500	.9	Ton	9,200
ALFALFA SEED		--			Pound	
SWEETCLOVER SEED		--			Pound	
VETCH SEED		--			Pound	
COWPEAS	GREEN	1/ *			Pound	
	DRY	--			Pound	

2. IRRIGATED CROPS

SELECTED CROP	ACRES PLANTED		ACRES HARVESTED		UNIT	YIELD PER HARVESTED ACRE	
	IRRIGATED	NOT IRRIGATED	IRRIGATED	NOT IRRIGATED		IRRIGATED	NOT IRRIGATED
UPLAND COTTON	--	*			Pound		
WHEAT	--	2,500			Bushel		
SORGHUMS FOR GRAIN	1/ --	1/ 5,000		300	Bushel		29.0
PEANUTS	1,100	7,100	1,100	7,000	Pound	1,500	725

3. VEGETABLES FOR FRESH MARKET AND PROCESSING

CROP	ACRES HARVESTED	CROP	ACRES HARVESTED	CROP	ACRES HARVESTED
BROCCOLI	--	SWEET CORN 2/	--	TOMATOES	--
CABBAGE	--	HONEYDEW MELONS	--	WATERMELONS	*
CANTALOUPS	--	LETTUCE	--	IRISH POTATOES	*
CARROTS	--	ONIONS	--	SWEETPOTATOES	--
CAULIFLOWER	--	GREEN PEPPERS	--		
CUCUMBERS	--	SPINACH 2/	--	ALL VEGETABLES	*

4. FRUITS AND PECANS

CROP		PRODUCTION
PEACHES (Bu.)		*
GRAPEFRUIT (80 Lb. box)		--
ORANGES (90 Lb. box)		--
PECANS (LBS.)	1970 3/	950,000
	1971	1,180,000

5. 1971 LIVESTOCK PRODUCTION OR MARKETING

EGGS PRODUCED (Dozen)	385,000
BROILERS PRODUCED (Number)	--
TURKEYS PRODUCED (Number)	--
MILK PRODUCED (Cwt.)	98,260
WOOL PRODUCED (Pound)	15,000
MOHAIR PRODUCED (Pound)	66,000
CATTLE MARKETED FROM FEEDLOTS (Number)	7,000

6. JANUARY 1 LIVESTOCK ON FARMS

ITEM	1972
	NUMBER
ALL CATTLE	28,000
MILK COWS THAT HAVE CALVED	800
BEEF COWS THAT HAVE CALVED	14,000
CATTLE ON FEED	4,000
ALL HOGS 4/	2,800
ALL SHEEP	2,000
EWES 1 YEAR AND OVER	2,000
ALL ANGORA GOATS	3,000
HENS AND PULLETS OF LAYING AGE	14,000

7. GOVERNMENT PAYMENTS IN 1971

ITEM	DOLLARS
FEED GRAIN PROGRAM	19,514
WHEAT PROGRAM	452
UPLAND AND A-P COTTON PROGRAM	117
SUGARBEET PROGRAM	--
WOOL AND MOHAIR PROGRAM	39,021
GREAT PLAINS CONSERVATION PROGRAM	2,491
CROPLAND ADJUSTMENT PROGRAM	10,833
RURAL ENVIRONMENTAL ASSISTANCE PROGRAM	26,531
EMERGENCY CONSERVATION MEASURE	--

8. CASH RECEIPTS FROM FARM MARKETINGS

ITEM	1970 3/	1971
	1,000 DOLLARS	
ALL CROPS 5/	1,847	1,273
LIVESTOCK AND LIVESTOCK PRODUCTS	3,330	4,223
TOTAL CROPS AND LIVESTOCK	5,177	5,496
GOVERNMENT PAYMENTS	103	99
TOTAL FARM MARKETINGS AND GOVERNMENT PAYMENTS	5,280	5,595

* Items reported but not published on a county basis because of either limited production or to avoid disclosure of individual operations. 1/ Planted for all purposes. 2/ Fresh market only but processing included in all vegetables. 3/ Revised 4/ On hand preceding December 1.

5/ DOES NOT INCLUDE VALUE OF STANDING TIMBER SOLD FROM INDUSTRIAL, PUBLIC, AND OTHER NON-FARM TIMBERLANDS. FOR VALUES SEE BULLETIN 90, 1971 CASH RECEIPTS, PAGE 32. HOOD

TABLE 2.2-8

SOMERVELL COUNTY 1971 AGRICULTURAL STATISTICS

1. CROPS

CROP		PLANTED ACRES	HARVESTED ACRES	YIELD PER HARVESTED ACRE	UNIT	PRODUCTION
UPLAND COTTON		*			Lb./Bale	
AMERICAN – PIMA COTTON		—			Lb./Bale	
WHEAT		*			Bushel	
OATS		1,600	100	10.0	Bushel	1,000
BARLFY		—			Bushel	
RYE		—			Bushel	
FLAXSEED		—			Bushel	
SORGHUMS GRAIN	1/	2,500	500	15.6	Bushel	7,800
SORGHUMS SILEAGE		—			Ton	
SORGHUMS HAY		—	600	2.5	Ton	1,500
CORN GRAIN	1/	*			Bushel	
CORN SILAGE		—			Ton	
SOYBEANS		—			Bushel	
PEANUTS		3,000	2,750	668	Pound	1,838,000
RICE		—			Lb./Cwt.	
BROOMCORN		—			Lb./Ton	
CASTORBEANS		—			Pound	
SUGARBEETS		—			Ton	
GUAR		—			Pound	
ALFALFA HAY		—			Ton	
ALL HAY, EXCLUDING SORGHUM		—	3,200	.8	Ton	2,550
ALFALFA SEED		—			Pound	
SWEETCLOVER SEED		—			Pound	
VETCH SEED		—			Pound	
COWPEAS GREEN	1/	*			Pound	
COWPEAS DRY		—			Pound	

2. IRRIGATED CROPS

SELECTED CROP	ACRES PLANTED		ACRES HARVESTED		UNIT	YIELD PER HARVESTED ACRE	
	IRRIGATED	NOT IRRIGATED	IRRIGATED	NOT IRRIGATED		IRRIGATED	NOT IRRIGATED
UPLAND COTTON	—	*			Pound		
WHEAT	—	*			Bushel		
SORGHUMS FOR GRAIN	1/ *	1/ 2,100		500	Bushel		15.6
PEANUTS	*	2,850		2,600	Pound		638

3. VEGETABLES FOR FRESH MARKET AND PROCESSING

CROP	ACRES HARVESTED	CROP	ACRES HARVESTED	CROP	ACRES HARVESTED
BROCCOLI	—	SWEET CORN 2/	—	TOMATOES	—
CABBAGE	—	HONEYDEW MELONS	—	WATERMELONS	*
CANTALOUPS	*	LETTUCE	—	IRISH POTATOES	—
CARROTS	—	ONIONS	—	SWEETPOTATOES	*
CAULIFLOWER	—	GREEN PEPPERS	—		
CUCUMBERS	—	SPINACH 2/	—	ALL VEGETABLES	*

4. FRUITS AND PECANS

CROP	PRODUCTION
PEACHES (Bu.)	*
GRAPEFRUIT (80 Lb. box)	—
ORANGES (90 Lb. box)	—
PECANS (LBS.) 1970 3/	75,000
PECANS (LBS.) 1971	144,000

5. 1971 LIVESTOCK PRODUCTION OR MARKETING

EGGS PRODUCED (Dozen)	*
BROILERS PRODUCED (Number)	—
TURKEYS PRODUCED (Number)	—
MILK PRODUCED (Cwt.)	*
WOOL PRODUCED (Pound)	2,000
MOHAIR PRODUCED (Pound)	10,000
CATTLE MARKETED FROM FEEDLOTS (Number)	—

6. JANUARY 1 LIVESTOCK ON FARMS

ITEM	1972
	NUMBER
ALL CATTLE	9,000
MILK COWS THAT HAVE CALVED	*
BEEF COWS THAT HAVE CALVED	4,000
CATTLE ON FEED	--
ALL HOGS 4/	900
ALL SHEEP	*
EWES 1 YEAR AND OVER	*
ALL ANGORA GOATS	1,000
HENS AND PULLETS OF LAYING AGE	*

7. GOVERNMENT PAYMENTS IN 1971

ITEM	DOLLARS
FEED GRAIN PROGRAM	10,870
WHEAT PROGRAM	207
UPLAND AND A-P COTTON PROGRAM	13,705
SUGARBEET PROGRAM	—
WOOL AND MOHAIR PROGRAM	11,822
GREAT PLAINS CONSERVATION PROGRAM	6,343
CROPLAND ADJUSTMENT PROGRAM	—
RURAL ENVIRONMENTAL ASSISTANCE PROGRAM	11,887
EMERGENCY CONSERVATION MEASURE	—

8. CASH RECEIPTS FROM FARM MARKETINGS

ITEM	1970 3/	1971
	1,000 DOLLARS	
ALL CROPS 5/	498	309
LIVESTOCK AND LIVESTOCK PRODUCTS	848	1,036
TOTAL CROPS AND LIVESTOCK	1,346	1,345
GOVERNMENT PAYMENTS	64	55
TOTAL FARM MARKETINGS AND GOVERNMENT PAYMENTS	1,410	1,400

* Items reported but not published on a county basis because of either limited production or to avoid disclosure of individual operations. 1/ Planted for all purposes.
2/ Fresh market only but processing included in all vegetables. 3/ Revised 4/ On hand preceding December 1.

5/ DOES NOT INCLUDE VALUE OF STANDING TIMBER SOLD FROM INDUSTRIAL, PUBLIC, AND OTHER NON-FARM TIMBERLANDS. FOR VALUES SEE BULLETIN 90, 1971 CASH RECEIPTS, PAGE 32.

TABLE 2.2-9

IRRIGATION IN HOOD AND SOMERVELL COUNTIES, 1958, 1964, AND 1969

	Hood			Somervell		
	1958	1964 (Acres)	1969	1958	1964 (Acres)	1969
Cotton	200	0	0	10	0	0
Grain Sorghum	50	0	0	35	0	0
Forage Crops	0	0	0	30	0	0
Peanuts	250	0	250	100	0	271
Pecans	200	340	356	0	0	0
Alfalfa	60	0	0	20	0	0
Other Permanent-Hay-Pasture	445	560	739	0	211	230
Vegetables-Shallow Root	45	0	0	0	0	23
Total	1,250	900	1,345	195	211	524

NOTE: Total estimated irrigational water use in Hood and Somervell Counties was 795 and 338 acre/feet in 1969, respectively, nearly all of which came from surface water sources.

Source: Reference [27]

TABLE 2.2-10

LAND USE WITHIN A FIVE-MILE RADIUS OF CPSES

Land Use	Percent	Acres
Range	46	23,120
Cultivated Land	31	15,340
Mixed Woodland	22	11,160
Urban & Parks	1	610
Total	100	50,230

TABLE 2.2-11

LOCATION OF DOMINANT FOOD CROPS WITHIN A FIVE-MILE RADIUS OF CPSES

Food Crop (s)	Direction (Range)	Direction (Range)
Peanut	1-2 miles	S-SW
Peanut	2¼ - 2 3/4 miles	WSW - W
Peanut	2-5 miles	W - NW
Peanut	2½ - 3½ miles	NNE
Peanut	2½ - 3 3/4 miles	ENE
Peanut	3½ - 5 miles	E - ESE
Peanut	3-5 miles	ESE
Pecan (200 acres)	4 - 4½ miles	ENE
Cotton (50 acres)	3 - 3½ miles	ESE
Vegetables (40-50 acres) a. Okra b. Peas c. Squash d. Cucumbers e. Tomatoes	4½ miles	E

TABLE 2.2-12

PUBLIC SUPPLY, INDUSTRIAL, STOCK, DOMESTIC AND IRRIGATION WELLS IN COUNTIES ADJACENT TO CPSES SITE* AS OF 1973

COUNTY	STATE WELL NO.	OWNER	PIEZOMETRIC ELEVATION (FT.)	YIELD gpm	RATE OF DECLINE** (-) OR RISE (+) OF PIEZOMETRIC SURFACE, FT/YEAR	USE***
BOSQUE	BB-32-58-502	Flat Top Ranch	734	-	-5.1	ST.
	BB-32-59-402	City of Walnut Springs	657	135	-6.7	P.S.
	BB-32-60-602	Kepperl Deep Well Co.	538	10	-5.3	P.S.
	BB-32-60-701	City of Morgan	602	75	-4.8	P.S.
	BB-32-61-703	Lakeside Water Supply District	557	175	-5.0	P.S.
	BB-40-02-108	M. L. Dunn	741	-	-4.0	IRR.
	BB-40-02-109	H. R. Storbeck	730	500	+1.4	IRR.
	BB-40-03-601	City of Meridian	599	350	-3.0	P.S.
	BB-40-03-901	T. H. Degt	639	55	0	IND.
	BB-40-04-801	N. P. Powell Ranch	647	-	-13.8	DOM.,ST.
	BB-40-05-701	Ronnie Jones	501	-	-9.2	DOM.,ST.
	BB-40-05-903	J. W. Murtishas	440	120	-10.7	P.S.
	BB-40-05-904	U.S. Army Corps of Engineers	483	-	-5.6	P.S.
	BB-40-10-801	City of Granfills Gap	683	20	-5.6	P.S.
	BB-40-11-401	J. Bruce Parks	692	10	-4.4	ST.
	BB-40-11-602	H. A. Webb	590	-	-4.3	DOM.,ST.
	BB-40-12-201	Harold Wiede	550	-	-9.3	DOM.,ST.
	BB-40-12-805	City of Clifton	541	125	-7.8	P.S.
	BB-40-14-702	E. S. Dorman	438	-	-7.6	DOM.,ST.
	BB-40-19-101	John Hollingsworth	628	-	+5.6	DOM.
	BB-40-20-301	Charlie Thlele	500	-	-8.1	DOM.,ST.
	BB-40-20-602	H. E. Prosser	518	-	-3.2	DOM.,ST.
	BB-40-21-701	City of Valley Mills	447	140	-10	P.S.
	BB-40-21-702	City of Valley Mills	431	160	-14.7	P.S.

TABLE 2.2-12 (continued) Page 2 of 4

COUNTY	STATE WELL NO.	OWNER	PIEZOMETRIC ELEVATION	YIELD gpm	RATE OF DECLINE** (-) OR RISE (+) OF PIEZOMETRIC SURFACE, FT/YEAR	USE***
ERATH	JP-31-38-702	T. C. Sellers	1203	-	-4.0	ST.
	JP-31-39-502	F. E. Baranch	1113	75	0	IRR.
	JP-31-39-101	Melvin Tipton	1208	10	0	DOM.
	JP-31-47-501	Collier Ranch	1065	-	-2.0	ST.,DOM.
	JP-31-48-901	E. S. Stocks	942	8	-2.0	ST.,DOM.
	JP-31-52-303	Gayle Manan	1316	100	+1.0	IRR.
	JP-31-53-203	Louis Bays	1257	130	+0.60	IRR.
	JP-31-53-303	Aaron Henslee, Jr.	1220	-	+0.50	ST.,DOM.
	JP-31-53-403	J. H. Fair	1280	220	-0.50	IRR.
	JP-31-53-301	Wayne Keith	1268	35	-0.60	IRR.
	JP-31-53-601	Ted Robbins	1196	-	-1.10	IRR.
	JP-31-53-718	Walter Ripptoe	1231	25	-1.60	IRR.
	JP-31-53-805	B. W. Mathis	1234	75	-0.2	IRR.
	JP-31-55-107	City of Stephenville	1070	-	+1.0	P.S.
	JP-31-55-114	City of Stephenville	1080	75	+0.3	P.S.
	JP-31-55-202	City of Stephenville	1050	200	-1.50	P.S.
	JP-31-55-301	C. A. Bradley	1030	170	-3.0	IRR.
	JP-31-55-801	City of Stephenville	1070	225	-0.40	P.S.
	JP-31-55-803	M. S. Fowler	1261	180	-1.70	IRR.
	JP-31-61-301	T. House	1216	338	+0.20	IRR.
	JP-31-62-104	City of Dublin	1176	-	+1.0	P.S.
	JP-31-62-803	G. G. Hall	1172	-	+2.7	DOM.
	JP-31-63-301	J. P. McConnell	1018	-	-8.1	IRR.
	JP-31-63-901	M. L. Gage	966	-	-2.7	DOM.
	JP-31-64-101	Glen Kelsay	964	-	+7.5	IRR.
	JP-31-64-301	M. C. Lowry	885	-	-1.0	DOM.
	JP-31-64-402	L. F. Allams	940	105	-1.50	IRR.
	JP-31-54-801	Leander Kikes	1162	300	+0.9	IRR.

2

TABLE 2.2-12 (continued)

COUNTY	STATE WELL NO.	OWNER	PIEZOMETRIC ELEVATION	YIELD gpm	RATE OF DECLINE** (-) OR RISE (+) OF PIEZOMETRIC SURFACE, FT/YEAR	USE***	
ERATH	JP-31-64-602	J. B. Woodard	898	500	+8.5	IRR.	
	JP-32-49-501	E. L. Huffman	859	-	-1.5	IRR.	
	JP-41-08-202	Holliday	912	-	-1.60	IRR.	
HOOD	LY-31-32-901	Herman D. Howard	932	15	+0.80	P.S.	
	LY-32-25-701	T .L. Compton	871	-	0	DOM.,ST.	
	LY-32-26-701	O. P. Leonard	686	-	-1.0	DOM.	
	LY-32-27-402	A. W. Hall	856	-	+3.0	ST.	
	LY-32-27-403	A. W. Hall	619	-	0	DOM.	
	LY-32-34-608	City of Granbury	602	-	-4.0	Not Used	
	LY-32-41-102	S. Allen	835	-	+0.2	IRR.	
	LY-32-41-301	Rufus Vest	761	-	-2.0	DOM.,ST.	
	LY-32-42-303	A. J. kiesling	608	-	-0.5	Not Used	2
	LY-32-42-403	A. L. Hurley	744	-	+1.5	DOM.	
	LY-32-43-103	V. D. Wheeler	614	-	-5.0	DOM.	
JOHNSON	PX-32-52-202	Texas Lime Co.	429	-	-11.0	IND.	
	PX-32-38-901	Bethany Water Supply	57	-	-19.3	P.S.	
	PX-32-45-601	Cleburne	146	350	+85.0	P.S.	
SOMERVELL	XJ-32-41-902	J. B. Sanderson	751	6	-0.7	IRR.	
	XJ-32-42-801	L. P. Jones	676	-	-2.3	DOM.	
	XJ-32-43-402	B. B. Halbert	592	-	-0.80	ST.	
	XJ-32-43-406	J. O. Hardy	590	-	+0.7	DOM.	
	XJ-32-43-703	W. B. Stewart	597	-	-1.70	DOM.	
	XJ-32-43-805	R. E. Cresswell	583	-	-2.9	DOM.	
	XJ-32-49-601	J. W. Tottenbam	997	-	+0.30	ST.	
	XJ-32-50-202	W. A. Wood	697	2½	-0.30	DOM.	
	XJ-32-50-304	City of Glen Rose	612	250	-1.20	P.S.	
	XJ-32-50-402	Otis Shipman	740	-	-1.10	DOM.	
	XJ-32-50-503	Kelly Lewellan	697	-	-0.80	DOM.	

TABLE 2.2-12 (continued)

COUNTY	STATE WELL NO.	OWNER	PIEZOMETRIC ELEVATION	YIELD gpm	RATE OF DECLINE** (-) OR RISE (+) OF PIEZOMETRIC *SURFACE, FT/YEAR*	USE***
SOMERVELL	XJ-32-51-104	R. P. Walker	646	-	-1.0	DOM.
	XJ-32-51-501	H. C. Polley	660	-	+2.4	DOM.
	XJ-32-51-601	Dr. Lee Yater	520	-	-3.8	ST.

2

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* Groundwater resources of part of Central Texas with emphasis on Travis Peak Formation, Texas Water Development Board, in Press.

** Estimated, based on water level data from 1966 through 1973.

*** Use: P.S., Public Supply; Ind. Industrial; St., Stock; Dom., Domestic; Irr., Irrigation.

TABLE 2.2-13

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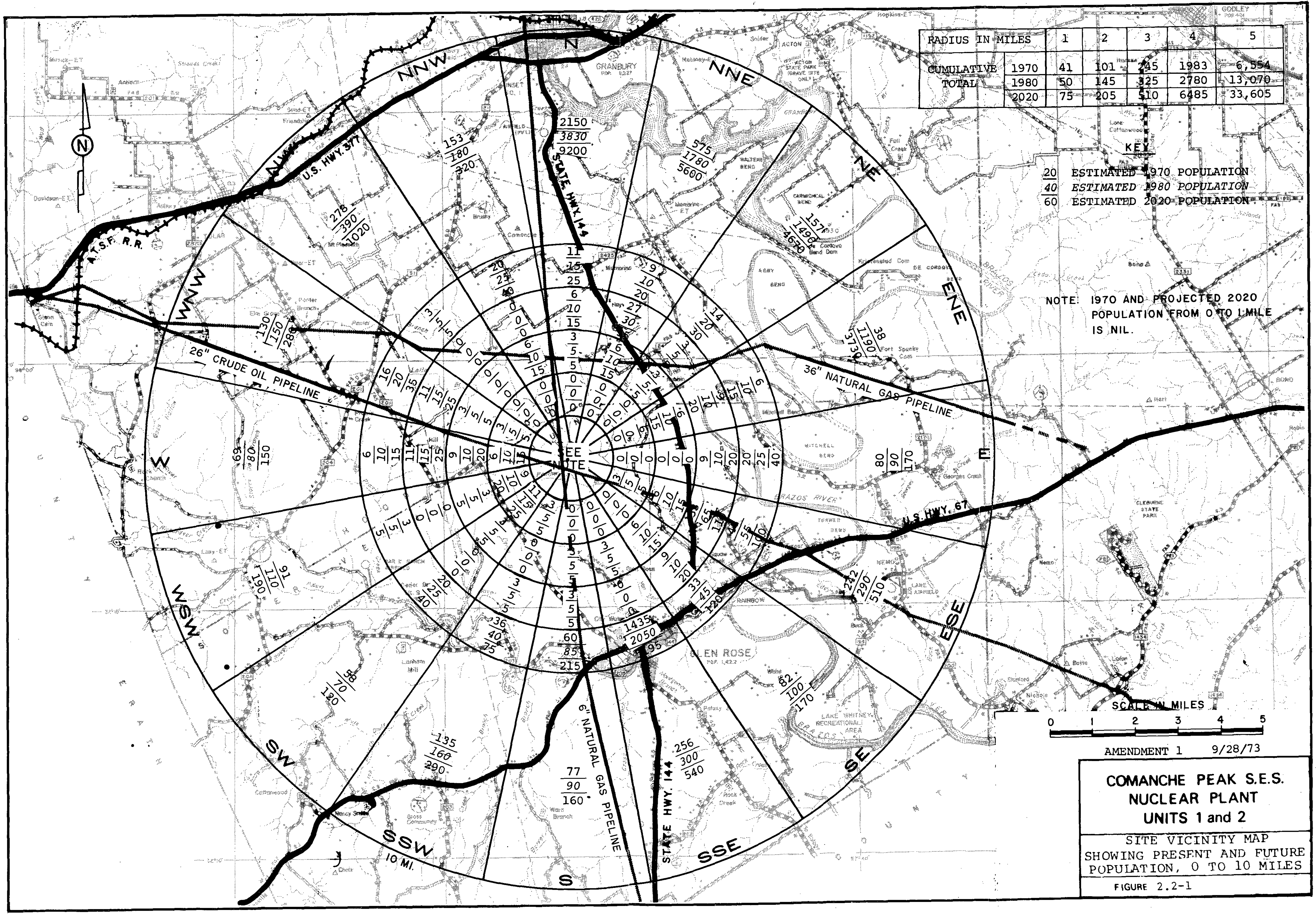


RADIUS IN MILES		1	2	3	4	5
CUMULATIVE TOTAL	1970	41	101	245	1983	6,554
	1980	50	145	325	2780	13,070
	2020	75	205	510	6485	33,605

KEY

20	ESTIMATED 1970 POPULATION
40	*ESTIMATED 1980 POPULATION*
60	ESTIMATED 2020 POPULATION

NOTE: 1970 AND PROJECTED 2020 POPULATION FROM 0 TO 1 MILE IS NIL.

SCALE IN MILES

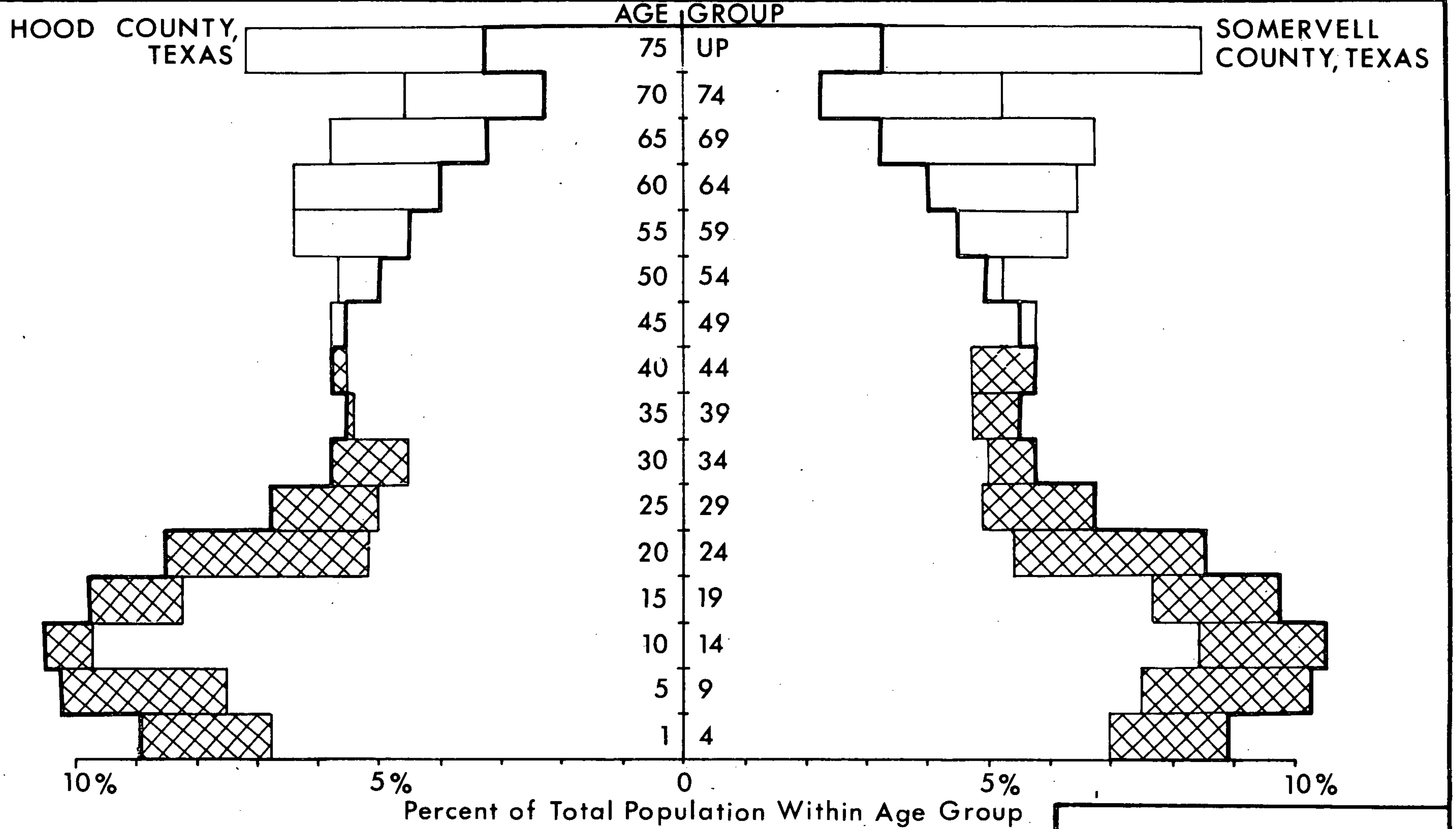
0 1 2 3 4 5

AMENDMENT 1 9/28/73

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

SITE VICINITY MAP
SHOWING PRESENT AND FUTURE
POPULATION, 0 TO 10 MILES

FIGURE 2.2-1



KEY

Bar–chart representing total Texas population is inscribed by darkened lines on both sides of figure to facilitate comparision.

▨ Percentage in age group less than state average.

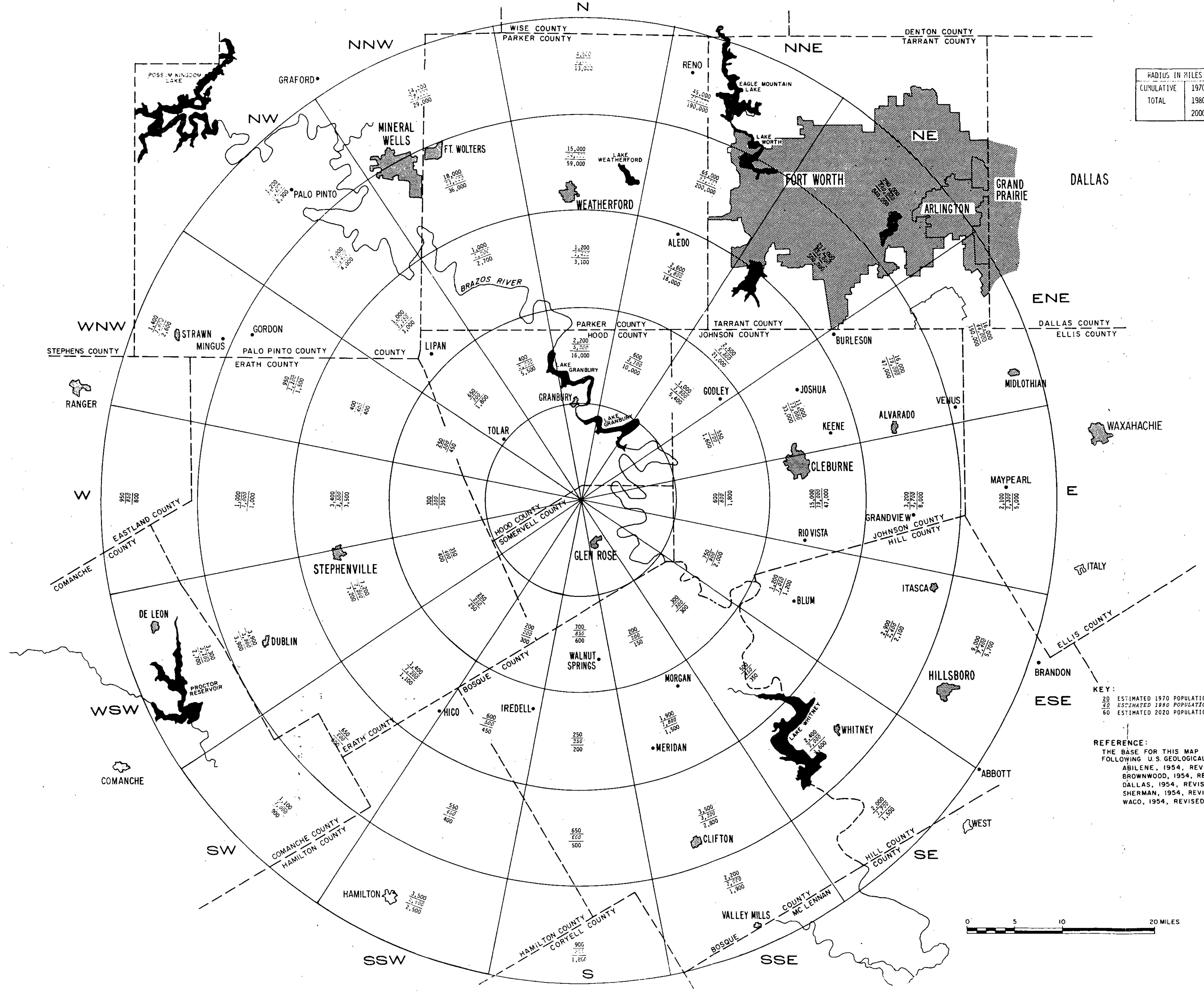
Adapted from U.S. Dept. of Commerce, Bureau of the Census, 1971, General Population Characteristics, 1970.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

POPULATION AGE DISTRIBUTIONS IN HOOD AND SOMERVELL COUNTIES

FIGURE 2.2–2

RADIUS IN MILES		10	20	30	40	50
CUMULATIVE	1970	6,554	15,854	67,004	419,704	816,854
TOTAL	1980	13,070	31,000	94,200	483,500	997,100
	2000	33,605	80,500	222,200	1,090,600	2,340,300



REFERENCE:

THE BASE FOR THIS MAP WAS PREPARED FROM PORTIONS OF THE FOLLOWING U.S. GEOLOGICAL SURVEY 1:250,000 MAPS:

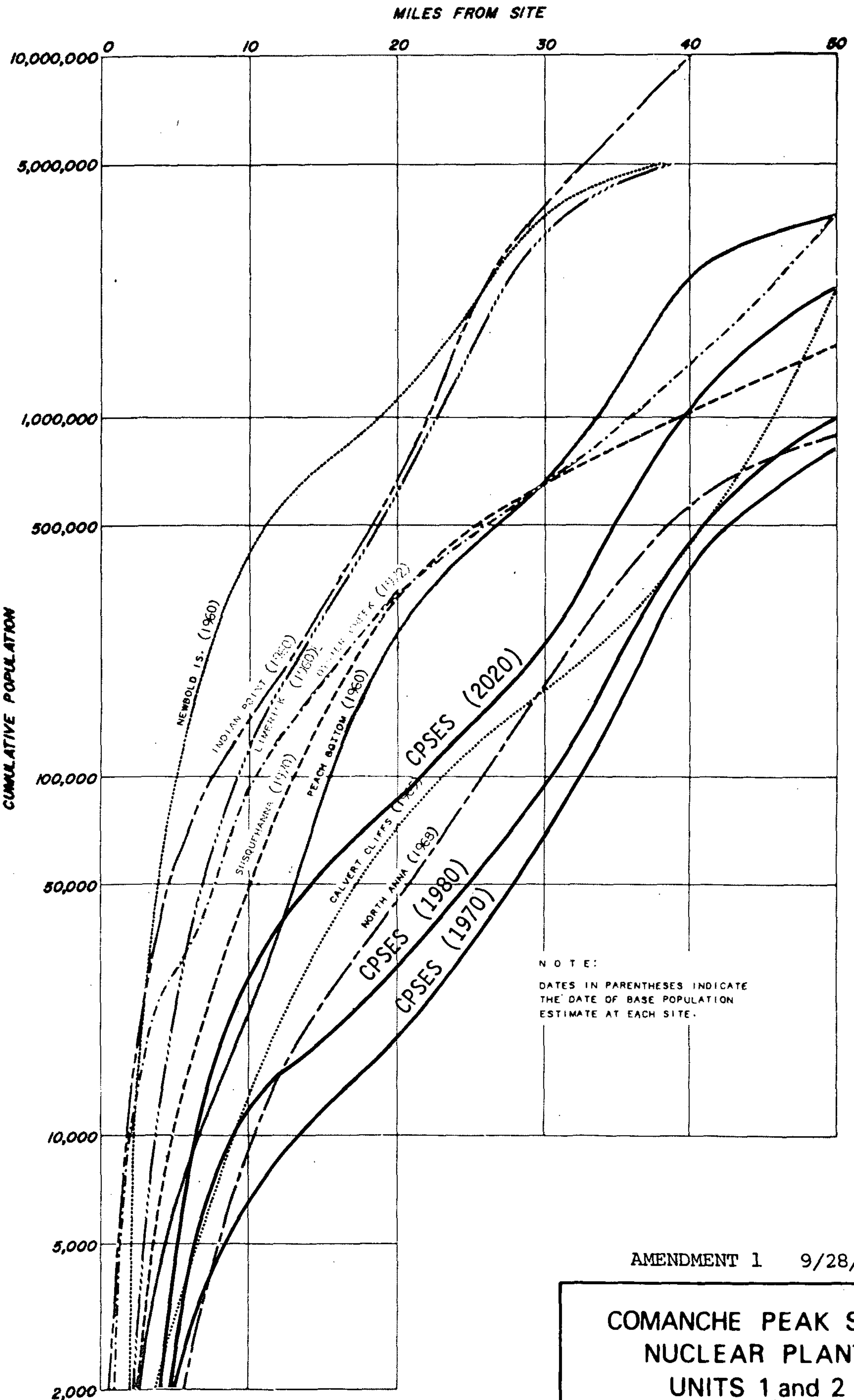
ABILENE, 1954, REVISED 1965
BROWNWOOD, 1954, REVISED 1964
DALLAS, 1954, REVISED 1963
SHERMAN, 1954, REVISED 1963
WACO, 1954, REVISED 1963

1/21/74 Amendment 2

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

REGIONAL MAP SHOWING PRESENT AND FUTURE POPULATION, 10 TO 50 MILES

FIGURE 2.2-3



NOTE:

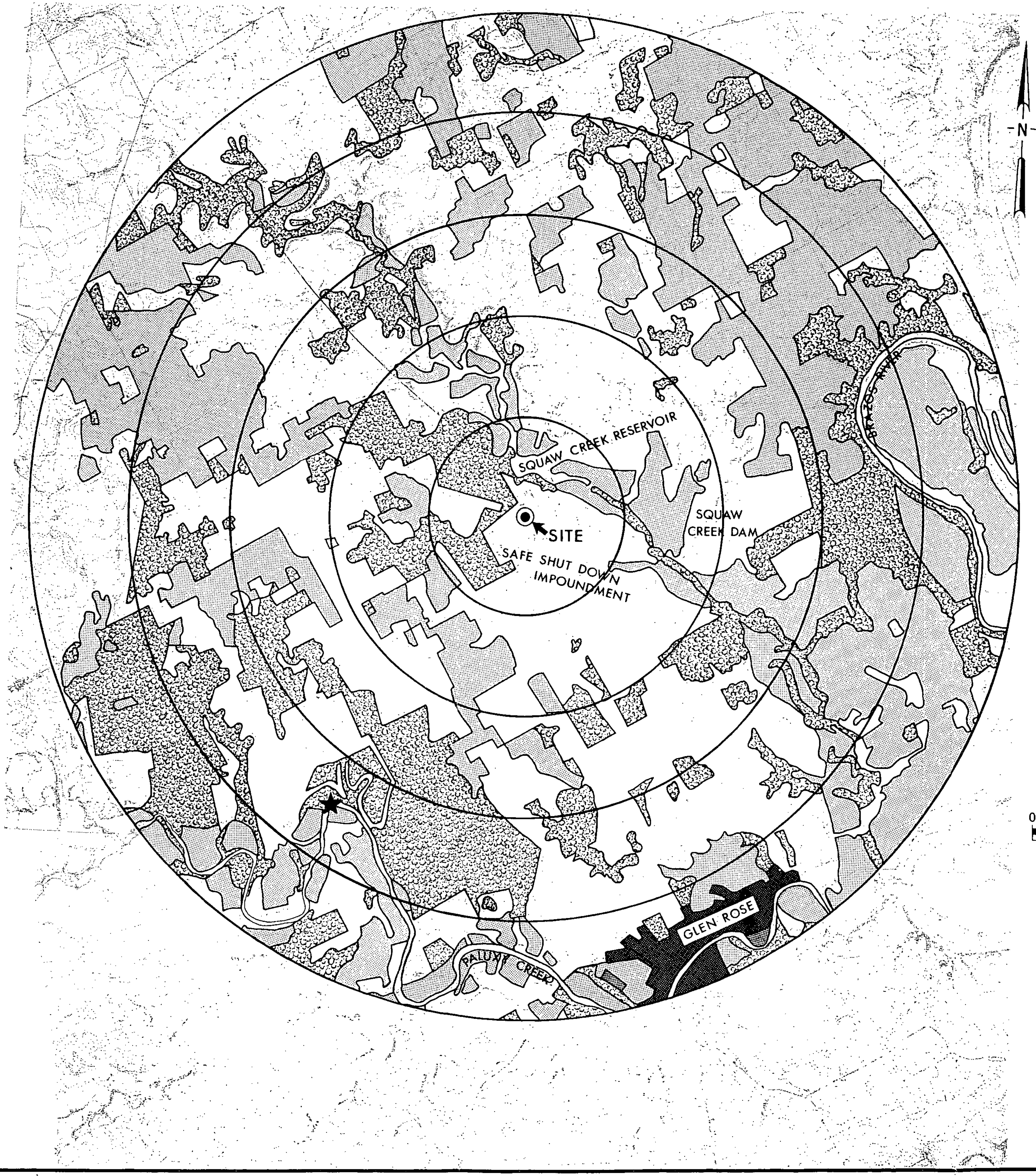
DATES IN PARENTHESES INDICATE THE DATE OF BASE POPULATION ESTIMATE AT EACH SITE.

AMENDMENT 1 9/28/73

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

CUMULATIVE 1970, 1980 AND 2020 POPULATION OF SITE REGION, 0 TO 50 MILES

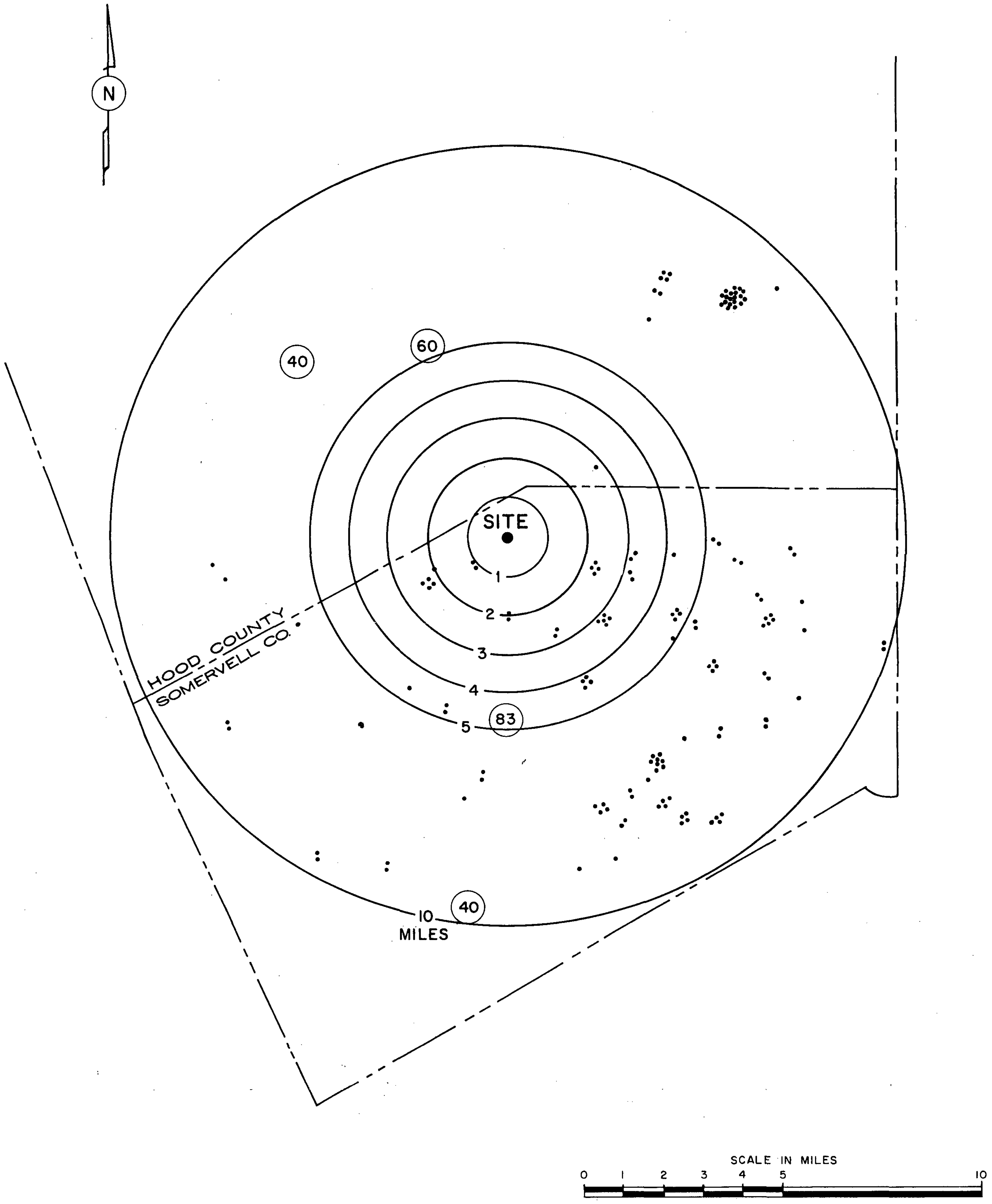
FIGURE 2.2-4



COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

SITE VICINITY MAP SHOWING
NUCLEAR PLANT
0 to 5 MILES

FIGURE 2.2-5



KEY

●∴ EACH DOT REPRESENTS ONE DAIRY COW

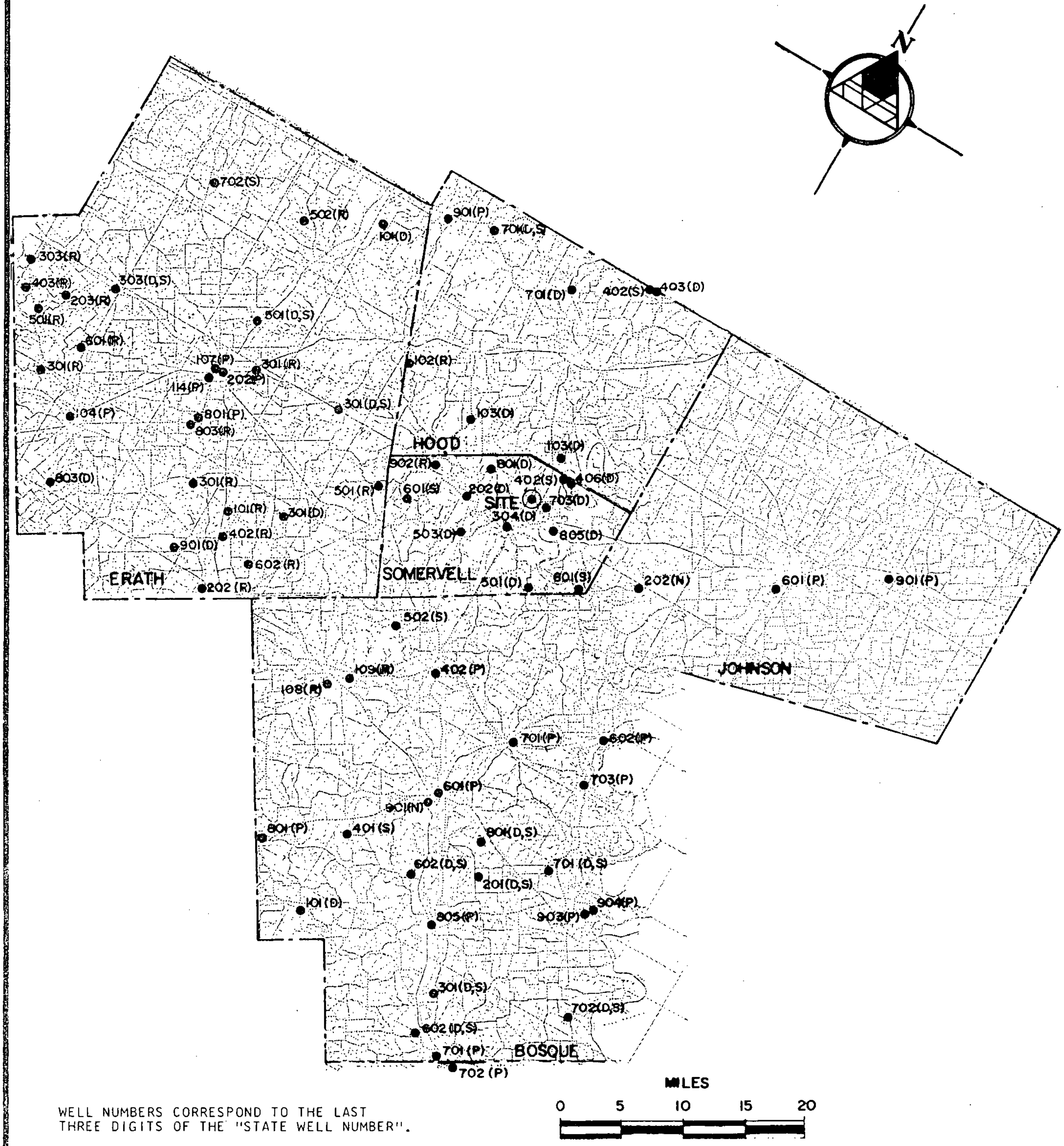
(40) CIRCLED NUMBERS REPRESENT NUMBER OF COWS IN A DAIRY HERD

DATA REPRESENT DAIRY CATTLE DISTRIBUTION IN 1972. DAIRY CATTLE USUALLY ARE PASTURED NEAR FARM-RANCH BUILDINGS, FOR CONVENIENCE OF MILKING, AND USUALLY GRAZE ON IMPROVED PASTURE AREAS WHICH ARE OF LIMITED EXTENT. BECAUSE OF THESE FACTORS, DAIRY CATTLE DO NOT RANGE FAR FROM THE POSITIONS INDICATED.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

DAIRY CATTLE,
0 TO 10 MILES

FIGURE 2.2-6



WELL NUMBERS CORRESPOND TO THE LAST
THREE DIGITS OF THE "STATE WELL NUMBER".

WELL NUMBER

LEGEND

● 801(P)	PUBLIC SUPPLY WELL
● 202(N)	INDUSTRIAL WELL
● 202(R)	IRRIGATION WELL
● 101(D)	DOMESTIC WELL
● 602(D,S)	DOMESTIC, STOCK WELL
● 601(S)	STOCK WELL

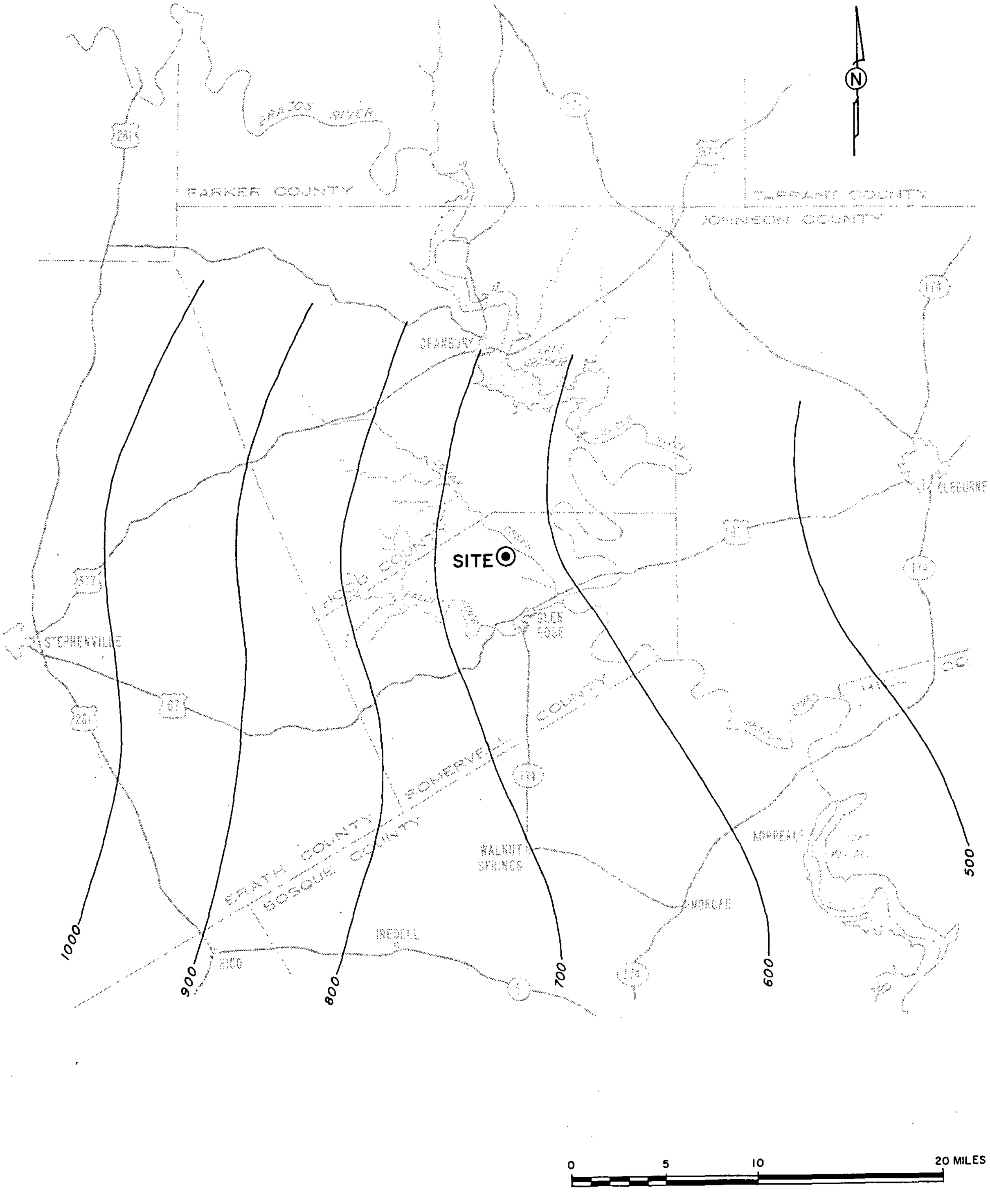
SOURCE TEXAS WATER DEVELOPMENT
BOARD, AUSTIN, TEXAS

1/21/74 Amendment 2

COMANCHE PEAK S.E.S
NUCLEAR PLANT
UNITS 1 and 2

PUBLIC SUPPLY, INDUSTRIAL
IRRIGATION, DOMESTIC AND
STOCK WELLS IN THE STUDY AREA

FIGURE 2.2-7



LEGEND

600 PIEZOMETRIC SURFACE ELEVATION CONTOUR

REFERENCE: The base map for this illustration was prepared from portions of U.S.G.S. quadrangle maps for Abilene, Brownwood, Dallas and Waco.

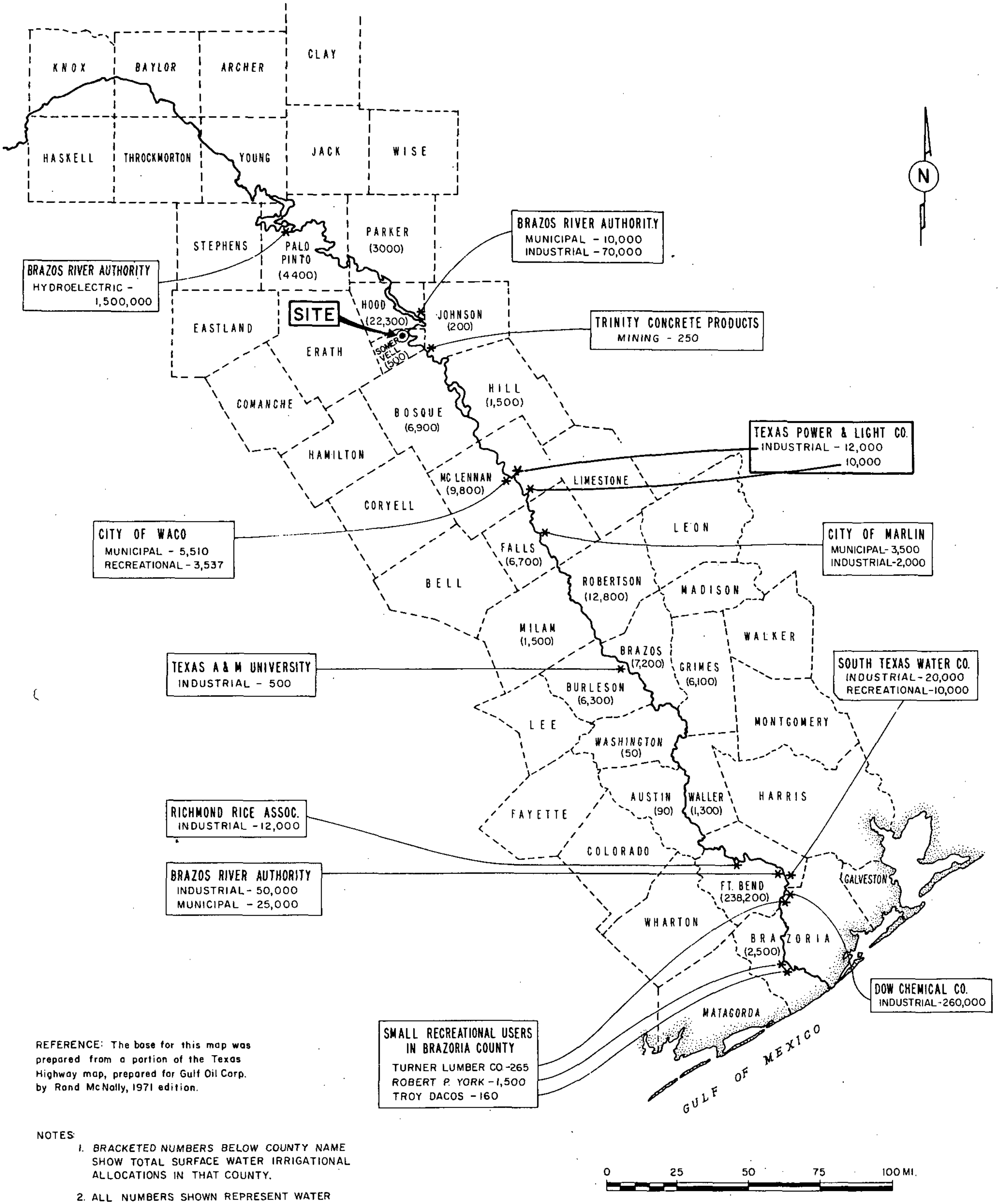
COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

PIEZOMETRIC SURFACE,
TWIN MOUNTAINS FORMATION,
SITE REGION

FIGURE 2.2-8

FIGURE 2.2-9

DELETED



REFERENCE: The base for this map was prepared from a portion of the Texas Highway map, prepared for Gulf Oil Corp. by Rand McNally, 1971 edition.

NOTES:

1. BRACKETED NUMBERS BELOW COUNTY NAME SHOW TOTAL SURFACE WATER IRRIGATIONAL ALLOCATIONS IN THAT COUNTY.
2. ALL NUMBERS SHOWN REPRESENT WATER ALLOCATIONS IN ACRE-FEET PER YEAR FROM THE BRAZOS RIVER.
3. THIS MAP INCLUDES ALLOCATED WATER WITHDRAWALS FROM BRAZOS RIVER ONLY, WITH TRIBUTARIAL USERS BEING OMITTED.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

SURFACE WATER USER
MAP OF BRAZOS RIVER

FIGURE 2.2-10

2.3 REGIONAL HISTORIC, SCENIC, CULTURAL AND NATURAL LANDMARKS

2.3.1 HISTORICAL SITES AND LANDMARKS

Within a five-mile radius of the Comanche Peak Steam Electric Station (CPSES), the only natural or historical landmark, site, or place listed by the Federal Register of Historic Places and Natural Landmarks is Dinosaur Valley State Park. The Park is located about 4.5 miles southwest of the proposed facility [1].

The Guide to Official Texas Markers lists eight historical markers within the Glen Rose area [2]. Historical markers, sites, and places within a five-mile radius of CPSES are listed in Table 2.3-1. Of the nine sites listed, only one is expected to be affected by the proposed facility. This is the Squaw Creek Indian Fight "Battleground", as described on an historical marker on State Highway 144. The Indians, numbering 12 to 25, were on a horse-stealing expedition. The "fight" consisted of several skirmishes between settlers and war party. The results of the "fight" were: one dead white settler, one dead slave, a wounded white settler, a wounded dog, and several horses killed by the Indians. It is not known if any Indians were hurt or killed [3].

The proposed plant is named after Comanche Peak, a prominent landmark located 5.5 miles to the north. Comanche Peak (actually, more of a mesa) was a prominent Indian and pioneer landmark.

In 1846, commissioners representing the United States of America undertook a peace mission to the Texas Plains Indians. Their purpose was to meet with the local Comanches and other Indians and to negotiate a peace. Comanche Peak was chosen by the commissioners as the most likely meeting place, since it was known to be an Indian meeting place and supply center, as well as a place to celebrate successful raids [4]. Several preliminary meetings were held during March, 1846. The only real difficulty encountered was the inability of the commissioners' party to find the peak and the Comanches during February.

Shortly thereafter conference was adjourned because, as it turned out, Comanche Peak was not suited for the large gathering. Not enough grass was available for all the horses and the warriors were afraid that their women and children might run short of food during the lengthy conference.

The peace mission was eventually successful however. A treaty was signed between the United States and the Texas Plains Indian tribes, consisting of the Comanches, Wacoes, Kichaei, Tonkawa, Wichita, and Towaparros.

2.3.2 ARCHAEOLOGICAL SITES

A search of archaeological records was conducted at the Balcones Research Center in Austin, Texas for listings of archaeological sites near the proposed CPSES. The State Archaeologist of Texas, Mr. Curtis Tunnel, was also consulted as to the possibility of any known archaeological sites within the CPSES site. No sites were recorded, probably due to the lack of work in the area. In order to fully assess the archaeological potential of the area, Southern Methodist University's Department of Anthropology was engaged to conduct a literature and field search for possible archaeological sites in the area of the proposed facility and reservoir. The results of the study are presented in Appendix A.

2.3.3 PROXIMITY OF PLANT FACILITIES AND RIGHTS OF WAY TO AREAS OF HISTORIC OR ARCHAEOLOGIC SIGNIFICANCE

Results of the archaeological survey are summarized in the following paragraphs. The locations of historical and archeological sites are shown in Figures 2.3-1 and 2.3-2. Table 2.3-2 describes the sites.

2.3.3.1 Access Road to Plant Site

The access road does not approach any historical features. The possibility of finding archaeological sites is not anticipated, since the access road is located on the interfluve between Panther Branch and another unnamed tributary stream of Squaw Creek. The nearest site recorded on the survey is approximately 500 feet to the North.

2.3.3.2 Railroad Right-of-Way

The railroad ROW does not approach any sites of historical interest. The probability of finding unrecorded archaeological sites would seem remote because of the topography crossed by the spur. The ROW is located on the interfluves of Squaw Creek, the Paluxy River and their tributaries. The greatest number of archaeological sites are usually found along alluvial flood plains and on bluffs overlooking the valleys.

2.3.3.3 Transmission Line Right-of-Way

The transmission line ROW from CPSES to the DeCordova switch yard will approach one historical feature, Hopewell Cemetery. The closest approach of the line is approximately 900 feet east. The ROW avoids the archaeological sites discovered by the Archaeological Survey. An archaeological reconnaissance of the ROW not covered by the survey will be made prior to construction.

2.3.3.4 Diversion and Return Pipeline Right-of-Way

The pipeline ROW from Squaw Creek Reservoir to Lake Granbury avoids historical features. The closest historical feature is the Hopewell Cemetery, approximately 900 feet north. The ROW avoids recorded archaeological sites.

2.3.3.5 Squaw Creek Reservoir

A total of 29 of 57 sites recorded during the archaeological survey are within the reservoir limits. (Table 2.3-2) These sites and their disposition are discussed fully in Appendix A.

The site numbers in Table 2.3-2 are listed in numerical sequence and by county, Somervell (SV), Hood (HD). (*) indicates that the site was recorded during the survey but is outside the reservoir limits. The following six landforms are keyed numerically in Table 2.3-2:

1 - Upper and middle Squaw Creek and adjacent floodplain

2 - Limestone bench

3 - Uplands

4 - Brazos/Paluxy Rivers and adjacent floodplain

5 - Alluvial terrace along lower Squaw Creek, Paluxy and Brazos Rivers

6 - Steep limestone bluff

Site description described in the table pertains to the kind and amount of cultural material observed on the surface of the site and the area over which this material was observed. Stage designation is based on the artifacts observed, collected or reported, but at many sites temporally diagnostic artifacts were absent and stage placement was not possible. It must be remembered that other time periods may be present at some sites or that the absence of diagnostic tools does not mean that the occupation might not be dated by the use of other dating techniques.

Certain artifacts present at a site are considered to be indicative of specific techno-economic maintenance activities. These are indicated numerically in Table 2.3-2 as follows:

1 - Tool manufacture and repair - indicated by the presence of chips, flakes, cores, chipped stone tools and hammerstones

2 - Hide preparation - indicated by the presence of scrapers and utilized flakes

3 - Hunting - indicated directly by the presence of projectile points and indirectly by hide preparation tools

4 - Cooking - indicated by the presence of hearths, midden accumulation or food remains

5 - Gathering and preparation of foods - indicated by the presence of manos, metates or nutting stones

6 - Historic - includes homesteads, ranch house, school, and other activities associated with Anglo-American occupation

Each site is evaluated as to the need for collecting additional information about the aboriginal and historic occupation of the area. This potential is presented numerically in Table 2.3-2 according to the following key:

1 - No need to excavate or test

2 - Testing necessary

3 - Excavation recommended

4 - Controlled surface collection suggested

2.3.3.6 Contact with State Agency

As discussed in Section 12.1.2, the Texas State Historical Survey Committee was contacted regarding the CPSES project. A copy of a letter from this agency is included in that Section.

3 A meeting was held with the Texas Historical Commission on April 24, 1974, at which time plans for further archaeological field surveys were discussed. These plans include the awarding of a contract to Southern Methodist University for additional salvage work at the only site in the project area which was felt by SMU to be of potential archaeological significance. In addition, SMU will conduct a survey of the water pipeline and transmission line rights-of-way to determine potential construction impacts upon any cultural, historical and/or archaeological resources.

In the judgement of SMU, there are no sites in the project area which are either listed or suitable for nomination to the national or state registers. The Texas Historical Commission has concurred with this opinion and is cognizant of the impact that implementation of this project will have on the cultural, historical and/or archaeological resources of the area.

2.3.4 REFERENCES

1. The National Register of Historic Places 1969, National Park Service, Washington, D.C. & supplements, March 15, 1972, March 7, 1972, April 4, 1972, May 2, 1972, June 6, 1972.

2. Guide to Official Texas Historical Markers, 1971 Texas State Historical Survey Committee.

3. Hood County History in Picture and Story, 1970. Junior Woman's Club, Granbury, Texas.

4. Vance J. Maloney, 1970, The Story of Comanche Peak, Landmark of Hood County, Texas, Historical Publishers, Fort Worth, Texas.

5. Interview with Dr. David S. Dibble, Acting Director, Texas Archeological Salvage Project, Balcones Research Center, University of Texas at Austin.

6. Skinner, A. Alan, and Hunphreys, Gerald K., The Historic & Prehistoric Archaeological Resources of the Squaw Creek Reservoir, Contributions in Anthropology No. 9, Southern Methodist University, 1973.

TABLE 2.3-1

HISTORICAL SITES WITHIN A FIVE-MILE RADIUS OF CPSES

Site	Location
Squaw Creek Indian Fight	Squaw Creek Valley in site vicinity
Dinosaur Valley State Park	4-1/2 miles southwest of site
Barnard Mill (Old Marks English Hospital, Abandoned)	Glen Rose, 4-1/2 miles SSE
Campbell Building	Glen Rose, 4-1/2 miles SSE
Dinosaur Tracks (Courthouse Grounds)	Glen Rose, 4-1/2 miles SSE
First National Bank	Glen Rose, 4-1/2 miles SSE
Somervell County - Courthouse Grounds	Glen Rose, 4-1/2 miles SSE
Somervell County Courthouse - Courthouse Grounds	Glen Rose, 4-1/2 miles SSE
Somervell County Veterans - Courthouse Grounds	Glen Rose, 4-1/2 miles SSE

Table 2.3-2 ARCHEOLOGICAL SITES OF THE SQUAW CREEK AREA

SITE	ELEV.	MICRO.	DESCRIPTION	ACTIVITY	POTENTIAL
SV6*	620'	2	Concentration of lithic debris, chipped stone tools and a mano, covering an area approximately 100 m. in diameter; Archaic.	1, 2, 3, 5	1
SV7*	720'	6	Thin scattering of flakes and chips (no tools observed) in an area 5 m. in diameter; stage undetermined.	1	1
SV8*	750'	6	Scattering of lithic debris (no tools observed) eroding out of a shallow deposit, 30 m. in diameter; stage undetermined.	1	4
SV9*	665'	6	Dense concentrations of cultural materials mark the location of three separate living areas; freshwater mussel shells, burned limestone, lithic debris, chipped stone tools, hammerstones and other artifacts occur over an area 500 m. (N-S) by 140 m.; Archaic, Neo-American.	1, 2, 3, 4, 5	3, 4
SV10*	660'	6	Lithic debris, chipped stone tools and mussel shells are scattered over an area 130 m. (E-W) by 50 m.; a midden (10 m. in diameter) containing burned rock, mussel shells and other cultural refuse is located in the northcentral part of the site and has been disturbed by vandals; stage undetermined.	1, 2, 3, 4, 5	3, 4
SV11*	670'	6	Dense scatter of lithic debris, burned rock, mussel shell and other artifacts cover an area 10 m. in diameter; this midden deposit has been disturbed by vandals; stage undetermined.	1, 4	1
SV12*	680'	6	Lithic debris, mussel shell and other artifacts mark the location of a small midden area, 10 m. in diameter; stage undetermined.	1, 4	1
SV13*	715'	6	Two middens and associated scattered lithic debris, hammerstones, manos, metates, chipped stone tools cover an area 50 m. in diameter, the middens are each about 5 m. in diameter and both have been vandalized; Archaic.	1, 2, 3, 4, 5	3, 4

Table 2.3-2 Continued

SITE	ELEV.	MICRO.	DESCRIPTION	ACTIVITY	POTENTIAL
SV14*	610'	5	A few flakes and chips were noted eroding out of a low rise which was covered by a thick stand of Bermuda grass; area of deposit uncertain; stage undetermined.	1	2
SV15*	650'	5	Lithic debris (no tools observed) widely scattered over the surface of a previously cultivated sandy field; stage undetermined.	1	1
SV16*	670'	6	Thin scatter of lithic debris and chipped stone tools over an area 100 m. (E–W) by 50 m.; stage undetermined.	1, 2, 3	1
SV17*	770'	3	Light concentration of flakes and chips on the surface of a sand deposit and exposed in a road cut; area is 30 m. by 15 m.; stage undetermined.	1	1
SV18*	770'	3	Lithic debris and chipped stone tools occur in eroded areas and are exposed in a road cut over an area 70 m. in diameter; stage undetermined.	1, 2, 3	1
SV19*	640'	6	Dense concentration of lithic debris, chipped stone tools and hammerstones in a sandy deposit which covers an area 30 m. (N-S) by 20 m.; Archaic, Neo-American.	1, 2, 3, 4, 5	3, 4
SV20*	640'	6	Dense scatter of lithic debris, chipped stone tools, pecked stone tools and other artifacts occur in two separate concentrations, each 30 m. by 20 m. in area; Archaic, Neo-American.	1, 2, 3, 4, 5	3, 4
SV21*	640'	6	Scatter of lithic debris and chipped stone tools on the site surface covering an area 60 m. (E-W) by 20 m.; stage undetermined.	1, 2	3
SV22*	640'	6	Two small concentrations of mussel shells, lithic debris, chipped and pecked stone tools on either side of a drainage ditch; site area is 30 m. (N-S) by 10 m.; stage undetermined.	1, 3, 4, 5	3

Table 2.3-2 Continued

SITE	ELEV.	MICRO.	DESCRIPTION	ACTIVITY	POTENTIAL
SV23*	620'	6	Scattering of lithic debris and chipped stone tools on the surface and buried within a sandy deposit covering an area 110 m. (N-S) by 60 m.; Archaic, Neo-American.	1, 2, 3	2
SV24*	630'	5	Scattering of chips, flakes, chipped stone tools and various historic Anglo-American artifacts over an area 100 m. in diameter; stage undetermined.	1, 2, 6	1
SV25*	770'	3	Occasional flake and chip scattered over an area 25 m. in diameter; stage undetermined.	1	1
SV26*	655'	1	Lithic debris and chipped stone tools scattered over an area 250 m. (E-W) by 60 m. along the base of a bluff; Archaic, Neo-American.	1, 2, 3, 4, 5	1
SV27*	770'	3	Thin concentration of flakes and chips in an area 50 m. by 30 m.; stage undetermined.	1	1
SV28	830'	3	Thin scatter of lithic debris over an area 50 m. (N-S) by 30 m.; Archaic.	1,2	1
SV29	680'	1	Scattering of glass, pottery, and iron artifacts associated with a collapsed stone chimney; Historic.	6	1
SV30	695'	2	Dense concentration of lithic debris, chipped stone tools, ground stone tools, hammerstones, burned limestone and freshwater mussel shells exposed in an area 100 m. (E-W) by 50 m.; Late Archaic, Neo-American, also the location of the Hopewell Community School. (See excavation section).	1, 2, 3, 4, 5	3
SV31	700'	2	Thin scatter of lithic debris and chipped stone in an area 30 m. in diameter; Archaic.	1, 3	1
SV32	700'	2	Thin scattering of flakes, chips and chipped stone tools over an area 20 m. in diameter; stage undetermined.	1	1

Table 2.3-2 Continued

SITE	ELEV	MICRO.	DESCRIPTION	ACTIVITY	POTENTIAL
SV33	700'	2	Lithic debris and a hammerstone scattered in an area 10 m. in diameter; stage undetermined.	1	1
SV34	700'	2	Dense concentration of lithic debris, chipped stone tools and fragmentary Anglo-American artifacts spread over an area 70 m. (N-S) by 40 m.; Archaic, Neo-American.	1, 3, 4	2
SV35	740'	1	House remains (chimney), barn and corral associated with a modern windmill, corral fences are made of stone, historic artifacts are absent; Historic.	6	1
SV36	710'	3	Concentration of flakes, chips and chipped stone tools in an area 10 m. in diameter; stage undetermined.	1, 2, 3	1
SV37	715'	3	Small concentration of lithic debris in area 10 m. in diameter; stage undetermined.	1, 2, 3	1
SV38	710'	3	Thin scatter of lithic debris in area 10-15 m. in diameter; stage undetermined.	1	1
SV39	680'	3	Two light concentrations on either side of a narrow wash mark the site, lithic debris and retouched pieces were recovered from the site area which is 100 m. (N-S) by 50 m.; stage undetermined.	1, 2, 3	1
SV40	675'	1	Dispersed scatter of lithic debris, burned limestone, chipped stone tools and a piece of pottery cover an area 150 m. (E-W) by 90 m.; Archaic, Neo-American. (See excavation section).	1, 2, 3, 4, 5	1
SV41	760'	3	Thin scatter of flakes and chips; stage undetermined.	1	1
SV42	725'	1	Chimney of hand-hewn local limestone associated with glass, iron and ceramic artifacts; Historic.	6	1

Table 2.3-2 Continued

SITE	ELEV.	MICRO.	DESCRIPTION	ACTIVITY	POTENTIAL
SV43	690'	1	Rectangular house foundation with chimney in both ends and associated with a stone-lined well or storm cellar; Historic.	6	1
SV44	670'	1	Thin scatter of lithic debris over an area 100 m. (N-S) by 25 m. exposed by plowing, probably represents a buried occupation zone; stage undetermined.	1, 4	2
SV45	670'	1	Scatter of flakes and chips in a plowed field are scattered over an area 50 m. (E-W) by 25 m.; stage undetermined.	1	2
SV46	695'	2	Standing stone chimney associated with house foundation that appears to have been burned, artifacts include glass, iron and ceramic remains; Historic.	6	1
SV48	670'	1	Buried midden deposit exposed in creek bank are meter below present ground surface, flakes, chips and chipped stone tools were observed; stage undetermined.	1, 3, 5	2
SV49*	610'	5	Dense concentration of lithic debris, hammerstones, manos, chipped stone tools exposed in a sandy field and covering an area 100 m. (E-W) by 50 m.; Archaic.	1, 2, 3, 4, 5	1
SV50*	620'	5	Concentration of cultural materials including lithic debris, hammerstones, manos and chipped stone tools covering an area 75 m. in diameter; Archaic, Neo-American.	1, 3, 4, 5	1
SV51*	610'	5	Scatter of lithic debris, mussel shell, hammerstones, chipped stone tools and burned rock cover an area 75 m. (N-S) by 50 m.; Paleo-Indian, Archaic, Neo-American.	1, 3	1
SV 52	880'	3	Thin deposit of lithic debris scattered over an area 300 m. (NE-SW) by 50 m.; stage undetermined.	1	1

Table 2.3-2 Continued

SITE	ELEV.	MICRO.	DESCRIPTION	ACTIVITY	POTENTIAL
SV53	800'	3	Historic lime kiln located in bank of Panther Creek, no associated artifacts; Historic.	6	1
SV54	705'	1	Scatter of flakes, chips and a mano in an area 50 m. (E-W) by 30 m.; stage undetermined.	1, 4, 5	1
HD55	740'	1	Thin scatter of lithic debris and dart points in an area 130 m. (E-W) by 50 m.; Paleo-Indian, Archaic. Single test pit demonstrated absence of subsurface manifestations.	1, 3	1
HD56	770'	1	An abandoned farm house associated with a barn, windmill, stone-lined storm cellar and well; Historic.	6	1
HD 57	715'	1	Thin concentration of flakes, chips and a dart point mid-section; Archaic.	1, 3	1

2.4 GEOLOGY

The project area is favorably located geologically within the Lower Cretaceous outcrop area. The geologic section involved, the Glen Rose Formation of the Trinity Group, is remarkably free of objectionable factors often of immediate concern in limestone sections.

Physiography, stratigraphy, structure, geologic history, and seismologic considerations for the region around the site are discussed in this section. The final section concerns the site geologic conditions.

Geologically, the terrain is well suited for an engineering facility of this magnitude. There are no appreciable problems evident at the site or in its vicinity.

2.4.1 PHYSIOGRAPHY

The site is located within the Comanche Plateau subdivision of the Central Texas Section of the Great Plains Province (see Figure 2.4-1). To the north is the Central Lowland Province and to the east is the Coastal Plain Province. The boundary separating the Great Plains Province from the Coastal Plain Province coincides with the contact of upper and lower Cretaceous formations.

The Central Texas Section lies northeast of the Edwards Plateau. It differs from the Edwards Plateau in that it has been stripped, in varying degrees, of its cover of resistant Cretaceous limestone. The section is subdivided on the basis of two factors: the extent to which the topography has been dissected; and the nature of rocks exposed on removal of the Edwards limestone. The Comanche Plateau subdivision is a belt of submaturely dissected plateau land which slopes east at a rate determined by the dip of the lower Cretaceous rocks. The eastern boundary, from near Waco south, is marked by the Balcones Escarpment.

Three geologic formations outcrop in the vicinity of the site:

1. Paluxy Sand - The outcrop area is characterized by gentle rolling hills of red, sandy soil supporting deciduous trees and native grasses.

2. The Glen Rose Formation - Characterized by a prairie of relatively steep stair-stepped slopes developed on alternating limestone and marl. Its black soil supports cedar and sparse grassland vegetation.

3. The Basal Trinity Sands - Forms a flat, broadly undulating region which supports vegetation similar to the Paluxy Sands.

The plant site is located in the Squaw Creek drainage area, approximately five miles northwest of the Brazos River. The reactor site is on a flat area between Squaw Creek and Panther Branch, a tributary of Squaw Creek. The main dam will be located on Squaw Creek just below the mouth of Panther Branch, and a smaller dam for emergency water supply will be located on Panther Branch about 3000 feet upstream from Squaw Creek.

Maximum relief in the site area is approximately 200 feet, with elevations ranging from 640 feet to 860 feet above sea level. The flood plains of Panther Branch, and Squaw Creek range in width up to 1000 feet and 2000 feet, respectively. Surface materials in the flood plains are erratic mixtures of silt, sand, gravel, cobbles, and boulders.

The valley slopes extending above the flood plain deposits are typically steep, ranging from 15 to 30 degrees or more, and generally exhibit a stair-stepped appearance. Rock outcrops of limestone and claystone comprise approximately 40 to 60 percent of these slopes. The remaining areas, including the higher flat-topped plateau remnants, are mantled by a thin cover of soil which at the surface generally consists of silt and sand.

2.4.2 STRATIGRAPHY

Figure 2.4-2 summarizes the stratigraphy of the area around the site [1, 2]. Sedimentary rocks of the lower Cretaceous Comanche Series (beginning 136 million years ago) outcrop in the site vicinity. Because of the easterly dip of the strata, increasingly younger beds outcrop to the east, extending up through the Gulf Series sediments, (Upper Cretaceous, beginning 100 million years ago).

West of the site the sediments dip westerly. The coastal plain sediments thin out in this direction, exposing older, more resistant, Paleozoic sedimentary rocks exceeding 225 million years in age (Permian and older).

The section provided in Figure 2.4-3 illustrates the stratigraphic relationships in the region along an east-west line. The Gulf Series consists of the Navarro, Taylor, Austin, Eagle Ford, and Woodbine Formations. Total thickness of the series ranges up to about 2800 feet. The materials consist of a sequence of marls, limestones, limey shales, chalk, shale, sand, sandstone, and clay, along with minor lignite and gypsum.

The Comanche Series of Lower Cretaceous age rests below the Gulf Series. Though no regional unconformities were developed in the Lower Cretaceous secion, there are many facies changes -- both along the strike and in the dip directions -- caused by changing depositional environments [1]. The Washita Group, at the top of the Comanche Series, consists of the Buda Formation (limestone), the

Del Rio Formation (shale), and the Georgetown Formation (limestone). The group does not exceed 300 feet in thickness.

The Fredericksburg Group, below the Washita, has a maximum thickness of about 600 feet. The group consists of the Kiamichi Formation (limestone), the Edwards Formation (limestone), the Comanche Peak Formation (limestone), and the Walnut Formation (shale).

The next lower group in the stratigraphic section is the Trinity, which is synonymous with the basal Cretaceous part of the section. In the vicinity of the site, three formations comprise the Trinity Group, each making up approximately 1/3 of the basal Cretaceous sequence:

1. The Paluxy Formation, at the top, is a sand which thins to the south and downdips to the east. This formation has been eroded from the site area, but it does crop out on its periphery as shown in Figure 2.4-4. In these areas the Paluxy Formation consists of fine to very fine grained, well sorted, poorly cemented, friable sandstone with occasional siltstone and claystone interbeds. The formation is mined locally for industrial uses which include glass making, foundry molds and mineral filler [2].

2. The Glen Rose Formation, underlying the Paluxy, constitutes the entire bedrock section in the site area. It pinches out updip to the north and is absent in northern Wise County. It thickens substantially to the east and contains a massive emporite bed in McLennan County. Alternating beds of resistant strata (limestone) and weak rocks (claystone) form stair-step topography where the Glen Rose Formation is exposed.

3. The Twin Mountains Formation underlies the Glen Rose Formation, their contact being a gradational one. Most of the formation underlying the site is gray to greenish-gray claystone. The sandstones are water bearing and constitute the aquifer for domestic water supplies in much of the local area [3].

2.4.3 STRUCTURES WITHIN THE SITE REGION

The Llano Uplift, more than 100 miles southwest of the site, is structurally a large dome. Precambrian rocks (more than 570 m.y. *) are exposed in the center of the dome in an area roughly 40

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* million years

by 70 miles and are surrounded by formations of Paleozoic (225 m.y. to 570 m.y.) and Cretaceous (65 m.y. to 136 m.y.) age. The Precambrian of the uplift consists of metamorphic rocks, (schists, gneisses, and marbles), batholitic intrusions (granite), and late dike intrustions (felsites). Extensive faulting is associated with the Llano Uplift and extends to the northeast and southwest under a covering of late Pennsylvanian and Cretaceous sediments. No evidence of this faulting extending to the vicinity of the site could be found by stereoscopic study of aerial photographs. Several major structural folds or arches also originate in the Llano Uplift and they, too, extend under the Cretaceous and Upper Pennsylvanian formations. One of the features, the San Marcos Arch, plunges southeastward into the Coastal Plain and coincides in position and trend with the known Precambrian folds. Other structures, namely the Lampasas Arch trending northeast, the Edwards Arch trending southwest, and the Bend Arch trending north, possess an axial orientation at approximately right angles to the lines of Precambrian folding.

North of the Llano Uplift and east of the Bend Arch is the Strawn or Fort Worth basin where considerable thicknesses of Middle Pennsylvanian sediments underlie the Cretaceous (Figure 2.4-5.

The site is located on the south flank of the Fort Worth basin.
3 In that area the dip of sediments is to the east-northeast at approximately 25 feet per mile.

The Red River Uplift and the Muenster Arch bound the Fort Worth basin on the north and northeast. The Muenster Arch, concealed beneath late Paleozoic deposits, is an extension of the Red River Uplift, which is itself covered by Cretaceous sediments.

2.4.4 SEISMOLOGIC CONSIDERATIONS

The plant site is situated in an area which has experienced only very minor earthquake activity. It is unlikely that the site has experienced greater than Intensity III on the modified Mercalli Intensity Scale (less than 0.05 g) in historic time (Table 2.4-1 describes the earthquake intensity scale). No
2 physical evidence exists at the site to indicate that it experienced major seismic activity at any time. The locations of regional earthquake epicenters are shown in Figure 2.4-6.

Only 13 seismic events have been reported with epicenters within 200 miles of the site. Two events are within 100 miles but no events are closer than 90 miles. The closest earthquake epicenter is an Intensity V-VI shock 90 miles southeast of the site in 1932. The closest large event occurred in 1882 near Paris, Texas, 155 miles northeast of the CPSES site. Another Intensity VII event occurred in 1891 near Rusk, Texas approximately 160 miles from the site.

Comanche

An isolated seismic event of Intensity V-VI occurred 85 miles southeast of the site, near Mexia. The possibility exists that the focus for this event was in the Mexia-Talco Fault Zone, but it was so shallow that it may well have been associated with petroleum withdrawals [9].

Several earthquakes, one with a maximum Intensity of VII, have occurred in or bordering on, the area of the Sabine Uplift. The closest of these to the site was 160 miles away. Two events falling within a 200-mile radius of the site were most likely in the northeast-trending Mt. Enterprise Fault Zone which intersects the Sabine Uplift.

Several earthquakes have occurred in a concentrated area on the edge of the Coastal Plain northeast of the site, in Oklahoma and Arkansas. Some shocks in this group are known to have been located in areas of very sharp gravity anomalies, which are underlain by basement rocks at shallow depths [4]. Several earthquakes (none exceeding Intensity VII) are shown on the epicenter map (Figure 2.4-6) along the edge of the Coastal Plain and in the Ouachita Uplift.

Other quakes even further away have occurred in the vicinity of the buried Appalachian folds to the east. The Ouachita Uplift has been considered by some geologists as a continuation of the Appalachian Belt [5]. It is not unlikely, therefore, that the reported quakes are in some cases the result of orogeny. This seismic activity, of small scale, has occurred at distances greater than 300 miles from the site.

Over 150 miles northwest of the site are epicenters (of maximum Intensity VII) associated with the Wichita Mountains uplift in Okalhoma. The possibility exists here, too, that mountain-building activity has not altogether ceased. 2

The "earthquake swarm" in the Panhandle of Texas is likely attributable to activity related to petroleum production, including water flooding [6].

Several earthquakes have been recorded in far west Texas, including the highest intensity quake to hit the state (1931 Valentine event of Intensity VIII). These earthquakes occurred in a heavily faulted area along the southwest margin of the Marathon basin. Structures in this area have a northwest orientation, normal to the usual strike of the Balcones-Luling-Mexia fault systems, and are associated with a postulated "Texas Lineament.) Major movement along this structure occurred in late Paleozoic time. The presence of several thermal springs in the vicinity of the Lineament may be noteworthy as they are the only ones in Texas [7, 8]. Thermal springs are frequently associated with active tectonic structures and their absence over the rest of the state may be significant. They offer evidence to support a case for non-active tectonics for structures in the site region. The

Texas Lineament is nowhere closer than 250 miles from the site. Three events, the closest of which was 160 miles southeast of the site, occurred in the Coastal Plain. They were of low intensity (IV and V) and could have been associated with early fluid withdrawals.

Two major fault systems occur within 200 miles of the site. The nearest, the Balcones Fault System, passes within 44 miles of the site and is situated just each of the Ouachita Tectonic front [10]. The Mexia-Talco Fault System passes within 80 miles east of the site and generally is parallel to the trend of the Balcones System. There is no evidence that these faults are active, although relief of tectonic stress through creep is a possibility along portions of either of these fault systems [11, 12]. 2

Based on the tectonic provinces and recorded earthquake activity, a conservative value of 0.12 g horizontal acceleration was chosen for the Safe Shutdown Earthquake. 3

The possibility that certain of the moderate events (Intensity V) are not associated with known structures has been considered, but the resulting figure for ground motion is less than for the event selected for the Safe Shutdown Earthquake.

2.4.5 SITE GEOLOGIC CONDITIONS

2.4.5.1 General

Throughout the immediate site area, the strata consists entirely of the Glen Rose Formation of the Trinity Group. The sediments underlying the Cretaceous formations in the area are of Pennsylvanian age and are dipping gently to the northwest into the Permian Basin. However, the Pennsylvanian stratigraphy will not affect the construction of any part of the plant and none was penetrated by any of the exploratory core borings drilled at or near the project site. It is believed that the irregular, undulatory surface of the denuded Witchita Paleoplain has had some influence on the immediate area of the sites. This influence is expressed in somewhat erratic, localized changes in the dip of the Cretaceous sediments. This irregularity of dip is believed to be largely a result of differential sedimentation, compaction, and lithification of the more unctuous sediments of Cretaceous age which rest upon the irregular surface of the Wichita Paleoplain. As subsequent deposition and loading occurred, there was a thinning near the crest and a thickening near the valleys of these undulatory surface areas which resulted in the irregular dip of the Cretaceous sediments in the area.

2.4.5.2 Subsurface Investigation

Subsurface investigations for the proposed structure included the undisturbed sampling of overburden materials and primary sedimentary rocks. No deleterious earth materials, such as gypsum or anhydrite, was encountered in the exploration.

Rock excavation will proceed from 4 feet to as much as 60 feet below plant grade elevation (810±). Indications are that limestone is the main founding material for the deeper excavations while some interbedding of claystone and limestone will be the foundation material for the more shallow excavations (-4 feet level). Laboratory results indicate that the strength of the limestone is considerably higher than that of the claystone; however, the allowable bearing capacity of the claystone alone is such that it will carry all anticipated loads safely and with a very adequate factor of safety.

The piezometric surface is below the bottom of the excavation and groundwater therefore will not be a problem. 3

The shear strength of the materials at the site is such that a vertical cut will not create a deep-seated failure.

2.4.6 MINERAL RESOURCES

Sand, gravel, and local dimension stone removed from the vicinity of the site in minor quantities are the only resources known to have been exploited. The remaining voids can in no way affect the site. Sand and gravel sources on the site itself are essentially nonexistent. 3

The regional geology, test borings, and other indicators reveal no mineral resources (oil, gas, sulphur, salt, metallic minerals) underlying the site at economic depths. A potential loss of mineral resources due to construction and operation of the plant is, therefore, not likely [13, 14].

2.4.7 REFERENCES

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TABLE 2.4-1

MODIFIED MERCALLI INTENSITY (DAMAGE) SCALE OF 1931

(Abridged)

I. Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel Scale.)

II. Felt only by a few persons at rest, especially on upper floors of building. Delicately suspended objects may swing. (I to II Rossi-Forel Scale.)

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel Scale.)

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel Scale.)

V. Felt by nearly everyone, many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbances of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale.)

VI. Felt by all, many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale.)

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel Scale.)

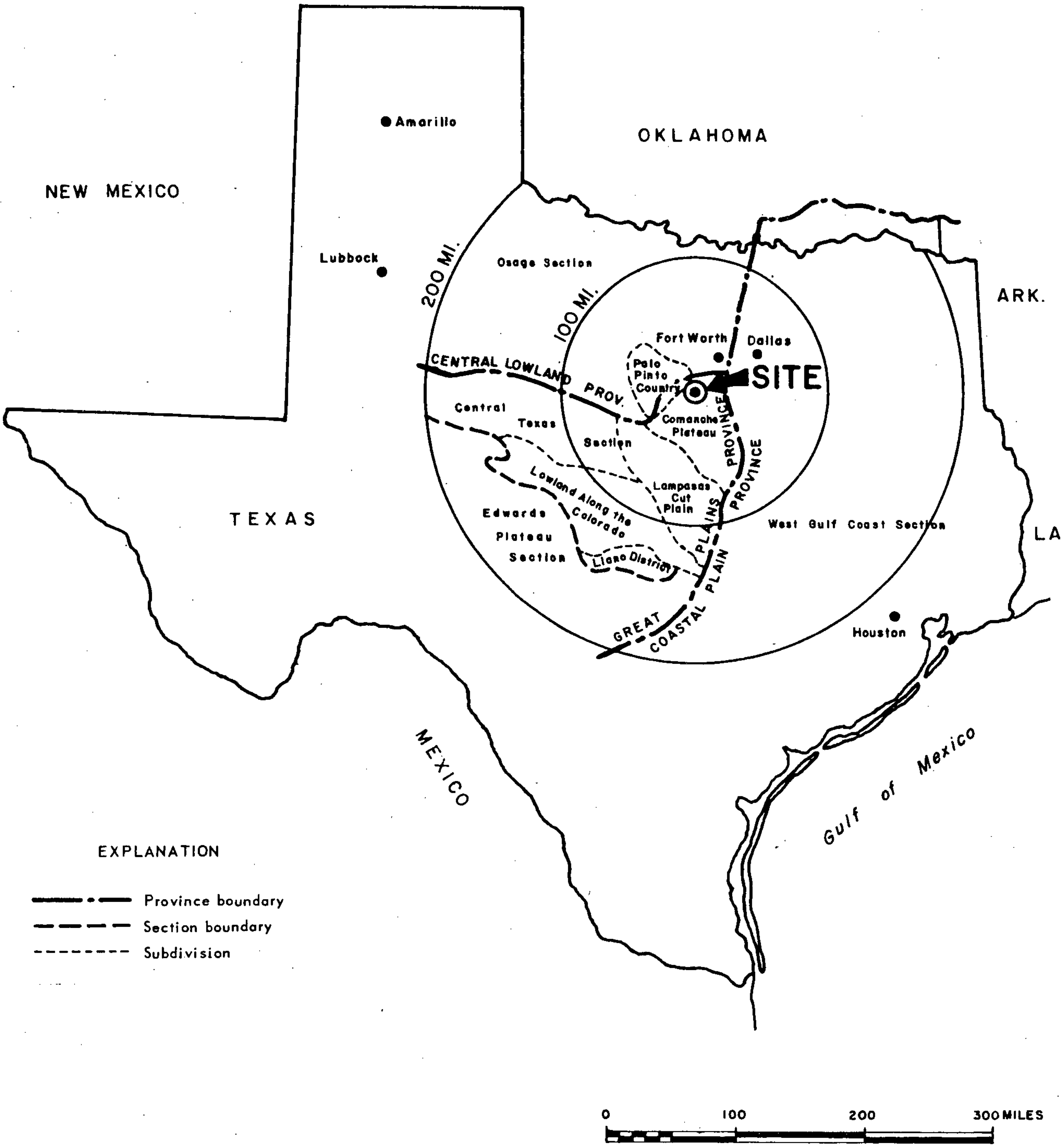
VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX Rossi-Forel Scale.)

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale.)

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale.)

XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surface. Lines of sight and level distorted. Objects thrown upward into the air.



SOURCE: From Texas Water Development Board Report 53, 7/67,. 'The Climate and Physiography of Texas'.

Based on the map, 'Physical Divisions of the United States' (Fenneman and Douglas, 1946), and on the two volumes, 'Physiography of Western United States' and 'Physiography of Eastern United States' (Fenneman, 1931, 1938).

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

PHYSIOGRAPHY

FIGURE 2.4-1

Era	System	Series	Group	Stratigraphic Units	Approximate Thickness (Feet)	Character of Rocks
Cenozoic	Quaternary	–	–	–	0-100	**Silt, some sand and gravel**
	Tertiary	–	–	**Not Present in Site Region**	–	–
Mesozoic	Cretaceous	Gulf	Navarro		0-550 ±	Shale, marl and sand
			Taylor		0-1100 ±	Marl and limy shale
			Austin		0-600 ±	Chalky limestone
			Eagle Ford		0-300 ±	Shale
			Woodbine		0-200 ±	Ferruginous sand, sandstone, shale, sandy shale, clay and some lignite and gypsum
		Comanche	Washita	Buda Formation	0-50 ±	Limestone
				Del Rio Formation	0-100 ±	Shale
				Georgetown Formation	0-150 ±	Limestone
			Fredericksburg	Kiamichi	0-50 ±	Shale
				Edwards Formation	0-175 ±	Hard, fossiliferous limestone (often honey-combed), reef material, shale, chert and dolomite
				Comanche Peak Formation	0-150 ±	Limestone and limy shale
				Walnut Formation	0-200 ±	Shale and calcareous clay
			Trinity	Antlers Formation	0-225 ±	Fine to coarse grained sand with varicolored shale and streaks of limestone
				Paluxy Formation	0-200 ±	Fine to medium grained sand, shale, sandy and calcareous shale, some pyrite and iron nodules
				◆ Glen Rose Formation	0-1500 ±	Limestone, shale and anhydrite
				Travis Peak - Twin Mountains Formation	0-1800 ±	Sand, conglomerate, shale and limestone
				Hensel member	0-175 ±	Conglomerate, fine to coarse grained sand, sandstone, siltstone, shale, sandy shale, clay, limy clay and limestone
				Pearsall member	0-85 ±	Shale interbedded with sand
				Cow Creek member	0-130 ±	Limestone
				Hammett member	0-140 ±	Shale
				Sligo member	0-130 ±	Limestone
				Sycamore member	0-150 ±	Sand and conglomerate with calcareous cement, shale and limestone
				Hosston member	0-1550 ±	Conglomerate, fine to coarse sand and sandstone, siltstone, shale, sandy and calcareous shale, clay and limestone
	Jurassic		Cotton Valley	?	?	Sands, conglomerate and shale
Paleozoic	**Paleozoic rocks undifferentiated, including Ouachita Facies**				?	Shale, limestone, dolomite, sandstone, evaporites, and metamorphics

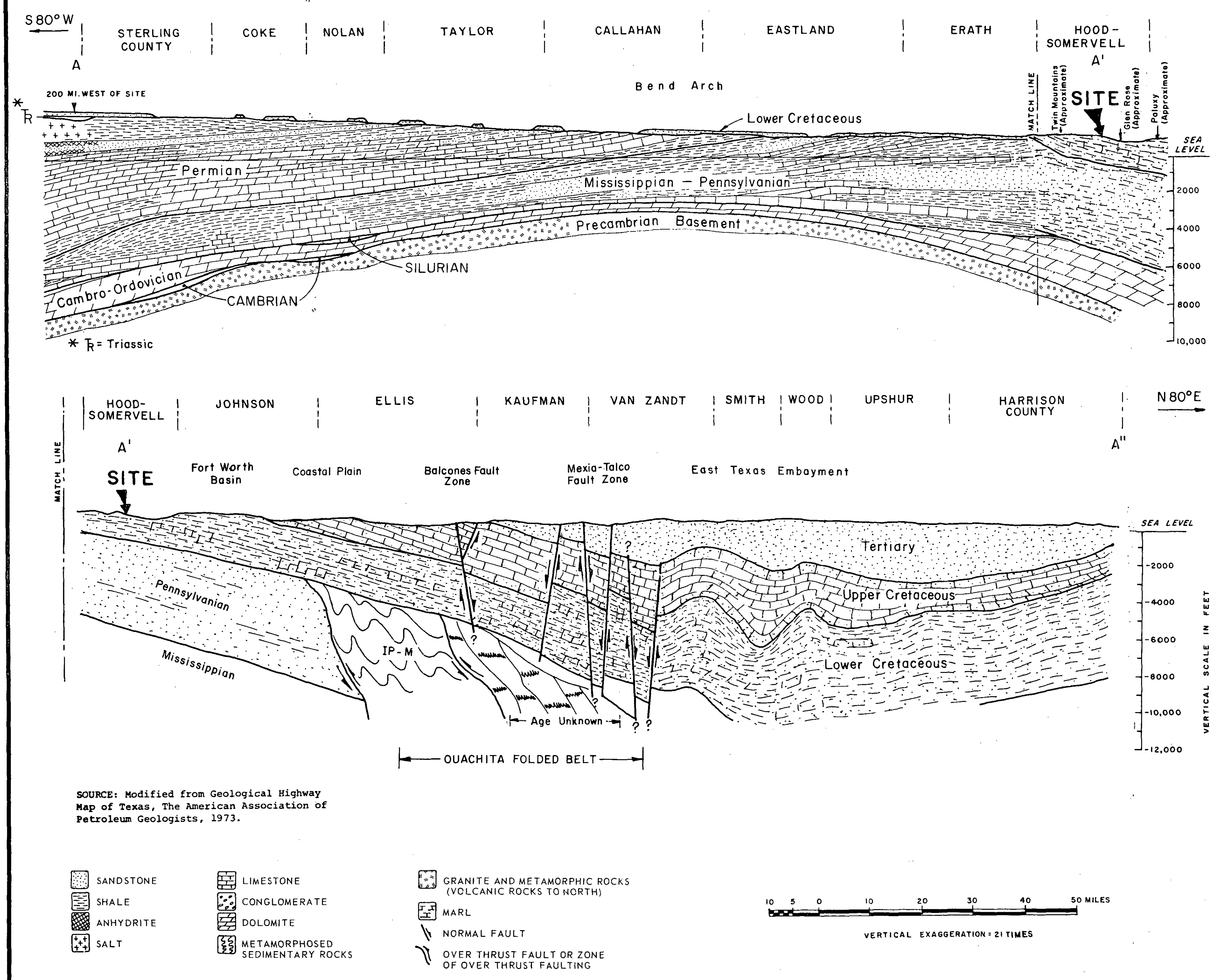
◆ **Station Site Position**

SOURCE: Texas Water Development Board, 1972

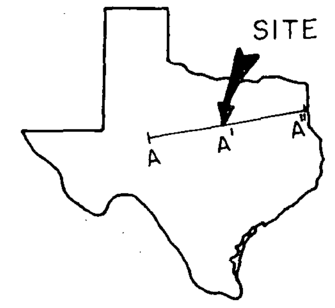
COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

REGIONAL
STRATIGRAPHIC COLUMN

FIGURE 2.4-2



SOURCE: Modified from Geological Highway Map of Texas, The American Association of Petroleum Geologists, 1973.



LOCATION OF CROSS-SECTION

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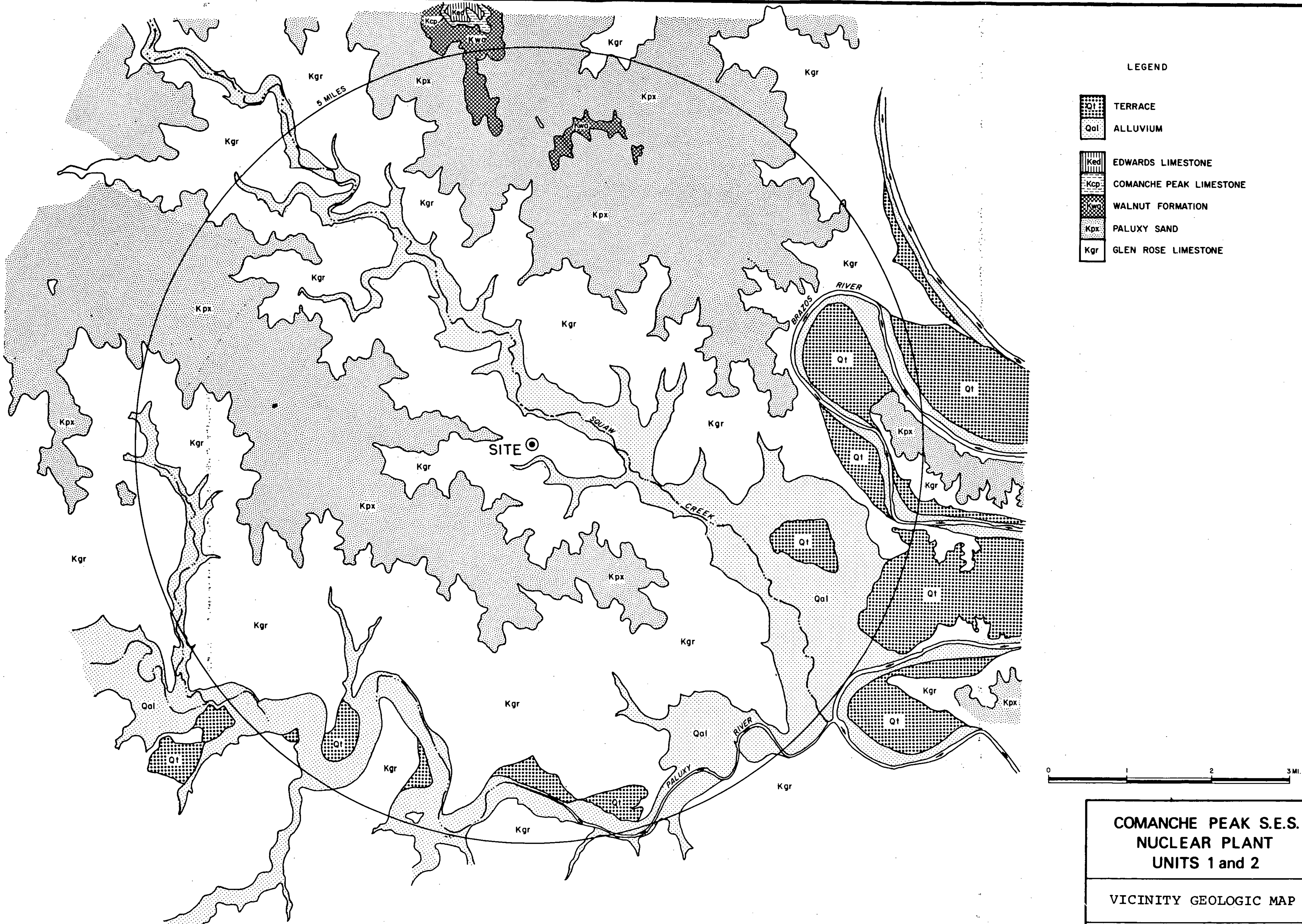
NUCLEAR PLANT
UNITS 1 and 2

REGIONAL EAST-WEST
GEOLOGIC CROSS SECTION

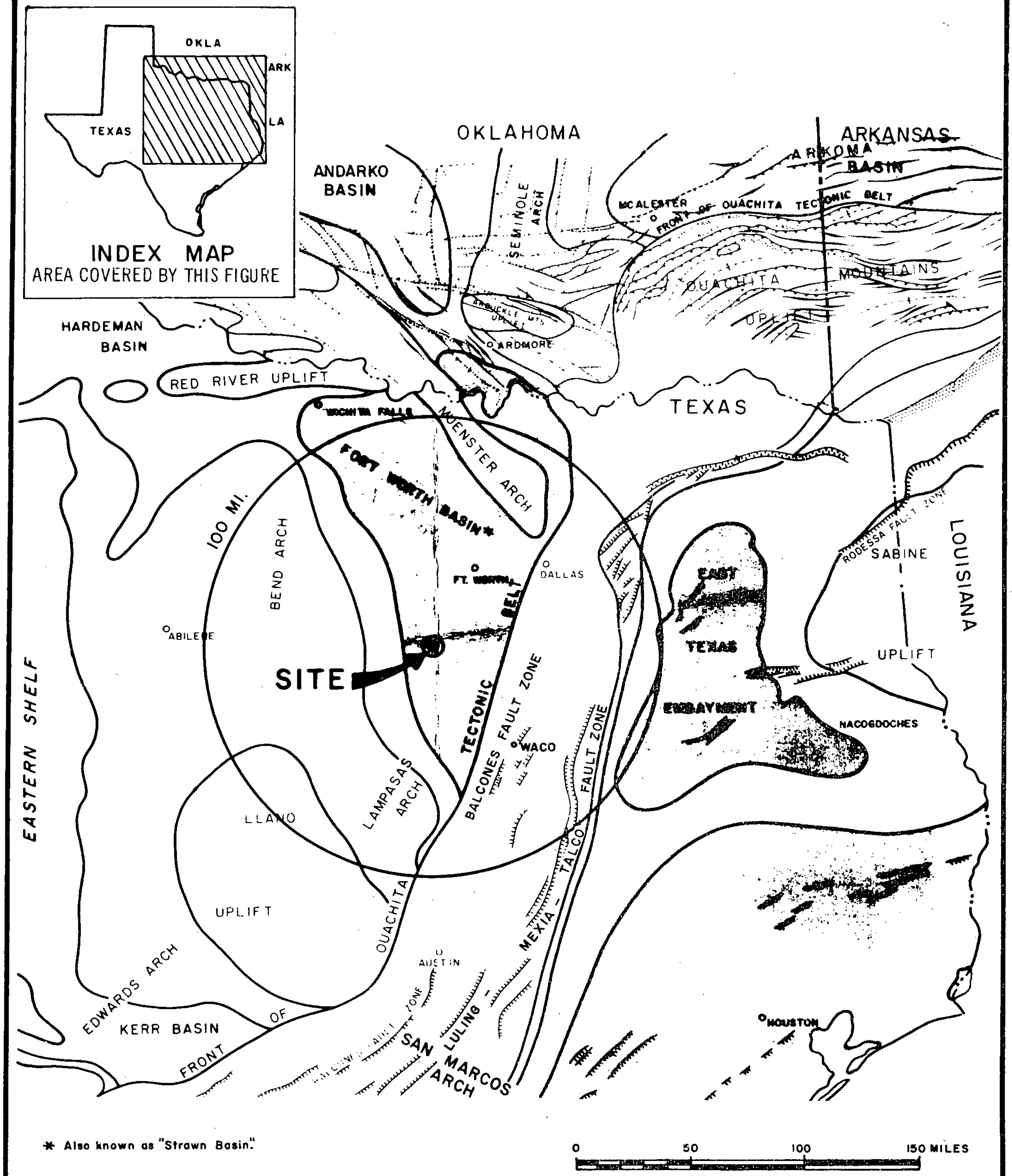
FIGURE 2.4-3



COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

VICINITY GEOLOGIC MAP

FIGURE 2.4-4



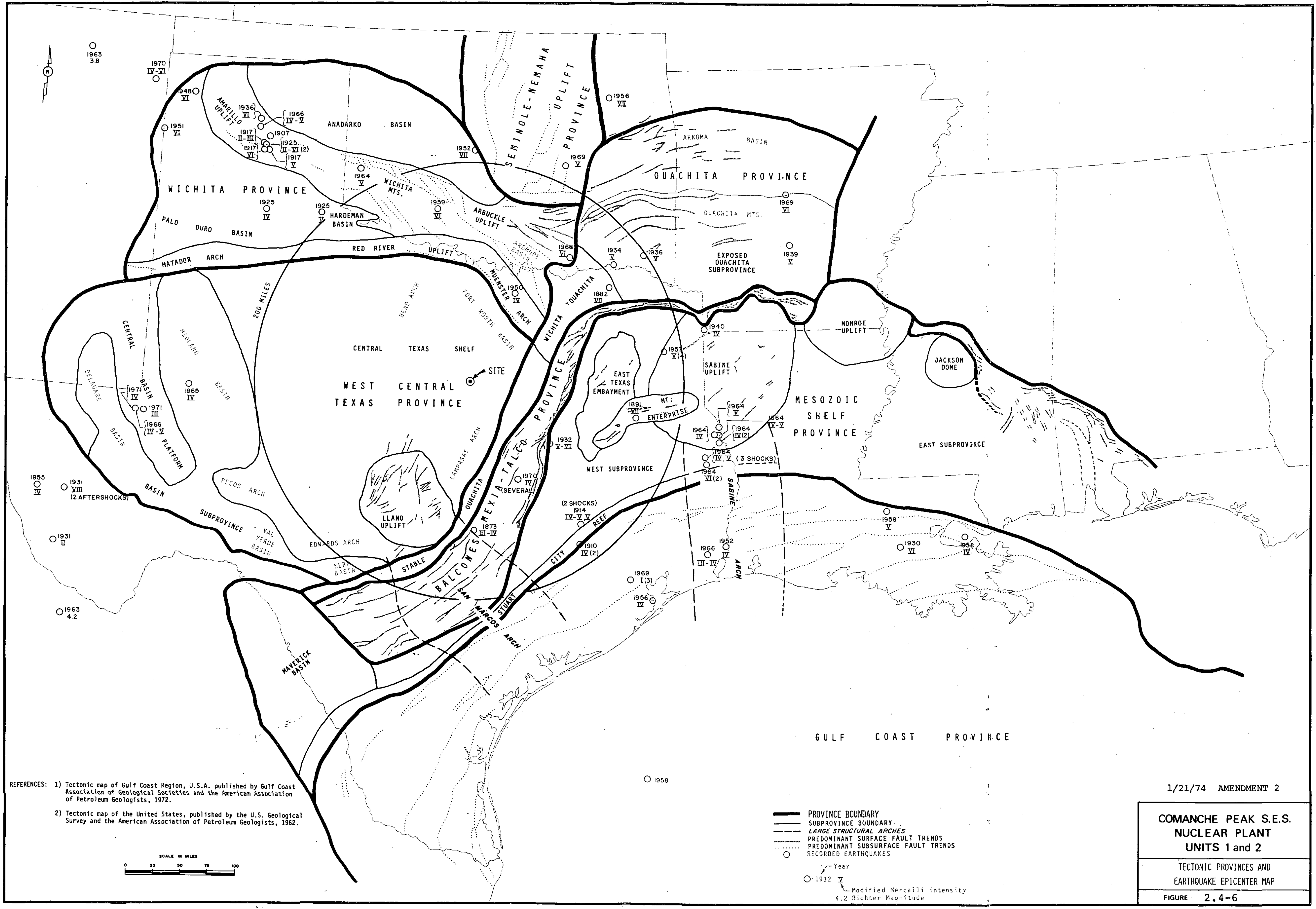
***** Also known as "Strawn Basin."

SOURCES: Tectonic Map of Texas, Geological Highway Map of Texas, Dallas Geological Society, 1963. Tectonic Map of the Mid-Continent Region, Geological Highway Map of the Mid-Continent Region, A.A.P.G., 1966

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

REGIONAL TECTONIC STRUCTURE

FIGURE 2.4-5



REFERENCES: 1) Tectonic map of Gulf Coast Region, U.S.A. published by Gulf Coast Association of Geological Societies and the American Association of Petroleum Geologists, 1972.

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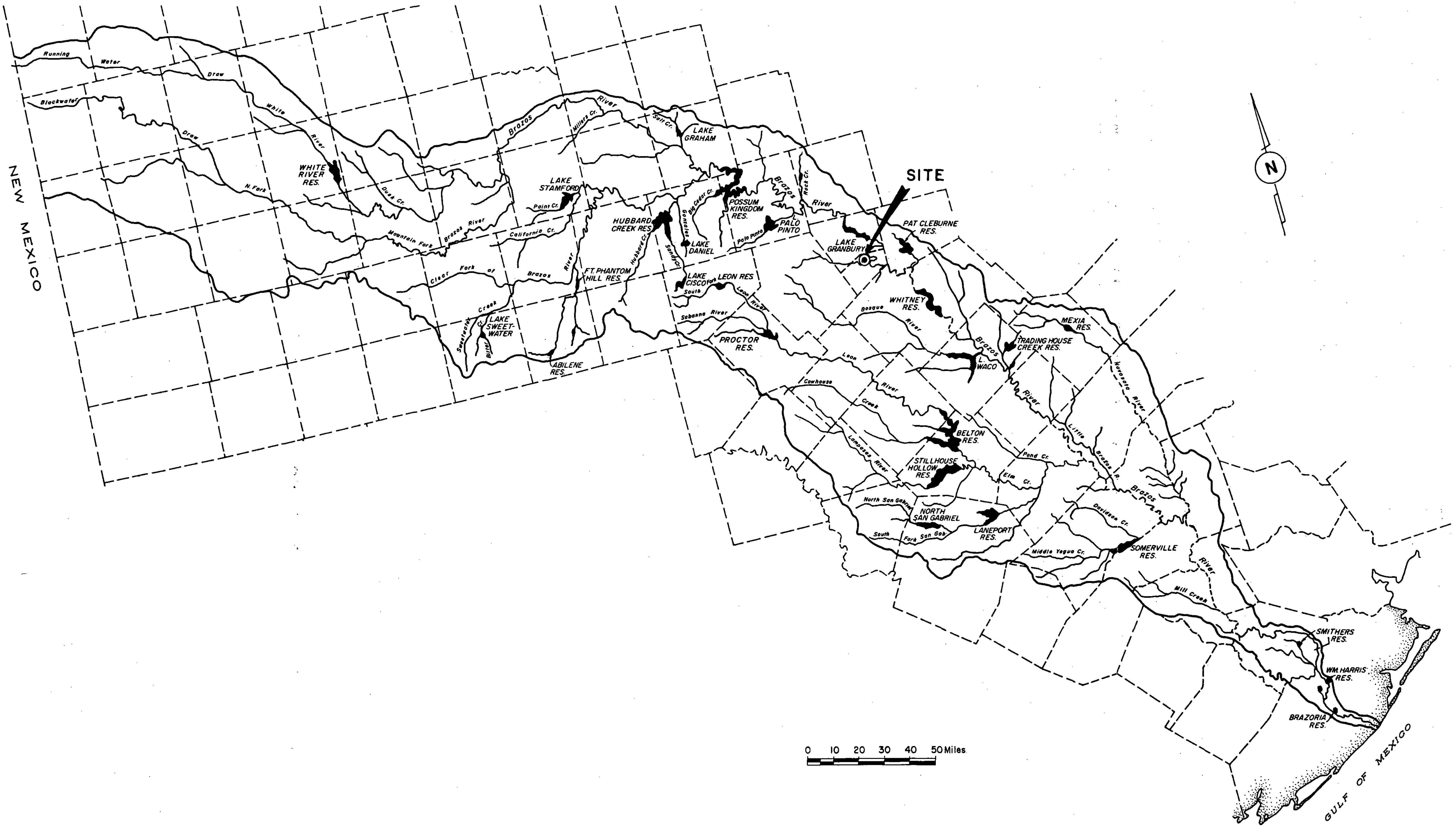
COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

TECTONIC PROVINCES AND
EARTHQUAKE EPICENTER MAP

FIGURE 2.4-6



REFERENCE: The base for this map was prepared from a portion of the Texas Highway map, prepared for Gulf Oil Corp. by Rand Mc Nally, 1971 edition, and the Surface-Water Development map of the Texas Water Development Board, November 1968.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

TEXAS PORTION OF
BRAZOS RIVER BASIN

FIGURE 2.5-1

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED
AT THE RECORD TITLED:
"SQUAW CREEK RESERVOIR
CATCHMENT,
FIGURE 2.5-2"

WITHIN THIS PACKAGE...OR
BY SEARCHING USING THE
DOCUMENT/REPORT NO.

D-01

2.5 HYDROLOGY

CPSES will be located on a ridge overlooking Squaw Creek. Figure 2.5-1 shows CPSES in relation to the Texas portion of the Brazos River Basin.

Squaw Creek Dam, to be constructed about 4.3 stream miles north of the creek's confluence with the Paluxy River, will form Squaw Creek Reservoir (SCR). Principal features of the 64-square mile Squaw Creek catchment above the dam are illustrated in Figure 2.5-2.

The reservoir will supply cooling water for CPSES. Make-up water to SCR will be supplied from natural runoff from the catchment, which will drain into the reservoir, and also from Lake Granbury, an existing impoundment formed by De Cordova Bend Dam on the Brazos River (see Figure 2.1-3).

The following subsections briefly describe the surface and groundwater regimes near the site; water usage has been discussed in Section 2.2.

2.5.1 SURFACE WATER

2.5.1. Squaw Creek

Squaw Creek begins about three miles northwest of Tolar and meanders southeastward to the Paluxy River. The creek has a relatively small catchment (64 square miles at the dam site) and moderate drainage gradients (about 30 feet per mile). A small floodplain has developed in the lower reaches.

Landforms in the Squaw Creek watershed are gently to steeply rolling, with elevations varying from over 1,100 feet MSL near the creek's origins to about 650 feet MSL near the dam site. The topgraphy is influenced by the underlying geology, which consists of sedimentary rocks of Lower Cretaceous age (poorly-cemented sandstones, limestones, and shales) which dip gently to the east.

A stream gaging station was established by the U.S. Geological
Survey in October 1973 on Squaw Creek at the Bridge on State High- 3
way 144. Accurate stream flow figures will be presented when
they become available, however, it is known that the stream is
intermittent and frequently dry during drought years. The United
States Geological Survey (USGS) has measured and published flow
rates of the neighboring Paluxy River since 1947 [1]; these re-
cords were used as a basis for estimating historical flow in
Squaw Creek. Because of the difference in watershed sizes, the
Paluxy River values were scaled down in proportion to the ratio of
the two drainage areas (64/410=0.156). The resulting average flow 3
is about 689 acre-feet per month (11 cubic feet per second),

although actual monthly flows vary greatly from the average, as shown below:

Jan. - 494 acre-feet
Feb. - 528 acre-feet
Mar. - 673 acre-feet
Apr. - 1,072 acre-feet
May - 2,722 acre-feet
June - 547 acre-feet
July - 330 acre-feet
Aug. - 157 acre-feet
Sept.- 304 acre-feet
Oct. - 820 acre-feet
Nov. - 275 acre-feet
Dec. - 340 acre-feet

Average Yearly - 8,262 acre-feet
Maximum Month - 8,250 acre-feet (occurred in May, 1968)
Minimum Month - 0 acre-feet (several months)

Tolar, with a 1970 population of 312 [2] is the only community in the catchment. Since the remainder is largely ranchland, with some cultivated areas, there are no serious pollution sources along Squaw Creek, although there is evidence of some fertilizer and organic wastes in the stream. The closest location for which water quality measurements have been published is at gaging station 8-0915 on the Paluxy River at Glen Rose (Figure 2.5-3) where eight samples were taken by the USGS during the 1962 water year [3]. More recent field measurements by the Texas Parks and Wildlife Commission [4] correlate well with the USGS data, although specific parameters studies varied somewhat. Results of the studies are summarized in Tables 2.5-1 and 2.5-2.

Chemical concentrations in Squaw Creek water are similar to those observed in the Paluxy River. Commercial samples taken from Squaw Creek on an occasional basis showed results not unlike those of the Paluxy River tests and led to the conclusion that the average dissolved solids content of Squaw Creek waters is approximately 275 to 325 milligrams per liter (mg/l). Temperatures can be expected to stay close to ambient air temperatures.

The location of the sample collection points are illustrated in Figure 2.5-2, while the results are summarized in Tables 2.5-3 and 2.5-4. (Note: Table 2.5-3 will be amended as additional data becomes available.)

2.5.1.2 Paluxy River

The Paluxy River Basin is hydrologically similar to that of Squaw Creek and can be used as a basis for developing hydrologic parameters for Squaw Creek and its sub-catchments. At gaging station 8-0915, the Paluxy River has a catchment of 410 square miles; the average flow is about 70 cfs [1].

The Paluxy watershed also is underlain by sedimentary rocks of Lower Cretaceous age; poorly cemented sandstones, limestones, and shales which dip gently to the east. The topography is governed somewhat by the geology; it generally is steeply rolling in limestone areas and gently rolling in sandstone and shale areas.

2.5.1.3 Brazos River and Lake Granbury

The Brazos River originates about 30 miles west of the New Mexico-Texas boundary, meanders southeastward through Texas and discharges into the Gulf of Mexico near Freeport, Texas. The total (straight-line) length of the Brazos River Basin is about 630 miles. Basin width varies from about 70 miles near the headwaters to about 110 miles near Waco, to under 10 miles near the Gulf of Mexico. The total basin size is about 44,640 square miles, of which approximately 9,240 square miles are non-contributing [1]. Elevations range from about 4,700 feet MSL near the headwaters, to sea level at the Gulf. Average annual precipitation varies from about 18 inches per year near the headwaters to about 31 inches per year at the site, to over 45 inches per year near Freeport [5]. The Texas portion of the Brazos River Basin (all but about a 100-square mile portion in New Mexico) is depicted Figure 2.5-1.

The principal tributaries of the Brazos River above Possum Kingdom Dam (see Figure 2.5-1) are the Salt, Double Mountain and Clear Fork. The catchment area above Possum Kingdom Dam is about 22,550 square miles, of which 9,240 square miles are probably non-contributing [1]. Of the contributing area, nearly half is in the Clear Fork Basin.

Palo Pinto and Rock Creeks enter the Brazos River between Possum Kingdom and De Cordova Bend Dams. The additional catchment area between the two dams is about 2,140 square miles, all of which contribute to flow in the river. De Cordova Bend Dam (which impounds Lake Granbury) is of special importance to this study, since SCR will receive make-up water and discharge blowdown water into Lake Granbury. The principal features of the 155,000 acre-foot reservoir are shown on Figure 2.5-4.

Although long-term records of inflow into Lake Granbury are unavailable (inasmuch as the dam was not closed until 1969), a good approximation can be obtained by studying historical flows at gaging station 8-0910, near Glen Rose, where the Brazos River catchment is only about 140 square miles larger (than at De Cordova Bend Dam). These records show that flow during the 48 years of record (1923 through 1971) averaged about 1,529 cfs (1.1 million acre-feet per year) [1]. A flow probability curve (Figure 2.5-5)for the years between completion of Possum Kingdom Reservoir and beginning of construction of De Cordova Bend Dam (1941 through 1962) shows the extreme variability of Brazos River flow. It should be noted, however, that the probability curve shown reflects the upstream regulation provided by Possum

Kingdom Dam [6], but does not reflect additional regulation provided by Lake Granbury and Lake Palo Pinto (see Figure 2.5-1).

Near the site, the Brazos River channel is located in incised meanders formed by the river. These meanders developed from uplift of the area after mature meandering drainage patterns had been established, and from sea level variations. The meanders eroded through, and are flanked by, rock slopes which confine the river within a relatively narrow channel. A narrow flood plain is immediately adjacent to the channel, within the meanders. The geometry of the banks is governed by their location with respect to the meander pattern; the bank on the outside of a bend generally is steep, whereas the bank on the inside of the bend usually has a gentler slope. Drainage gradients in the region (between Possum Kingdom and Whitney Dams) average about two feet per mile.

Supplemental water diverted from Lake Granbury will have noticeably higher concentrations of dissolved minerals than natural runoff of the Squaw Creek watershed. Because Lake Granbury has been in operation for only a short time, its long-term quality characteristics have not been established. In general, however, they can be expected to fall somewhere between the conditions observed at Possum Kingdom Reservoir and those at Lake Whitney. The USGS continuously monitors the chemical quality of water released from both of these reservoirs [3].

Summaries of the most recent 10 years of published records, (October, 1959 through September, 1969), for each station, are provided in Tables 2.5-5 and 2.5-6. The average concentration of total dissolved solids in water coming from Possum Kingdom Reservoir during that decade was 1,441 mg/l. In that same period, the average level of total dissolved solids observed in the Lake Whitney water was 835 mg/l. Most mineral contamination in the Brazos originates in the upper reaches of the basin. Inflows below Possum Kingdom are of basically good quality, and chemical concentrations tend to decrease with distance downstream. There are 3,620 square miles of watershed area between Possum Kingdom Dam and Whitney Dam, of which 2,140 square miles (about 59 percent) are upstream from Lake Granbury. Lake Palo Pinto intercepts runoff from 410 square miles of the segment between Possum Kingdom Reservoir and Lake Granbury. Texas Power and Light Company's De Cordova Bend Steam Electric Station under construction near Lake Granbury will utilize the reservoir for cooling.

Insofar as can be predicted from the above information, it is likely that the average concentration of total dissolved solids in Lake Granbury will be around 1,200 mg/l in the future. As shown in Table 2.5-7, concentrations in Possum Kingdom Reservoir and Lake Whitney vary appreciably through the year and from one year to the next. A similar range in values is anticipated in Lake Granbury. The U.S. Army Corps of Engineers has begun preliminary planning of water quality enhancement programs for the upper part of the Brazos River Basin; if these programs are found to be feasible and initiated, the quality of Lake Granbury water could be improved, along with that of the entire basin.

Although long-term records are not available for Lake Granbury, a limnological survey completed in 1972 [7] provides preliminary information on the chemical and biological nature of the lake. In general, this study verifies that the quality of Lake Granbury's water does indeed fall about midway between the brackish Possum Kingdom Reservoir (average total solids of 1,483 mg/l) and the less brackish Lake Whitney (average total dissolved solids of 906 mg/l). Table 2.5-8 summarizes the ranges of chemical parameters; the seasonal variation with depth of temperature, carbon dioxide levels, and dissolved oxygen levels are depicted in Figure 2.5-6. For more recent data, see Appendix D. 3

2.5.2 GROUNDWATER

The site is underlain by a sequence of sedimentary rocks which, at the surface, have been weathered to clayey, silty, and sandy overburden soils with some rock fragments. Overburden on the ridges and slopes generally ranges in thickness from a few inches to a few feet; rock outcrops are common. The soils and much of the rock are relatively impermeable. In valley bottoms, the rock is overlain by about 10 to 15 feet of alluvial sediments and underlying residual soils. The sediments are of minor thickness and vary from slightly alluvial, permeable material to essentially impermeable.

Water bearing strata in the area are mainly recharged in their outcrop areas, which are shown in Figures 2.5-7 through 2.5-9. In the site area, including the flood plain, infiltration into the subsurface formation is retarded because of low permeability of the strata. Most precipitation flows across the surface and drains away as surface runoff or returns to the atmosphere via evaporation and transpiration.

Most of the groundwater in the site region occurs in bedrock. Some does exist in the shallow floodplain alluvium along stream valleys but is not withdrawn for use. In the order of increasing age, bedrock aquifers in the site vicinity include: The Paluxy Formation, Glen Rose Formation, and Twin Mountains Formation, all of the Comanche series, Cretaceous age [8]. Locally, 3 CPSES and SCR are on the Glen Rose Formation outcrop, which, in turn, is underlain by the Twin Mountains Formation. The Paluxy Formation is absent at the CPSES location and within the limits of the SCR.

The three formations are regional in extent; their outcrops form a strip of land tens of miles wide that extends south from central Oklahoma, strikes westward in Central Texas and extends into Mexico [9]. In the site region the formations dip eastward.

The Twin Mountains and Paluxy Formations are principally sandstone, but also have shale, limestone, claystone, and siltstone inclusions. Limestone is the dominant rock type in the Glen Rose Formation, but the stratum also contains significant quantities of shale, siltstone, and claystone. In these formations groundwater percolates slowly along bedrock joints and fractures, and through interstices in the rock fabric.

The Twin Mountains Formation is the only moderately productive bedrock zone in the site vicinity, though the Paluxy Formation has nominal pumpage near the site. The Glen Rose Formation yields very little water in the site area and is usually less productive than the others.

At distances of 20 to 50 miles downdip from the outcrop, the groundwater becomes saline and the formations lose their importance as sourcesof fresh water [10]. The three water-bearing formations are discussed individually in succeeding sections.

2.5.2.1 Twin Mountains Formation

The principal origins of groundwater in the Twin Mountains Formation are rainfall and streamflow occurring in the outcrop area (Figure 2.5-7).

Downdip from the outcrop, groundwater in the Twin Mountains Formation is confined by fine-grained materials of the overlying Glen Rose Formation. Hydrostatic pressure in the Twin Mountains is great enough to create static water levels which rise above the formation and, sometimes, to cause flowing wells. The piezometric level, at the site, measured in a test boring in this formation, is approximately elevation 670 feet MSL about 60 feet above the formation surface.

Groundwater is discharged in the outcrop area by evapotranspiration, localized springs, and seepage into drainage channels incised below the water table. Downdip from the outcrop area (where the formation is confined) the natural discharge is limited to a small upward movement into overlying formations.

Although the Twin Mountains Formation is a moderately productive stratum in the site area, packer-pressure tests of 60 feet of this rock in a boring at the CPSES site did not result in water take. This indicates there are essentially impermeable rock zones within this formation.

2.5.2.2 Glen Rose Formation

This formation is predominately limestone, but significant amounts of shale, siltstone, and claystone are also present. The principal origins of groundwater in the Glen Rose Formation are rainfall in the outcrop area and minor seepage from both the overlying Paluxy Formation and underlying Twin Mountains Formation. The Glen Rose Formation outcrop area is shown on Figure 2.5-8. 3

CPSES and SCR will be constructed on the Glen Rose Formation, thus the character and rate of groundwater movement in this formation is of special interest. The Glen Rose limestones are essentially impermeable due to slight amounts of argillaceous impurities present. These limestones are resistant to solution effects; open voids, caverns, joints, collapse features, and frequent fractures -- frequent in some limestone formations -- are notably absent in the Glen Rose Formation near the site. Groundwater, therefore, moves very slowly into and through the formation; entrance is afforded principally through existing joints and fractures. Occasional isolated sand lenses also contain groundwater.

Detailed examination of cores from test borings revealed minor solutioning features and minimal fractures. Packer-pressure tests in the Glen Rose Formation, performed in most borings in the site area, incurred essentially no water take in rock beneath the upper, usually thin, weathered zone. (Drill water occasionally was lost while drilling through the upper weathered zone.) Northwest of the site, where the formation is covered by outliers of the Paluxy, a few domestic water wells are completed in the Glen Rose Formation. These wells produce potable water and are reliable during droughts, generally due to the slow release of groundwater to the Glen Rose Formation from the overlying Paluxy Formation. Elsewhere, wells completed in the Glen Rose are often unreliable during droughts.

In its outcrop areas, the Glen Rose Formation discharges water naturally through springs and seeps. In confined portions of the formation, there is a little transfer of water into overlying or underlying formations when differential pressures occur.

2.5.2.3 Paluxy Formation

This formation is predominately sandstone, but shale, siltstone, claystone, and limestone are also present. Recharge to the Paluxy Formation occurs in the outcrop areas (Figure 2.5-9) from infiltration of rainfall and seepage from streams.

It also receives water from water-bearing units under greater hydraulic heads which adjoin the Paluxy Formation. South of the CPSES site, across the Paluxy River, the formation is confined by overlying fine-grained strata.

Groundwater discharges from the formation as springs and seeps in some outcrop areas. Where the Paluxy Formation is confined, there is a limited water movement into overlying or underlying confining units when those units are at a lower hydraulic head.

2.5.2.4 On-Site Water Table

Following the subsurface exploration program, a number of the geologic and foundation test borings were observed to determine water levels. Of these borings, one was completed in the Twin Mountains aquifer; the piezometric water level in that boring is elevation 670 feet MSL. The rest of the boreholes monitored for groundwater were completed in the Glen Rose Formation. Static water levels observed in these borings range from 749 to 830 feet MSL.

Water levels in the Glen Rose Formation are expected to show some variation in response to seasonal climatic changes; those in the Twin Mountains Formation should be much less influenced by seasonal conditions.

2.5.2.5 Water Quality

Potable groundwater occurs in the Twin Mountains, Glen Rose and Paluxy Formations.

Water in the Twin Mountains Formation is a sodium bicarbonate
type; with a dissolved solids content varying generally from
200-900 mg/l. In and near the outcrop areas, Twin Mountains
3 water is used for irrigation. At the site, however, the water
is unsuitable for irrigation because of local soil conditions
and the higher sodium content of the water.

The quality of water obtained from the Glen Rose Formation is variable; in localized areas it is not potable. Northwest of the site, water is drawn from this formation where it is capped by an outlier of Paluxy.

The Paluxy Formation is tapped by some domestic water wells south of the Paluxy River, where the water is typically a hard calcium bicarbonate type. Further downdip the water becomes a progressively softer, sodium bicarbonate type.

2.5.3 WATER QUALITY CRITERIA

Water quality criteria for Texas streams are established and enforced by the Texas Water Quality Board. The Texas Water Quality standards were approved by the Environment Protection 3
Agency (Region VI) on October 25, 1973. These standards have been included as Appendix B of this report. The major requirements of the standards that are applicable to CPSES effluents are summarized in the following paragraphs.

A. General Criteria

The surface waters of the State of Texas are divided into four main categories, i.e., River Basin Waters, Coastal Basin Waters, Bay Waters, and Gulf Waters. The criteria established for the River Basin Waters are applicable to the Brazos River in the vicinity of the CPSES site.

The protection of water quality and water uses requires the establishment of certain criteria, both numerical and narrative. Accordingly, the Texas Water Quality Board designates the following water uses that are known and suitable for the Brazos River near the CPSES site:

Contact and Non-Contact Recreation Waters
Domestic Raw Water Supply
Propagation of Fish and Wildlife
Irrigation Waters 3

The general criteria enumerated by the Texas Water Quality Board are applicable to all surface waters of the State at all times and specifically apply with respect to substances attributed to waste discharges or the activities of man as opposed to natural phenomena. Natural waters may, on occasion, have characteristics outside the limits established by these criteria; in which these criteria do not apply. The criteria adopted relate to the condition of waters as affected by waste discharges or man's activities. The critera listed do not override a specific exception to any one or more of the following if the exception is specifically stated in a specific water quality standard.

(1) Taste and odor producing substances shall be limited to concentrations that will not interfere with the production of potable water by reasonable water treatment methods, or impart unpalatable flavor to food fish, including shellfish, to result in offensive odors arising from the waters, or otherwise interfere with the reasonable use of the waters.

(2) Essentially free of floating debris and setteable suspended solids conducive to the production

of putrescible sludge deposits or sediment layers which would adversely affect benthic biota or lawful uses of the water.

(3) Essentially free of settleable suspended solids conducive to changes in the flow characteristics of stream channels, and to the untimely filling of reservoirs and lakes, and possibly resulting in unnecessary dredging costs.

(4) The surface waters in the state shall be maintained in an aesthetically attractive condition.

(5) There shall be no substantial change in turbidity from ambient conditions due to waste discharges.

(6) There shall be no foaming or frothing of a persistent nature.

(7) There shall be no discharge of radioactive materials in excess of that amount regulated by the Texas Radiation Control Act, Article 4590(f), Revised Civil Statutes, State of Texas and Texas Regulation for Control of Radiation.

Radioactivity levels in the surface waters of Texas, including the radioactivity levels in both suspended and dissolved solids for the years 1958 through 1960, were measured and evaluated by the Environmental Sanitation Services Section of the Texas State Department of Health in a report prepared for and at the direction of the Health Department by the Sanitary Engineering Research Laboratory at the University of Texas. The document is entitled, "Report on Radioactivity--Levels in Surface Waters--1958-1960" pursuant to contract No. 4413-407 and is dated June 30, 1960. This document comprises an authoritative report on background radioactivity levels in the surface waters in the State and quite importantly sets out the location where natural radioactive deposits have influenced surface water radioactivity. The impact of radioactive discharges that may be made into the surface waters of Texas will be evaluated and judgments made on the basis of the information in the report which was at the time made, and may still be the only comprehensive report of its kind in the nation. 3

Radioactivity in fresh waters associated with the dissolved minerals (measurements made on filtered samples) shall not exceed those enumerated in U.S. Public

Health Service, Drinking Water Standards, revised 1962, or latest revision, unless such conditions are of natural origin.

(8) The surface waters of the State shall be maintained so that they will not be toxic to man, fish and wildlife; and other terrestrial and aquatic life.

With specific reference to public drinking water supplies, toxic materials not removable by ordinary water treatment techniques shall not exceed those enumerated in U.S. Public Health Service, Drinking Water Standards, 1962 edition, or later revision.

For a general guide, with respect to fish toxicity, receiving waters outside mixing zones should not have a concentration of nonpersistent toxic materials exceeding 1/10 of the 96-hour TLm, where the bioassay is made using fish indigenous to the receiving waters. Similarly, for persistent toxicants, the concentrations should not exceed 1/20 of the 96-hour TLm.

In general, for evaluations of toxicity, bioassay techniques will be selected as suited to the purpose at hand. However, bioassay will be conducted under water quality conditions (temperature, hardness, pH, salinity, dissolved oxygen, etc.) which approximate those of the receiving stream as closely as practical. 3

(9) As detailed studies are completed, limiting nutrients are identified, and the feasibility of controlling excessive standing crops of phytoplankton or other aquatic growths by nutrient limitations are determined. It is anticipated that nutrient standards will be established on the surface waters of the state. Such decisions will be made on a case-by-case basis by the Board after proper hearing and public participation. The establishment of a schedule for decisions as to the need for nutrient standards for specific waters and what standards should be adopted is not feasible at this time.

(10) The surface waters of the State shall be maintained so that no oil, grease, or related residue will produce a visible film of oil or globules of grease on the surface, or coat the banks and bottoms of the watercourse.

The water uses deemed suitable and known on the Brazos River near the CPSES site include contact and non-contact recreation, propogation of fish and wildlife, and domestic raw water supply.

B. Numerical Criteria

The numerical criteria listed below apply to the specific waters of the Brazos River Basin identified as Segment No. 1205 which is Lake Granbury.

(1) Chloride, average not to exceed 600 mg/l
(2) sulphate, average not to exceed 300 mg/l
(3) total dissolved solids, average not to exceed 1600 mg/l
(4) dissolved oxygen, not less than 5.0 mg/l
(5) pH range, 6.5 - 8.5
(6) fecal coliform, logarithmic average not more than 200 per 100 milliliters
(7) temperature, maximum upper limit 93°F or 5°F rise over ambient temperature.

C. Application of Standards

The following paragraphs summarize the application of the Texas Water Quality Standards appropriate to the Brazos River Basin in the vicinity of the CPSES site.

Stream standards apply only to waters where standards are established and specifically apply with respect to substances attributed to waste discharges or the activities of man as opposed to natural phenomena.

Chemical concentration parameters, with the exception of dissolved oxygen and pH, apply to approximate midpoint of the segment with reasonable gradients applying toward segment boundaries. The numerical values shown represent annual arithmetic mean concentrations which will not be exceeded for any year where the sampling median flow for the year under consideration equals or exceeds 50 percent of the median flow for the period of record for the existing hydrological conditions. 3

The dissolved oxygen concentrations represent minimum values and shall apply at all times that the daily flow exceeds the 7-day minimum average flow for the existing hydrologic conditions with a recurrence interval of two years, except where this flow is zero. When the flow is zero, the dissolved oxygen standards shall not apply.

The temperature standards apply to the Brazos River in the same manner as the dissolved oxygen requirements described above, however, the temperature requirements do not apply to off-stream or privately owned reservoirs, constructed principally for industrial cooling purposes and financed in whole or in part by the entity or successor entity using, or proposing to use, the lake for cooling purposes.

Where the mixing zone is not defined by a specific TWQB order or permit, a reasonable zone shall be allowed. Because of varying local physical, chemical, and biological conditions, no single criterion is applicable in all cases. In no case, however, where fishery resources are considered significant, shall the mixing zone allowed preclude the passage of free-swimming and drifting aquatic organisms to the extent of significantly affecting their populations. Normally, mixing zones should be limited to no more than 25 percent of the cross-sectional area and/or volume of flow of the stream or estuary, leaving at least 75 percent free as a zone of passage unless otherwise specified. 3

2.5.4 REFERENCES

1. United States Geological Survey, Water Resources Data for Texas, Part 1, Surface Water Records. Annual publications from 1960 through 1971. Austin, Texas.

2. U. S. Department of Commerce, Bureau of the Census, Number of Inhabitants, 1970, Census of Population, Texas. Washington, D.C., 1971.

3. United States Geological Survey, Water Resources Data for Texas, Part 2, Water Quality Records. Annual Publications from 1960 through 1969. Austin, Texas.

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5. Arbingast, S.A., Bonine, M. E., and Kennamer, L. C., 1967, Atlas of Texas, Bureau of Business Research, University of Texas, Austin, Texas.

6. Goines, W. H., 1965, Streamflow Characteristics of the Brazos River Basin, Texas, U.S. Geological Survey - Water Resources Division, Open File 87.

7. Mecom, John O., 1972, The Limnology of Lake Granbury, Texas Dallas, Texas.

8. Texas Water Development Board (in press), "Groundwater Resources of Part of Central Texas with Emphasis on the Antlers and Travis Peak Formations".

9. Sellards, E. H., Adkins, W. S., and Plummer, F.B., 1932, The Geology of Texas, Volume 1, Stratigraphy. University of Texas Bulletin 3232, Bureau of Economic Geology.

10. Cronin, J. G., Follett, C. R., Shafer, G. H., and Rettman, P. L., 1963, Reconnaissance Investigation of the Groundwater Resources of the Brazos River Basin, Texas. Texas Water Commission Bulletin 6310.

TABLE 2.5-1

USGS CHEMICAL QUALITY OBSERVATIONS ON THE PALUXY RIVER AT GLEN ROSE

(Concentrations in Milligrams per Liter)

Date	Avg. Flow in cfs	Calcium	Magnesium	Sodium & Potassium	Bicarbonate	Sulfate	Chloride	Total Dis. Solids	Hardness as $CaCO_3$
12/5/61	41.6	45	22	24	206	45	27	274	203
1/10/62	56.8	39	26	22	200	47	28	269	204
3/20/62	27.2	31	27	26	176	52	32	265	188
5/3/62	27.1	53	22	23	213	47	34	322	222
6/5/62	10.4	39	26	23	198	43	32	276	204
7/11/62	5.18	40	20	20	196	30	23	248	182
9/10/62	27	31	11	16	143	20	12	170	123
9/18/62	5.55	37	16	18	179	26	16	211	158
Weighted Average:		40	22	22	191	42	27	262	191

Source: U.S. Geological Survey, Water Resources Data for Texas - Water Quality Records, Austin, Texas

3

TABLE 2.5-2

FIELD MEASUREMENTS OF PALUXY RIVER WATER QUALITY

	Temperature			Alkalinity							
Date	Air °C	Water °C	Oxygen mg/l	Phen. mg/l	M.O. mg/l	CO_2 mg/l	pH	Hardness mg/l	Turbidity JTU	Specific Conductance micromhos	Cl mg/l
8-21-71	33	31	7.2	12	252	0	8.6	*	*	*	15.8
5-23-72	23	23	9.5	0	210	1.6	8.2	108	10	540	26.0
5-23-72	35	27	9.7	0	214	1.9	8.1	122	5	617	30.0

Source: Texas Parks and Wildlife Department, 1972, Survey of the Paluxy River, Ft. Worth, Texas. 3

TABLE 2.5-3

CHEMICAL ANALYSIS OF SQUAW CREEK WATER*

	11-14-72	3-31-72
pH	7.7	7.7
	ppm	ppm
Silica, SiO_2	3.0	7.0
Iron and Alumina oxides, R_2O_3	5.0	4.0
CATIONS		
Calcium, Ca	49.2	67.7
Magnesium, Mg	10.2	40.0
Alkali metals as sodium, Na	26.0	30.7
ANIONS		
Bicarbonate, HCO_3	183.0	250.1
Sulfate, SO_4	30.5	83.0
Chloride, Cl	28.0	46.0
HYPOTHETICAL COMBINATIONS		
Calcium Bicarbonate, $Ca(HCO_3)_2$	199.0	273.8
Magnesium Bicarbonate, $Mg(HCO_3)_2$	39.9	52.7
Magnesium Sulfate, $MgSO_4$	17.8	101.5
Sodium Sulfate, Na_2SO_4	24.0	2.7
Sodium Chloride, NaCl	46.2	75.8
OTHER CONSTITUENTS		
Total solids	334.9	336.0
Phenolphthalein alkalinity	0.0	0.0
Methylorange alkalinity	150.0	205.0
Total suspended solids	33.0	13.0
Total volatile solids	23.0	6.0
Nitrate	4.0	0.5

*Source: Southwestern Laboratories, Dallas, Texas.

3

TABLE 2.5-

FIELD MEASUREMENTS OF SQUAW CREEK WATER QUALITY

DATE	POINT OF COLLECTION*	TEMPERATURE		DISSOLVED OXYGEN		ALKALINITY		pH	CARBON DIOXIDE* mg/1	SPECIFIC CONDUCTANCE micromhos	TURBIDITY JTU	CHLORIDE mg/1	HARDNESS AS $CaCO_3$ mg/1
		AIR °C	WATER °C	mg/1	% Sat.	Phen. mg/1	M.O. mg/1						
7/8/72	I	31	27	8.4	105	0	204	7.1	36.0	-	-	142	-
7/8/72	II	33	33	11.2	140	0	184	7.1	32.0	-	-	380	-
/9/72	III	32	27	3.1	38	0	200	7.5	11.5	463	1.0	295	460
/9/72	IV	32	26	8.8	108	0	234	7.7	7.5	583	2.5	370	556
/9/72	V	32	31	-	-	0	176	8.0	2.6	459	2.5	335	372
/9/72	VI	32	27	6.1	75	0	210	7.9	4.0	466	3.5	320	344

*From Nomograph for evaluation of free carbon dioxide content.

**Location of collecting sites:

I - Taken from a pool in the non-flowing section of the creek near F.M. 51 bridge.
II - Taken from a flowing section of Squaw Creek approximately 6 miles downstream from F.M. 51 bridge.
III - Taken from the large pool above low water bridge on gravel road 1-1/2 miles west of State Highway 144.
IV - Taken below bridge on State Highway 144.
V - Taken below bridge on U.S. Highway 67.
VI - Taken near mouth of Squaw Creek at the junction with the Paluxy River.

Source: Guthery, Fred S., Texas A&M University

Note: Additional Water Quality data are presented in Appendices C and D. 3

TABLE 2.5-5

USGS CHEMICAL QUALITY OBSERVATIONS ON THE BRAZOS RIVER BELOW POSSUM KINGDOM DAM WATER YEARS 1960 THROUGH 1969

(Annual Flow-Weighted Averages in Milligrams per Liter)

Water Year	Avg. Flow in cfs	Calcium	Magnesium	Sodium & Potassium *	Bicarbonate	Sulfate	Chloride	Total Dis. Solids	Hardness as $CaCO_3$
1960	749	129	22	345	114	288	546	1,400	412
1961	1,409	165	28	444	115	398	697	1,800	526
1962	1,138	133	25	325	115	313	500	1,360	434
1963	867	126	25	320	124	286	496	1,320	417
1964	231	129	27	329	123	307	515	1,380	434
1965	515	130	33	362	122	304	581	1,470	459
1966	1,275	127	20	298	110	279	467	1,250	401
1967	522	143	23	359	113	310	576	1,480	450
1968	1,010	133	24	366	117	287	583	1,460	430
1969	1,170	115	26	360	125	245	569	1,380	393
Weighted Average:		134	25	355	117	304	558	1,441	437

* Beginning with 1963, "Sodium & Potassium" is the weighted average reading for Sodium plus a constant average of 6 parts per million for Potassium.

TABLE 2.5-6

USGS CHEMICAL QUALITY OBSERVATIONS ON THE BRAZOS RIVER BELOW WHITNEY DAM

WATER YEARS 1960 THROUGH 1969

(Annual Flow-Weighted Averages in Milligrams per Liter)

Water Year	Avg. Flow in cfs	Calcium	Magnesium	Sodium & Potassium	Bicarbonate	Sulfate	Chloride	Total Dis. Solids	Hardness As $CaCO_3$
1960	1,882	79	14	147	136	130	229	705	254
1961	2,054	106	18	237	129	213	373	1,040	338
1962	1,737	104	19	234	115	227	364	1,030	339
1963	1,215	95	18	203	129	189	309	896	310
1964	434	104	25	252	130	226	396	1,070	361
1965	1,242	72	14	143	130	124	210	631	234
1966	1,969	84	14	171	125	148	265	749	267
1967	709	106	17	222	123	210	351	973	334
1968	2,400	85	13	169	133	144	255	737	267
1969	1,890	82	16	182	145	132	281	767	268
Weighted Average:		90	16	190	130	167	293	835	289

Note: Beginning with 1963, "Sodium & Potassium" is the weighted average reading for Sodium plus a constant average of 6 parts per million for Potassium.

TABLE 2.5-7

HISTORICAL RANGE OF TOTAL DISSOLVED SOLIDS CONCENTRATIONS ON THE BRAZOS RIVER
BELOW POSSUM KINGDOM DAM AND WHITNEY DAM
WATER YEARS 1960 THROUGH 1969

(Milligrams per Liter)

Water Year	Below Possum Kingdom Dam Average	Below Possum Kingdom Dam Maximum	Below Possum Kingdom Dam Minimum	Below Whitney Dam Average	Below Whitney Dam Maximum	Below Whitney Dam Minimum
1960	1,400	2,220	1,240	705	831	589
1961	1,800	3,770	1,220	1,040	1,430	783
1962	1,360	1,540	764	1,030	1,430	830
1963	1,320	1,520	966	896	1,060	810
1964	1,380	1,490	1,350	1,070	1,220	944
1965	1,470	1,530	1,380	631	1,030	453
1966	1,250	1,380	1,190	749	885	600
1967	1,480	1,810	1,160	973	1,090	893
1968	1,460	1,810	1,340	737	1,140	456
1969	1,380	1,670	1,000	767	951	606
10 Years:	**1,441**	**3,770**	**764**	**835**	**1,430**	**453**

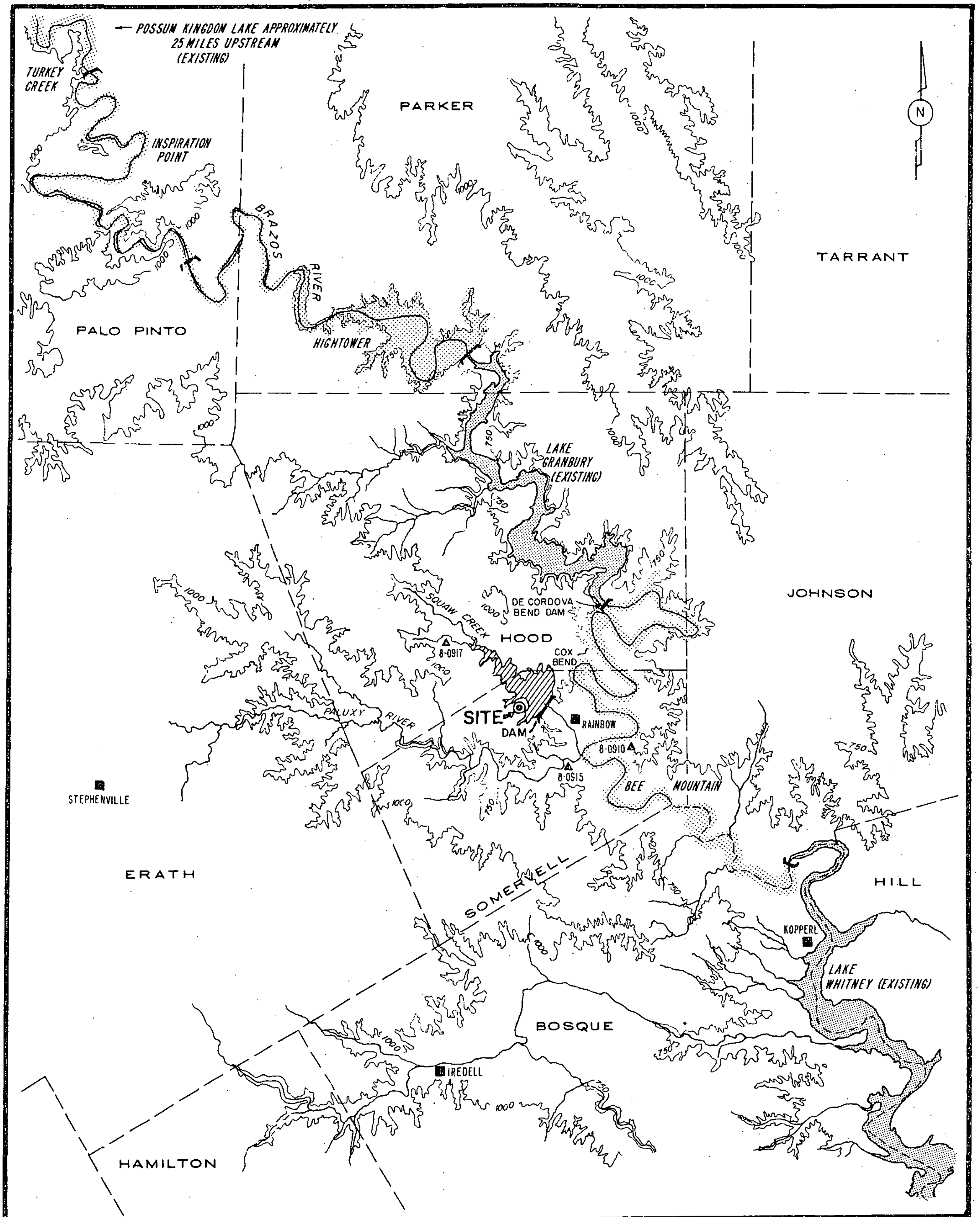
Table 2.5-8 Water Quality in Lake Granbury - Continued

PARAMETER	RANGE	COMMENTS
Sulfates	Average of 200 ppm	Very little variance, possibly due to leaching of upstream gypsum formations. Values approach the maximum allowable concentrations set forth by the U.S. Public Health Service.
Apparent Color	0 to 100 units	Generally low.
Relative Transparency	2.3 to 5.5 feet	Clarity is highest in January, lowest in July. Clarity increases in the downstream reaches of the lake, and is unusually high for a lake situated on a river system that normally carries a heavy silt load.
Biochemical Oxygen Demand	8 to 100 ppm BOD	High BOD probably due to decomposition of organic detritus from flooded grasslands.

Note: For more recent and comprehensive Lake Granbury water quality data, see Appendix D (SMU Report). 3

TABLE 2.5-9

<u>DELETED</u>



REFERENCE: The base for this map was prepared from portions of U.S.G.S. 1:250,000 quadrant maps of Abilene, Dallas-Fort Worth, Brownwood and Waco sections.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

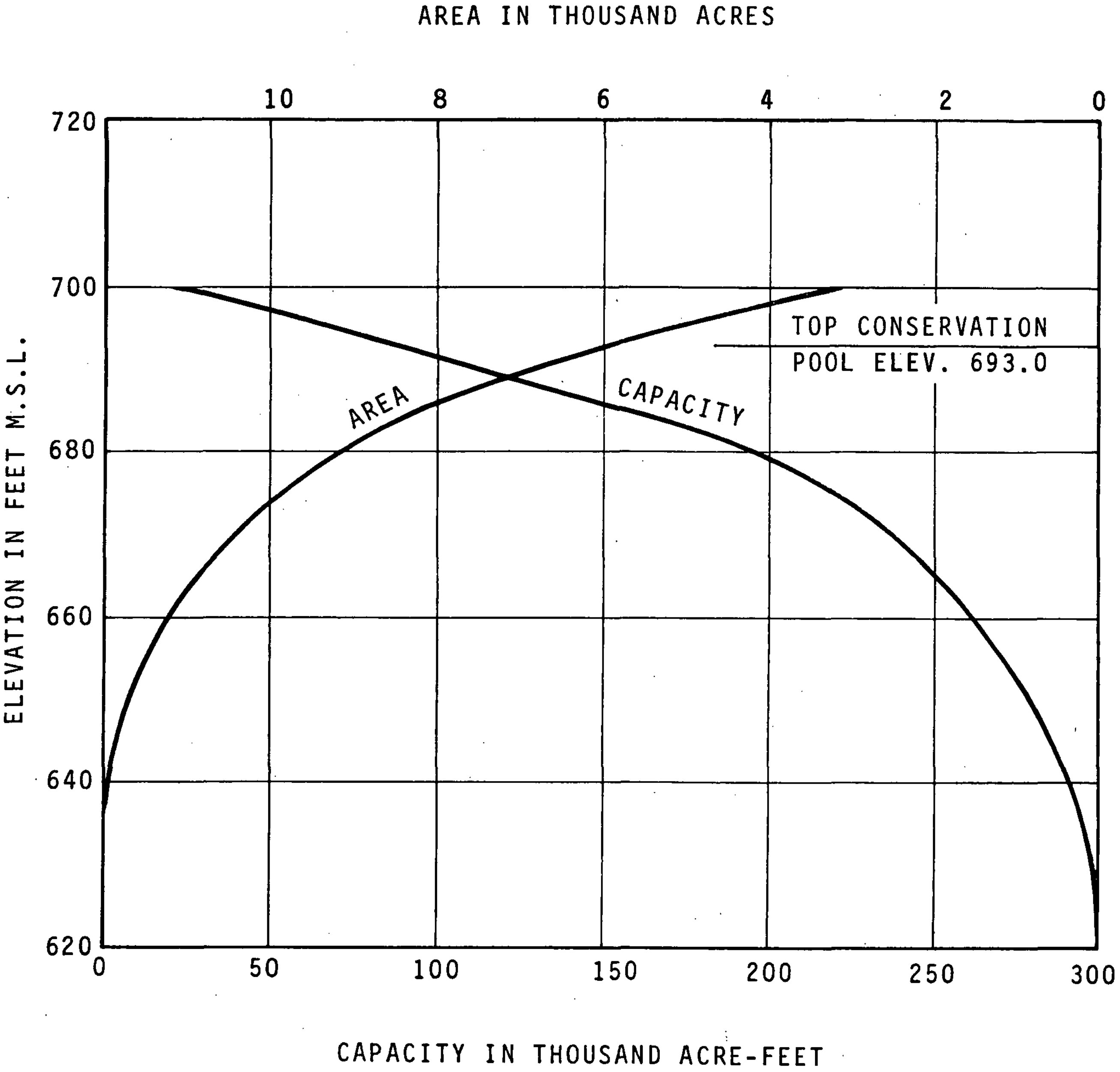
REGIONAL TOPOGRAPHIC MAP

FIGURE 2.5-3

REVISIONS BY ______ DATE ______

FILE ______

BY ______ DATE ______ CHECKED BY ______

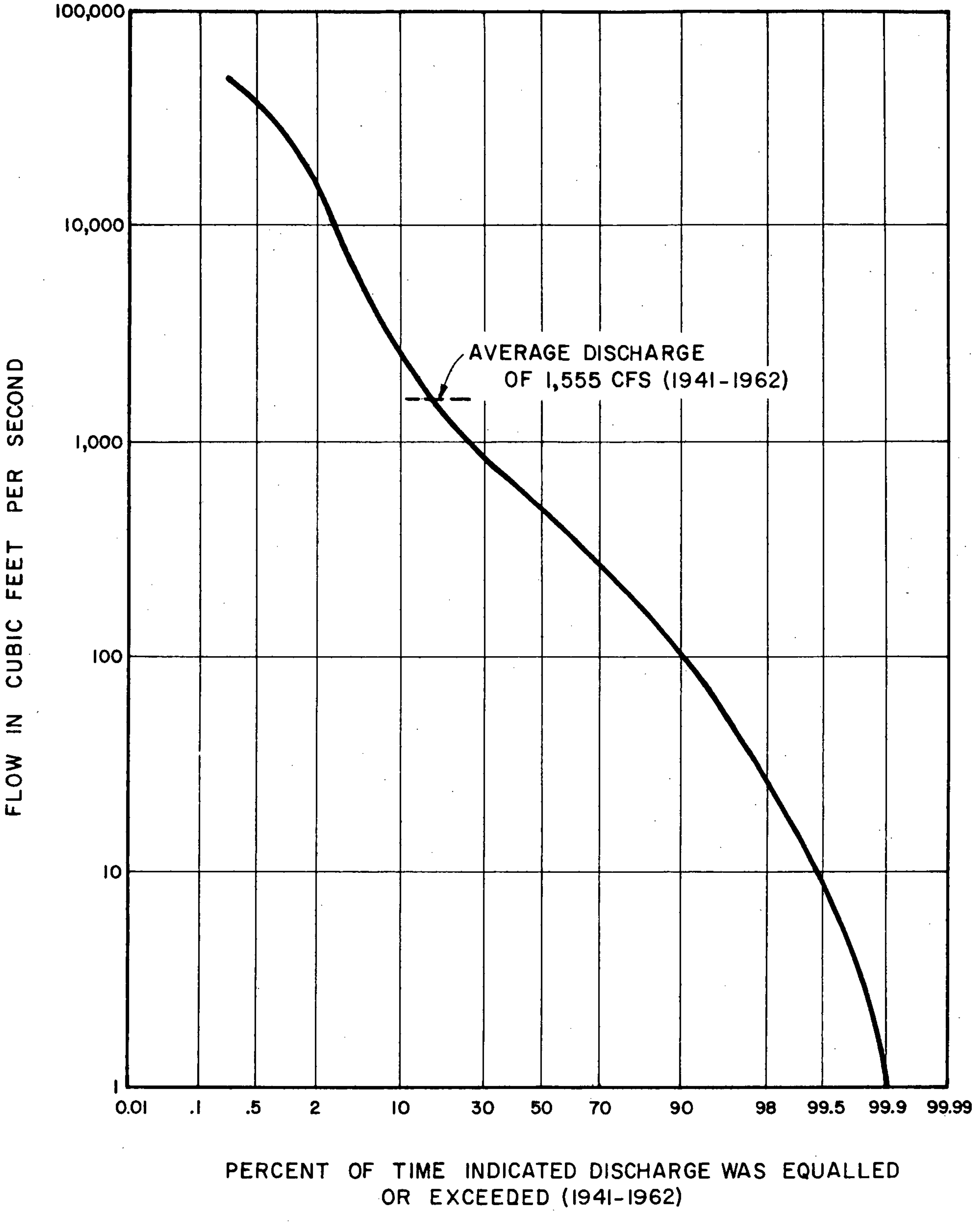


DAM NAME: DE CORDOVA BEND
OWNER: BRAZOS RIVER AUTHORITY
LOCATION: 8 MILES SOUTHWEST OF GRANBURY ON THE BRAZOS RIVER
DRAINAGE AREA: 15,450 SQUARE MILES (CONTRIBUTING)
IMPOUNDMENT YEAR: 1969
TOP CONSERVATION POOL ELEV. M.S.L.: 693.0
SURFACE AREA IN ACRES: 8,600
STORAGE CAPACITY: 153,500 AC.-FT.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

LAKE GRANBURY

FIGURE 2.5-4



SOURCE: GOINES, W.H., STREAMFLOW CHARACTERISTICS OF THE BRAZOS RIVER BASIN, U.S. GEOLOGICAL SURVEY. WATER RESOURCES DIVISION, OPEN FILE 87, 1965.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

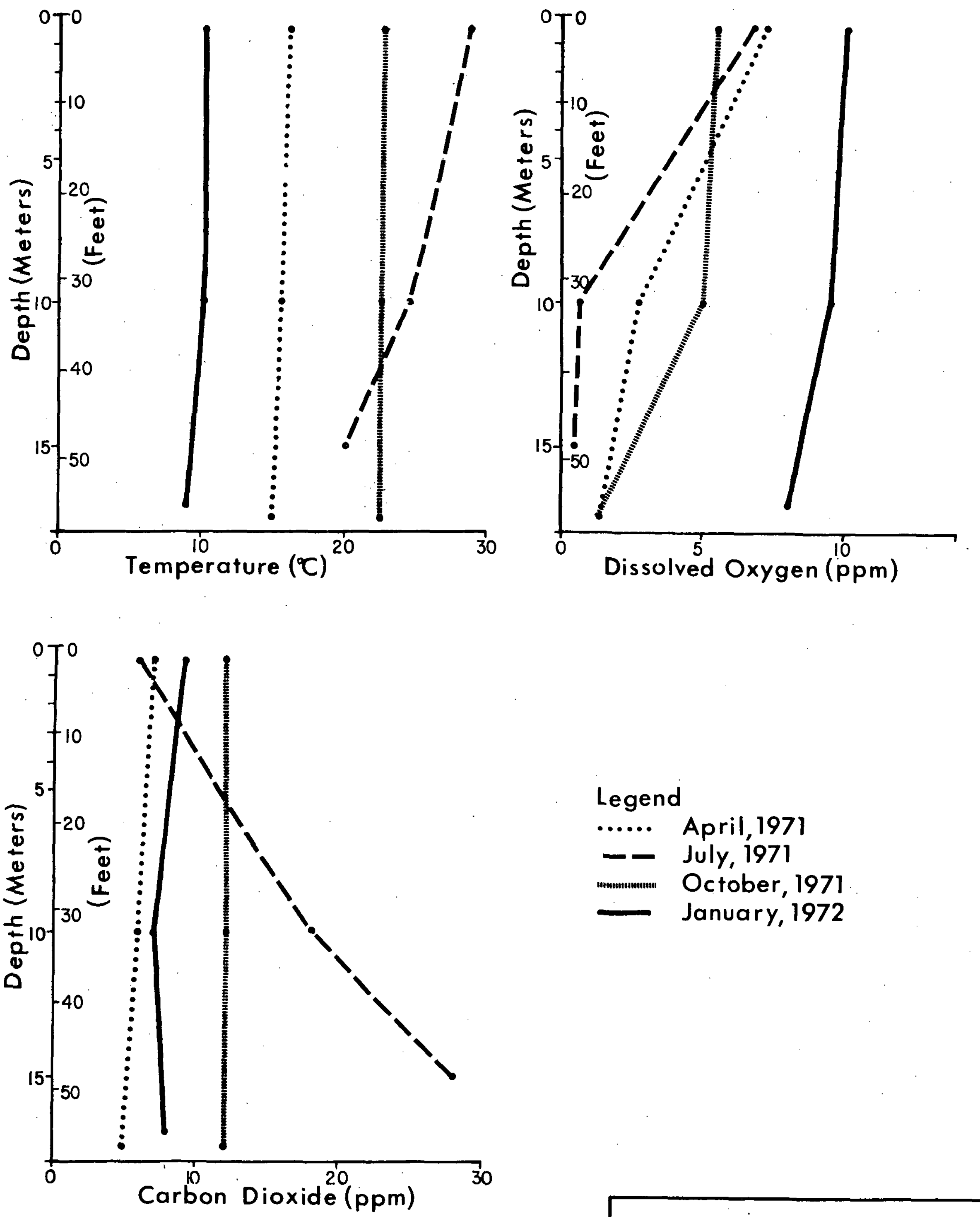
FLOW PROBABILITY CURVE
FOR THE BRAZOS RIVER
AT STATION 8-0910
NEAR GLEN ROSE

FIGURE 2.5-5

REVISIONS BY ______ DATE ______

FILE ______

BY ______ DATE ______ CHECKED BY ______

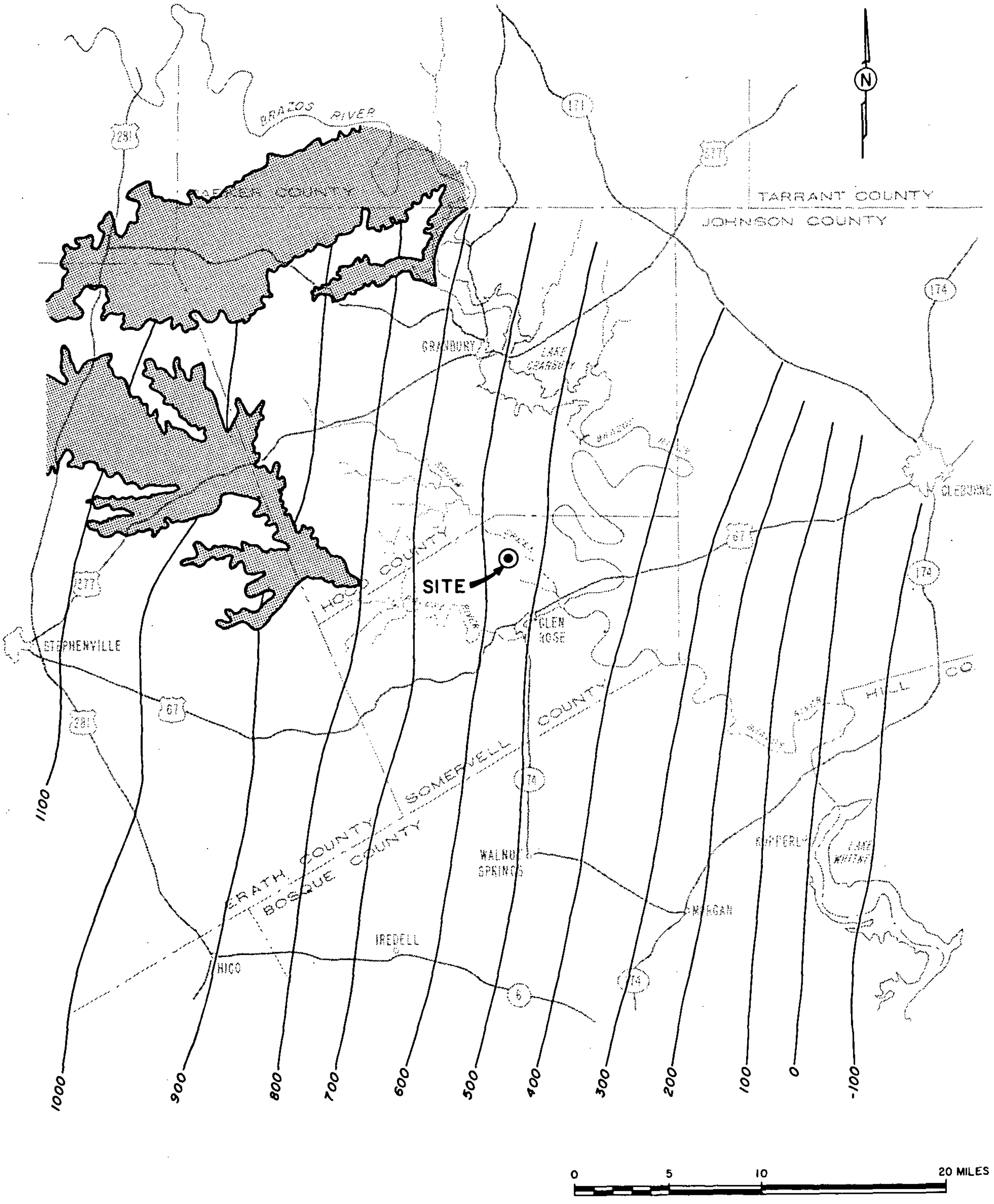


Adapted from John O. Mecom, The Limnology of Lake Granbury Texas, 1972.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

Oxygen and Carbon Dioxide in Lake Granbury

FIGURE 2.5–6



LEGEND

—600— ELEVATION CONTOUR

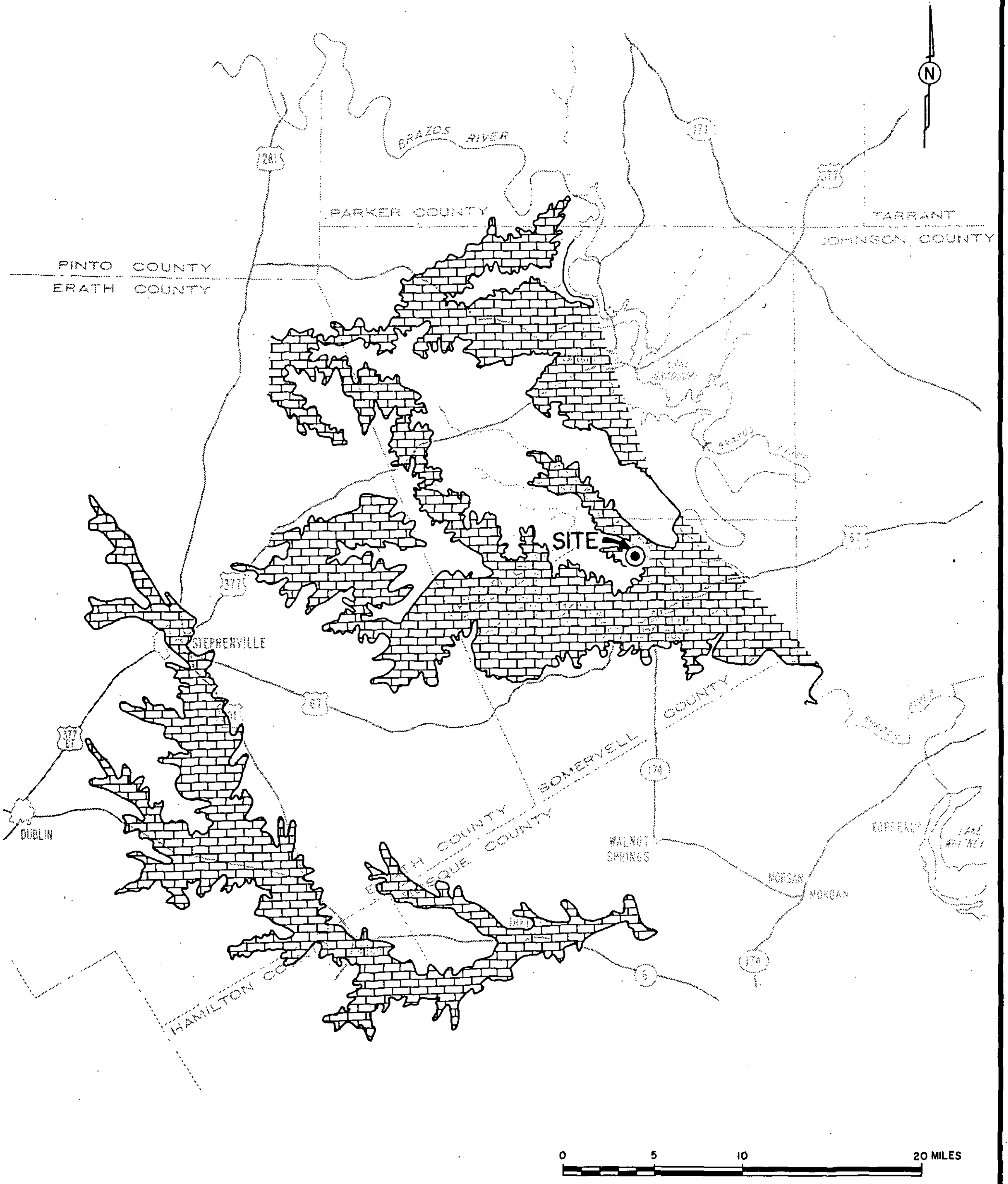
▨ AQUIFER OUTCROP

REFERENCE: The base map for this illustration was prepared from portions of U.S.G.S. quadrangle maps for Abilene, Brownwood, Dallas and Waco.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

ELEVATION OF TOP OF
TWIN MOUNTAINS FORMATION

FIGURE 2.5-7

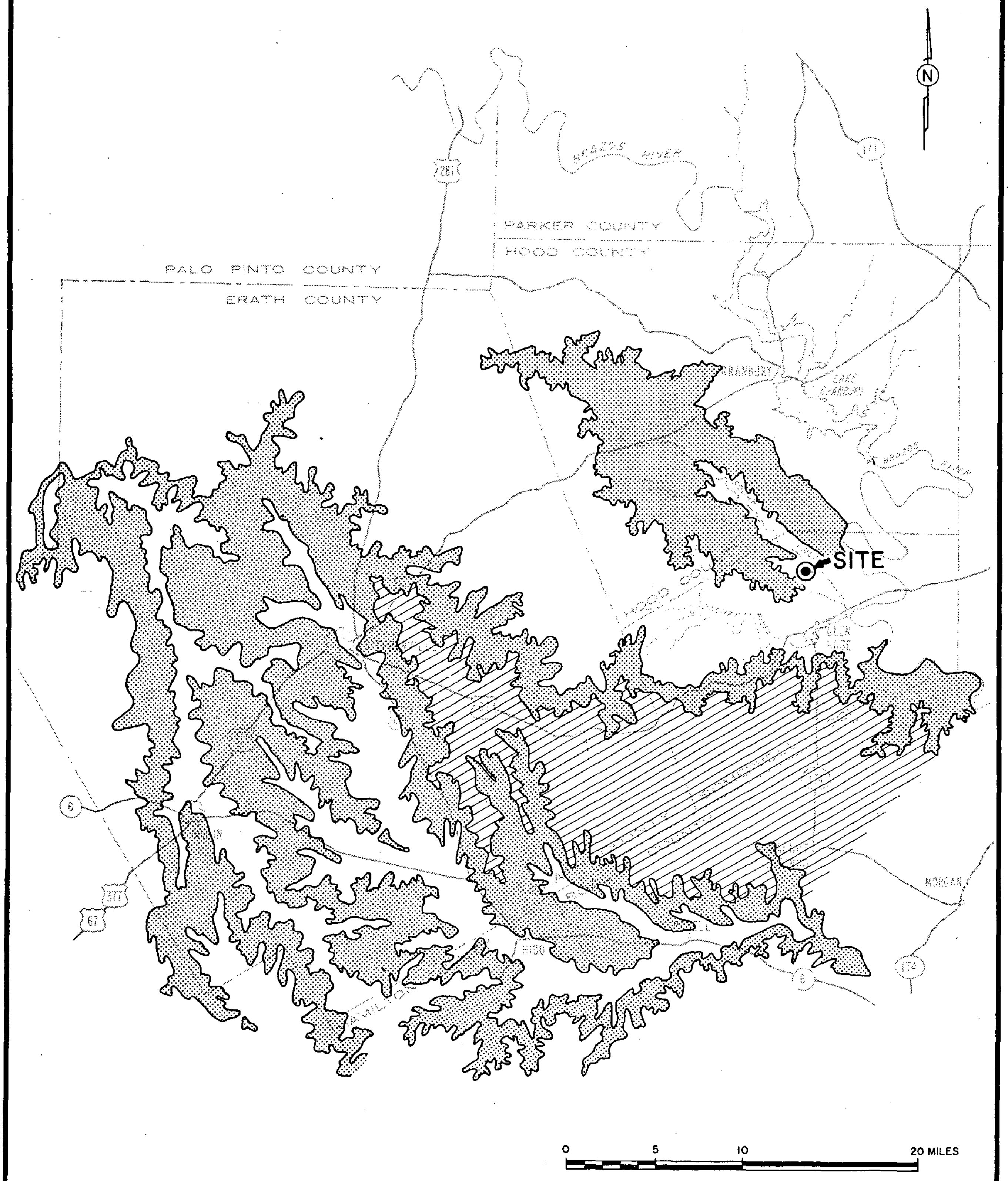


REFERENCE: The base map for this illustration was prepared from portions of U.S.G.S. quadrangle maps for Abilene, Brownwood, Dallas and Waco.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

OUTCROP OF
GLEN ROSE FORMATION

FIGURE 2.5-8



LEGEND

▨ OUTCROP OF PALUXY AQUIFER

▨ AREA WHERE AQUIFER IS CONFINED

REFERENCE: The base map for this illustration was prepared from portions of U.S.G.S. quadrangle maps for Abilene, Brownwood, Dallas and Waco.

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

OUTCROP OF
PALUXY FORMATION

FIGURE 2.5-9

2.6 METEOROLOGY

2.6.1 GENERAL

The regional climatology is described for an area bounded by 30° North, 100° West, 34° North, 96° West as shown in Figure 2.6-1. The climate of the region is continental and is characterized by rapid changes in temperature, marked extremes, and large daily and annual temperature ranges. The mean annual temperature decreases from southeast to northwest because of elevation and latitude changes. The general continental climate of the region is modified frequently by advancing warm moist air from the Gulf of Mexico resulting in high humidities and cloudiness. Rainfall generally decreases from east to west and is heaviest in late spring and early summer. Snowfall is generally light and has occurred during all winter months.

During the summer, individual daytime temperatures often exceed 100°F. Rainfall occurs during brief but sometimes intense showers and thundershowers.

Precipitation during winter (the driest season) is generally associated with outbreaks of polar continental air. The coldest weather occurs during January and February. However, weather changes are frequent and cold spells rarely last more than a few days.

Spring is characterized by rapid changes of temperature, i.e., alternating periods of warm and cold conditions. On the average, thunderstorms are more frequent and more violent in the spring than any other season.

The fall is characterized by fair weather, low wind speeds, and moderate temperatures. It is the most pleasant season of the year.

In the following sections, weather station summaries from proximal locations have been used to establish site climatology (except for stability wind roses). Stations used appear in Figures 2.6-1 and 2.6-2.

2.6.2 TEMPERATURE & WATER VAPOR

Monthly and annual values of the daily mean temperature, and the average and extreme daily maximum and minimum temperatures are shown in Table 2.6-1, based on data records for Fort Worth [2]. The annual mean temperature based on this data is 66°F. 1

Monthly and annual average relative humidity for the Comanche Peak area for four different times of day are given in Table

2.6-2. Humidities in the table are taken from eight years of record at the Fort Worth weather station [2]. The overall annual average relative humidity is 65 percent.

Monthly and annual average dewpoint temperatures, estimated from Fort Worth data [3] are shown in Table 2.6-3.

2.6.3 WIND CHARACTERISTICS

Percentage frequencies of surface wind (wind roses) at Love Field, Dallas, for the years 1951-1960 [4], are shown on an annual and monthly basis in Table 2.6-4. The symbol "+" indicates that the value is less than one-half of one percent but greater than zero. According to the annual table, surface wind directions at Dallas are from the southeast, south-southeast, and south 45 percent of the time. These directions predominate during the individual months also, but to a lesser extent during November through March. The annual average wind speed (not shown in Table 2.6-4) is 11.0 miles per hour. The maximum average wind speed occurs in the spring, while the minimum occurs in the fall. Calms occur only about two percent of the time, annually.

For the 9-1/2 months of on-site data at the Comanche Peak site, the annual frequency distribution of stability classes is presented in Table 2.6-5. Stability classes used are based on the Pasquill classification [5] as defined in Table 2.6-6.

2.6.4 PRECIPITATION

Monthly and annual precipitation normals and the mean number of days with precipitation equal to or greater than 0.5 inches, estimated for Comanche Peak by averaging data from Rainbow, Stephenville, Cleburne, Dublin and Fort Worth []], are presented in Table 2.6-3. Monthly precipitation extremes (maximum and mini-
mum), presented in Table 2.6-7 for several stations in the area,
1 indicate that the largest rainfall occurs during April and May
[],2].

The maximum recorded point rainfall for durations of 5 minutes to 24 hours at Abilene, Fort Worth and Waco [7] are given in Table 2.6-8.

On the other hand, drought conditions (extended periods of wide-
spread meager precipitation) are known to occur in Texas. The
most severe this century in Texas occurred during 1954-1956.
Fort Worth precipitation records illustrate the regional conditions;
1 they indicate that the annual precipitation for this three-year
period was 21.1 inches, with only 18.55 inches occurring in 1956
3 (Table 2.6-7). Although this period represents the worst
drought in Texas, there have been three occurrences of annual
precipitation less than 18.55 inches during the 77-year period
of record at Fort Worth. The extreme-minimum annual precipita-
tion recorded, 17.96 inches, occured in 1921 [14].

March is 0.3, 2.5, 0.5 and 0.1 percent, respectively [9]. Moderate to heavy ice storms can be quite damaging to utility lines and trees, as well as being a serious traffic hazard.

2.6.5 STORMS

2.6.5.1 Thunderstorms

Thunderstorms occur about 45 days each year at Fort Worth [2]; Table 2.6-3 presents the average monthly distribution. The maximum frequency of thunderstorm occurrences is April through June, while the months November through February have few thunderstorms.

2.6.5.2 Tornadoes

During the period 1955 through 1962, 58 tornadoes (4.46 mean annual
frequency) occurred within a one-degree square centered near the 3
Comanche Peak site [4]. The probability (P) of a tornado hitting
a point in a given year is:

$$P = 2.8209 \times \bar{t} \div A$$

where A is the area (in square miles) of a one-degree square centered on the point, and $\bar{t}$ is the mean annual frequency. The re-
turn period is the reciprocal of P[10]. Table 2.6-10 summarizes the 3
results for the site and nearby areas for the period 1953 through 1962.

2.6.5.3 Hurricanes

Tropical cyclones, including hurricanes, lose strength rapidly as they move inland and the greatest concern is potential damage from winds, or flooding due to excessive rainfall. The tropical cyclone season for Texas extends from June to October; storms are more frequent in August and September, and rarely occur after the first of October. The average frequency of tropical cyclones that affected Texas for the period 1931 to 1960 is approximately two per year; of these about one in four were of hurricane force, i.e., winds greater than 75 mph [11]. The monthly median increase in precipitation due to tropical cyclones is presented in Table 2.6-11 for selected stations in the region.

2.6.5.4 Extreme Winds

Estimated extreme winds (fastest mile) for the general area for return periods from 2 to 200 years are given in Table 2.6-12 based on the Fréchet distribution [12]. Fastest mile winds are sustained winds, normalized to 30 feet above ground and include all meteorological phenomena (thunderstorms, extratropical cyclones and tropical cyclones including hurricanes) except tornadoes.

The "fastest mile" wind recorded at Dallas and Fort Worth, are presented for each month [13] in Table 2.6-13.

2.6.6 REFERENCES

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8. "Extremes of Snowfall: United States and Canada," Weatherwise, December 1970.

9. Orton, R.B., 1964, The Climate of Texas and Adjacent Gulf Waters, U.S. Government Printing Office, Washington, D.C.

10. Thom, H.C.S., 1963, "Tornado Probabilities," Monthly Weather Review, October-December.

11. Cry, George W., "Effects of Tropical Cyclone Rainfall on the Distribution of Precipitation over the Eastern and Southern United States," ESSA Professional Paper 1, U.S. Department of Commerce, Washington, D.C., June 1967.

12. Thom, H.C.S., 1968, "New Distributions of Extreme Winds in the United States," Journal of the Structural Division, Proceedings of the ASCE, July.

13. National Atlas of the United States, U.S. Weather Bureau, U.S. Government Printing Office, Washington, D.C., 1964.

14. Severe Local Storm Occurrences, 1955-1967, U.S. Department of of Commerce, Weather Bureau, Office of Meteorological Operations, 1,3 Weather Analysis and Predicing Division, Silver Springs, Md., September, 1969.

and weathered rock as well as an appreciable quantity of the firm unweathered Glen Rose Limestone. All of the overburden soil and a portion of the upper and weathered limestone may be removed by conventional dirt moving equipment. The lower portion of the weathered limestone and all of the underlying firm limestone may require blasting, or other appropriate methods, to permit loading and transporting of excavated materials to waste areas remote from the site.

2.6.5.1 Excavation for Structures

Below the plant grade elevation, approximately elevation 810, which will be established by mass excavation operations, care must be taken to prevent any overexcavation or fracturing of foundation rock that is to receive structural concrete.

Although the strength of the underlying fundation rock formation is adequate to stand vertically during the excavation, it is desirable to make the excavations on a slight slope such as five vertical to one horizontal.

Continuous mapping of the excavation faces by a qualified engineering geologist will be made as the excavation progresses downward. In addition, all excavation faces will be protected as soon as practical after completion of any portion of the excavation by the use of a moisture proof membrane to prevent drying of any exposed claystone surface penetrated by the excavation.

Excavation techniques may consist of line drilling and broaching, controlled blasting following line drilling, or other approved procedures that wll insure no fracturing of the surrounding, massive, limestone.

Any inadvertent excavation below foundation level will be backfilled with adequate strength concrete prior to placing structural concrete.

2.6.6 GROUNDWATER - DEWATERING

Piezometers have been installed in selected borings at the plant site as shown on Figure 2.7.2.4-1. A more detailed description of groundwater is presented in Section 2.4.13.

The continuing observations of the piezometers indicate a ground water level above the mass excavation level (Figure 2.6.6-1), elevation 810, as well as the foundation excavation level for plant structures. The response time of the piezometers confirms the basic "imperviousness" of the Glen Rose Limestone and indicates that the volume of water that will be encountered during the excavation will be low to very low in quantity. Any groundwater inflows will occur in defects in the limestone formation and can be handled by an open sump in the lowermost excavation level.

Since groundwater elevations are expected to stabilize equal to the operating level of the reservoir created by the proposed dam on Squaw Creek, a pervious granular drain will be constructed around the perimeter of each structure below reservoir elevation and will be connected to a sump so as to remove inflows down to sump elevation.

2.6.7 BACKFILL

Backfill against the structural walls below the plant grade, Elevation 810, and the surrounding Glen Rose Limestone Formation will consist of select materials compacted to a density not less than 98% obtainable by the Standard AASHO method of testing.

2.6.8 LATERAL PRESSURES

Because of the rigidity of the proposed structures, all lateral pressures should be taken as "at rest" pressures. The value of Ko, coefficient of earth pressure at rest, for static loads will be determined when the specific conditions and materials are known.

TABLE 2.6-1

VALUES OF MEAN, AVERAGE AND EXTREME DAILY MAXIMUM, AND AVERAGE AND EXTREME DAILY MINIMUM SURFACE TEMPERATURES (^oF) DERIVED FROM STEPHENVILLE, CLEBURNE AND FORT WORTH DATA

Month	Mean	Average Daily Maximum	Extreme Maximum	Average Daily Minimum	Extreme Minimum
January	45	56	88	35	-3
February	49	60	93	39	-1
March	56	67	97	44	10
April	65	76	99	54	22
May	72	83	104	63	38
June	81	92	108	71	51
July	84	96	111	75	57
August	84	96	112	75	52
September	77	89	112	68	35
October	67	79	104	56	24
November	55	66	90	44	11
December	48	58	90	37	8
Annual	65	77	112	55	-3

TABLE 2.6-2

MONTHLY AVERAGE RELATIVE HUMIDITY (PERCENT) AT FORT WORTH (8 YEARS)

	Hour (CST)			
Month	00	06	12	18
January	74	81	59	58
February	72	79	57	53
March	72	80	58	52
April	76	86	60	55
May	81	89	63	60
June	74	86	56	51
July	65	79	50	44
August	70	82	53	48
September	79	88	60	58
October	76	85	54	57
November	74	82	54	58
December	77	82	61	62
Annual	74	83	57	55

TABLE 2.6-1

VALUES OF MEAN, AVERAGE AND EXTREME DAILY MAXIMUM, AND AVERAGE AND EXTREME DAILY MINIMUM SURFACE TEMPERATURE (°F) AT FORT WORTH (1931-1960)*

Month	Mean	Average Daily Maximum	Extreme Maximum#	Average Daily Minimum	Extreme Minimum#
January	46	56	88(1969)	35	4(1964)
February	49	60	87(1969)	39	12(1971)
March	56	67	91(1971)	44	19(1965)
April	65	76	89(1964)	54	31(1971)
May	73	83	96(1967)	63	42(1971)
June	82	92	101(1969)	71	51(1964)
July	85	96	105(1964)[+]	75	59(1970)[+]
August	85	96	108(1964)	75	56(1967)
September	78	89	102(1963)	68	46(1971)[+]
October	68	79	96(1963)	56	37(1966)[+]
November	55	66	88(1965)[+]	44	24(1970)
December	48	58	84(1966)	37	10(1963)
Annual	66	77	108(1964)	55	4(1964)

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* Period of record is in parentheses on this and succeeding tables except as otherwise indicated.

\# Period of record is July 1963 through 1971; year of occurrence is given in parentheses.

\+ Record also occurred in earlier year(s).

TABLE 2.6-2

MONTHLY AVERAGE RELATIVE HUMIDITY (PERCENT) AT FORT WORTH (1964-1971)

	Hour (CST)			
Month	00	06	12	18
January	74	81	59	58
February	72	79	57	53
March	72	80	58	52
April	76	86	60	55
May	81	89	63	60
June	74	86	56	51
July	65	79	50	44
August	70	82	53	48
September	79	88	60	58
October	76	85	54	57
November	74	82	54	58
December	77	82	61	62
Annual	74	83	57	55

1

TABLE 2.6-3

MONTHLY AND ANNUAL AVERAGE VALUES FOR SELECTED STATIONS NEAR THE COMANCHE PEAK SITE

Month	Dewpoint Temperature, ^{O}F(a)	Precipitation, Inches(b)	No. of Days With Precipitation $\geq$ 0.5 Inches(c)	Snow and Sleet, Inches(d)	Number of Thunderstorm Days(e)
January	31	2.0	1	1.6	1
February	35	2.2	1	0.7	2
March	40	2.5	1	0.4	4
April	51	3.6	3	0.0	7
May	59	4.6	3	0.0	7
June	67	3.0	2	0.0	6
July	67	1.8	1	0.0	5
August	69	1.7	1	0.0	5
September	67	2.5	1	0.0	4
October	58	2.6	2	0.0	3
November	42	2.5	2	T	1
December	42	2.4	1	0.2	1
Annual	52	31.4	19	2.9	45

1

(a) Based on 1970-1971 data from Fort Worth International Airport.

(b) Based on 1951-1960 data from Rainbow, Stephenville, Cleburne, Dublin and Fort Worth.

(c) Based on 1951-1960 data from Rainbow, Stephenville, Cleburne, Dublin and Fort Worth.

(d) Based on 1954-1971 data from Fort Worth International Airport.

(e) Based on 1954-1971 data from Fort Worth International Airport.

TABLE 2.6-4

ANNUAL PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	Wind Speed (Miles per Hour) 0-3	4-7	8-12	13-18	19-24	>25	Total
N	1	1	2	2	1	+	6
NNE	+	1	2	1	+	+	5
NE	1	2	2	1	+	+	5
ENE	+	1	1	1	+	+	4
E	+	1	2	+	+	+	4
ESE	+	1	2	1	+	+	5
SE	1	3	5	3	1	+	13
SSE	+	2	5	6	2	+	16
S	1	2	5	6	2	+	16
SSW	+	1	1	2	1	+	6
SW	1	1	1	1	+	+	4
WSW	+	+	+	+	+	+	1
W	+	1	+	+	+	+	2
WNW	+	1	1	+	+	+	2
NW	1	1	1	1	1	+	4
NNW	+	1	1	2	1	+	5
Calm	2						2
TOTAL	9	21	32	28	9	1	100

On Table 2.6-4 "+" indicates percentages less than 0.5 but greater than zero.

TABLE 2.6-4 (Continued)

JANUARY PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	Wind Speed (Miles per Hour) 0-3	4-7	8-12	13-18	19-24	≥25	Total
N	1	3	3	3	1	+	10
NNE	1	2	2	1	+	0	6
NE	1	2	1	+	0	0	5
ENE	+	1	1	+	0	0	2
E	+	1	1	+	0	0	2
ESE	+	1	1	+	+	0	3
SE	1	2	4	2	+	0	9
SSE	+	2	5	4	1	+	12
S	1	1	5	6	2	+	14
SSW	+	1	1	2	1	+	5
SW	1	1	1	1	+	+	4
WSW	+	+	+	+	+	0	1
W	1	1	1	+	+	0	2
WNW	+	1	1	1	+	+	3
NW	1	2	2	2	1	+	8
NNW	1	2	3	3	1	+	10
Calm	3						3
TOTAL	13	22	31	26	8	1	100

TABLE 2.6-4 (Continued)

FEBRUARY PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	Wind Speed (Miles per Hour) 0-3	4-7	8-12	13-18	19-24	≥25	Total
N	1	2	3	2	1	+	9
NNE	1	2	2	2	+	0	7
NE	1	3	2	1	+	0	6
ENE	+	1	1	+	+	0	3
E	1	1	1	+	+	0	3
ESE	+	1	2	1	+	0	4
SE	1	2	4	2	1	+	10
SSE	+	1	3	5	1	+	11
S	1	2	3	4	2	+	12
SSW	+	1	1	1	1	+	4
SW	1	1	1	1	+	+	5
WSW	+	+	+	+	+	+	1
W	1	1	+	+	+	+	3
WNW	+	1	1	1	1	+	3
NW	1	2	2	2	1	+	8
NNW	1	2	2	3	1	+	9
Calm	2						2
TOTAL	10	21	30	26	10	2	100

TABLE 2.6-4 (Continued)

MARCH PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	Wind Speed (Miles per Hour) 0-3	4-7	8-12	13-18	19-24	≥25	Total
N	1	2	3	2	1	+	8
NNE	+	2	2	2	+	0	6
NE	1	2	3	1	+	0	6
ENE	+	1	2	1	+	+	4
E	+	1	2	1	+	0	4
ESE	+	1	2	2	+	+	5
SE	+	2	4	3	1	0	9
SSE	+	1	3	6	3	+	13
S	+	1	2	5	3	1	12
SSW	+	+	1	2	1	+	5
SW	+	1	1	1	+	+	4
WSW	+	+	+	1	+	+	2
W	+	1	1	1	1	+	3
WNW	+	+	1	1	1	+	4
NW	+	1	1	2	1	1	6
NNW	+	1	2	3	2	+	8
Calm	1						1
TOTAL	6	17	29	31	14	3	100

TABLE 2.6-4 (Continued)

APRIL PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	Wind Speed (Miles per Hour) 0-3	4-7	8-12	13-18	19-24	≥25	Total
N	+	1	2	2	1	+	7
NNE	+	2	2	2	1	+	7
NE	1	2	2	1	+	+	6
ENE	+	1	1	1	+	+	3
E	+	1	1	1	+	0	3
ESE	+	1	1	1	+	+	4
SE	+	1	4	5	1	+	12
SSE	+	+	3	8	5	1	17
S	+	1	2	7	5	1	16
SSW	+	+	1	2	1	+	5
SW	+	1	1	1	+	+	3
WSW	+	+	+	1	+	+	2
W	+	1	1	+	+	+	2
WNW	+	+	+	1	1	+	2
NW	+	1	1	1	1	+	4
NNW	+	1	2	1	1	+	5
Calm	1						1
TOTAL	4	13	26	36	18	3	100

TABLE 2.6-4 (Continued)

MAY PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	0-3	4-7	Wind Speed (Miles per Hour) 8-12	13-18	19-24	≥25	Total
N	1	1	2	1	+	+	5
NNE	+	1	1	1	+	0	4
NE	1	2	2	1	+	+	5
ENE	+	1	2	1	+	+	4
E	+	1	2	+	+	+	4
ESE	+	1	2	1	+	0	5
SE	1	2	5	5	1	+	14
SSE	+	2	4	9	4	1	18
S	+	1	4	9	5	1	19
SSW	+	1	1	2	1	+	6
SW	+	1	1	1	+	0	3
WSW	+	+	+	+	+	+	1
W	+	1	1	+	+	+	2
WNW	+	+	1	+	+	+	1
NW	+	1	1	1	+	+	3
NNW	+	1	1	1	+	+	4
Calm	1						1
TOTAL	6	18	29	32	13	2	100

TABLE 2.6-4 (Continued)

JUNE PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	Wind Speed (Miles per Hour) 0-3	4-7	8-12	13-18	19-24	≥25	Total
N	+	1	1	+	+	+	2
NNE	+	1	1	1	+	+	3
NE	+	1	1	+	+	+	4
ENE	+	1	2	1	+	0	4
E	+	1	2	1	+	0	4
ESE	+	1	3	2	+	0	6
SE	+	2	6	6	1	+	16
SSE	+	2	6	10	4	+	23
S	+	2	5	9	5	1	22
SSW	+	1	2	3	1	+	7
SW	+	1	1	1	+	+	4
WSW	+	+	+	+	+	0	1
W	+	+	+	+	0	+	1
WNW	+	+	+	+	+	+	1
NW	+	+	+	+	+	0	1
NNW	+	+	+	+	+	0	1
Calm	+						+
TOTAL	4	14	32	36	13	1	100

TABLE 2.6-4 (Continued)

JULY PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	Wind Speed (Miles per Hour) 0-3	4-7	8-12	13-18	19-24	≥25	Total
N	+	1	1	+	+	0	2
NNE	+	1	1	1	+	+	2
NE	+	2	1	+	+	0	4
ENE	+	1	2	1	+	+	4
E	+	2	2	1	+	0	5
ESE	+	2	3	1	+	0	6
SE	1	4	6	4	1	+	16
SSE	+	2	7	8	1	+	19
S	+	3	8	8	2	+	21
SSW	+	1	3	3	1	+	9
SW	1	2	3	2	+	0	6
WSW	+	1	1	1	+	0	2
W	+	+	+	+	+	0	1
WNW	+	+	+	+	+	0	1
NW	+	+	+	+	+	0	1
NNW	+	+	+	+	+	+	1
Calm	1						1
TOTAL	5	21	39	29	6	+	100

TABLE 2.6-4(Continued)

AUGUST PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	0-3	4-7	Wind Speed (Miles per Hour) 8-12	13-18	19-24	≥25	Total
N	+	1	1	+	+	0	2
NNE	+	1	1	1	+	0	3
NE	1	2	1	+	+	+	4
ENE	+	2	2	1	+	0	5
E	1	2	2	1	+	0	5
ESE	+	2	3	1	+	+	7
SE	1	4	8	5	+	0	17
SSE	+	2	8	8	1	+	21
S	+	3	9	6	1	+	19
SSW	+	1	2	2	+	+	6
SW	+	1	2	1	+	+	5
WSW	+	+	+	+	0	0	1
W	+	+	+	+	0	0	1
WNW	+	+	+	+	+	0	1
NW	+	+	+	+	0	0	1
NNW	+	+	+	+	+	+	1
Calm	1						1
TOTAL	6	22	42	26	3	0	100

TABLE 2.6-4 (Continued)

SEPTEMBER PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	Wind Speed (Miles per Hour) 0-3	4-7	8-12	13-18	19-24	≥25	Total
N	1	1	1	1	+	0	4
NNE	1	2	2	1	+	+	6
NE	1	4	3	1	+	0	10
ENE	1	2	2	1	+	0	5
E	1	3	4	+	+	0	8
ESE	+	2	4	1	+	+	8
SE	1	4	8	3	+	0	16
SSE	+	2	6	5	1	+	15
S	1	2	5	5	1	+	14
SSW	+	1	1	2	+	0	4
SW	1	1	1	+	+	+	3
WSW	+	+	+	+	0	0	1
W	+	+	+	+	+	0	1
WNW	+	+	+	+	+	0	1
NW	+	1	+	+	+	0	2
NNW	+	1	1	+	+	0	2
Calm	2						2
TOTAL	9	26	40	22	3	+	100

TABLE 2.6-4 (Continued)

OCTOBER PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	Wind Speed (Miles per Hour)						
	0-3	4-7	8-12	13-18	19-24	≥25	Total
N	1	2	2	2	+	+	7
NNE	1	2	2	1	+	+	5
NE	1	3	1	+	+	0	6
ENE	+	2	1	+	+	0	4
E	1	2	1	+	+	0	4
ESE	1	2	3	+	+	0	6
SE	1	5	7	3	+	+	17
SSE	+	2	6	4	1	+	13
S	1	2	4	4	1	+	13
SSW	+	1	1	2	+	+	4
SW	1	1	1	1	+	0	4
WSW	+	+	+	+	+	0	1
W	+	1	+	+	+	0	2
WNW	+	1	+	+	+	+	2
NW	1	1	1	1	+	+	5
NNW	+	1	2	1	+	+	5
Calm	3						3
TOTAL	13	28	34	20	4	1	100

TABLE 2.6-4 (Continued)

NOVEMBER PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	Wind Speed (Miles per Hour) 0-3	4-7	8-12	13-18	19-24	≥25	Total
N	1	2	2	2	1	+	9
NNE	1	2	2	1	+	+	6
NE	1	3	1	+	+	0	6
ENE	+	1	1	+	0	0	3
E	1	2	1	+	+	0	4
ESE	+	1	1	+	0	0	3
SE	1	4	3	1	+	0	9
SSE	+	2	4	5	1	0	12
S	1	2	5	5	2	+	15
SSW	+	1	1	2	1	+	5
SW	1	1	1	1	+	+	4
WSW	+	1	+	+	+	0	2
W	1	1	+	+	+	+	2
WNW	+	1	1	1	+	+	3
NW	1	2	1	1	1	+	6
NNW	1	2	2	2	1	+	7
Calm	4						4
TOTAL	15	26	27	23	7	1	100

TABLE 2.6-4 (Continued)

DECEMBER PERCENT FREQUENCY DISTRIBUTION OF WIND AT LOVE FIELD (1951-1960)

Wind Direction	Wind Speed (Miles per Hour) 0-3	4-7	8-12	13-18	19-24	≥25	Total
N	1	2	2	2	1	+	8
NNE	+	1	1	1	+	+	4
NE	1	1	1	1	+	0	4
ENE	+	1	1	+	+	0	2
E	+	1	1	+	+	0	2
ESE	+	1	1	1	+	+	3
SE	1	3	3	2	+	0	9
SSE	+	2	5	5	1	+	14
S	1	2	4	5	1	+	13
SSW	+	1	2	2	1	+	6
SW	1	2	1	1	+	0	5
WSW	+	1	+	+	+	+	2
W	1	1	1	1	+	+	4
WNW	1	1	1	1	+	+	5
NW	1	2	2	2	1	+	9
NNW	+	2	2	3	1	+	8
Calm	2						2
TOTAL	12	24	29	27	7	1	100

TABLE 2.6-5

Joint Wind Frequency Distribution - 9.14 Meter Level
Stability Class: Pasquill A
Data Period: 72051511 to 73030111

Comanche Peak Steam Electric Station

Wind Sector	Wind Speed Categories (Meters per Second) 0.5-1.5	1.6-3.0	3.1-5.0	5.1-7.5	7.6-10.0	>10.0	Total	Mean Speed
N	0	8	11	0	0	0	19	3.18
NNE	2	8	6	0	0	0	16	2.58
NE	2	13	6	0	0	0	21	2.77
ENE	2	1	1	0	0	0	4	2.08
E	1	13	8	0	0	0	22	2.75
ESE	4	22	29	3	0	0	58	3.12
SE	1	18	33	0	0	0	52	3.28
SSE	2	15	42	4	0	0	63	3.53
S	3	18	56	7	0	0	84	3.67
SSW	1	8	31	3	0	0	43	3.77
SW	0	7	3	3	0	0	13	3.46
WSW	2	8	3	0	0	0	13	2.41
W	0	3	2	0	0	0	5	2.64
WNW	1	2	0	0	0	0	3	1.65
NW	0	3	2	0	0	0	5	2.53
NNW	0	4	4	0	0	0	8	3.04
CALM							0	
TOTAL	21	151	237	20	0	0	429	3.27

TABLE 2.6-5 (Continued)

Joint Wind Frequency Distribution - 9.14-Meter Level
Stability Class: Pasquill B
Data Period: 72051511 to 73030111

Comanche Peak Steam Electric Station

Wind Sector	Wind Speed Categories (Meters per Second) 0.5-1.5	1.6-3.0	3.1-5.0	5.1-7.5	7.6-10.0	>10.0	Total	Mean Speed
N	0	1	0	0	0	0	1	2.01
NNE	0	2	1	0	0	0	3	2.60
NE	0	1	1	0	0	0	2	2.86
ENE	1	2	0	0	0	0	3	2.01
E	0	1	3	0	0	0	4	2.99
ESE	1	6	11	2	0	0	20	3.53
SE	0	3	9	2	0	0	14	3.81
SSE	1	5	21	4	0	0	31	4.13
S	1	1	8	3	0	0	13	4.27
SSW	1	0	8	1	0	0	10	3.92
SW	0	1	2	2	0	0	5	3.96
WSW	0	0	1	0	0	0	1	3.65
W	0	0	0	0	0	0	0	0.
WNW	0	0	0	0	0	0	0	0.
NW	0	1	0	0	0	0	1	2.39
NNW	1	1	1	5	0	0	8	4.81
CALM							0	
TOTAL	6	25	66	19	0	0	116	3.83

TABLE 2.6-5 (Continued)

Joint Wind Frequency Distribution - 9.14-Meter Level
Stability Class: Pasquill C
Data Period: 72051511 to 73030111

Comanche Peak Steam Electric Station

Wind Sector	Wind Speed Categories (Meters per Second) 0.5-1.5	1.6-3.0	3.1-5.0	5.1-7.5	7.6-10.0	>10.0	Total	Mean Speed
N	1	1	10	5	0	0	17	4.58
NNE	2	1	3	0	0	0	6	2.51
NE	0	6	3	0	0	0	9	2.88
ENE	0	0	3	0	0	0	3	4.16
E	0	4	3	0	0	0	7	2.57
ESE	0	9	12	2	0	0	23	3.53
SE	0	7	8	3	0	0	18	3.52
SSE	0	8	26	12	0	0	46	4.17
S	2	6	20	9	0	0	37	3.93
SSW	0	7	4	4	0	0	15	3.60
SW	0	3	4	1	0	0	8	3.36
WSW	0	1	1	0	0	0	2	3.39
W	0	0	2	0	0	0	2	4.07
WNW	0	0	0	0	0	0	0	0.
NW	0	1	2	3	0	0	6	4.59
NNW	1	0	7	4	1	1	14	6.44
CALM							1	
TOTAL	6	54	108	43	1	1	214	3.95

TABLE 2.6-5 (Continued)

Joint Wind Frequency Distribution - 9.14-Meter Level
Stability Class: Pasquill D
Data Period: 72051511 to 73030111

Comanche Peak Steam Electric Station

Wind Sector	Wind Speed Categories (Meters per Second) 0.5-1.5	1.6-3.0	3.1-5.0	5.1-7.5	7.6-10.0	>10.0	Total	Mean Speed
N	3	25	61	46	17	2	154	4.87
NNE	11	46	44	5	2	0	108	3.03
NE	13	37	23	1	0	0	74	2.46
ENE	12	22	21	0	0	0	55	2.51
E	10	32	16	0	0	0	58	2.44
ESE	8	53	43	8	0	0	112	3.03
SE	13	84	50	15	0	0	162	3.05
SSE	13	55	111	47	0	0	226	3.81
S	7	38	102	58	5	1	211	4.43
SSW	5	15	34	26	10	0	90	4.46
SW	8	15	23	15	9	0	70	4.31
WSW	7	9	8	3	3	0	30	3.52
W	3	8	6	3	3	2	25	4.40
WNW	2	15	11	5	4	0	37	3.82
NW	5	12	20	26	4	1	68	4.62
NNW	2	19	81	74	22	14	212	5.64
CALM							10	
TOTAL	122	485	654	332	79	20	1702	3.96

TABLE 2.6-5 (Continued)

Joint Wind Frequency Distribution - 9.14-Meter Level
Stability Class: Pasquill E
Data Period: 72051511 to 73030111

Comanche Peak Steam Electric Station

Wind Sector	Wind Speed Categories (Meters per Second) 0.5-1.5	1.6-3.0	3.1-5.0	5.1-7.5	7.6-10.0	>10.0	Total	Mean Speed
N	15	41	46	38	27	4	171	4.63
NNE	16	27	27	2	0	0	72	2.65
NE	14	28	8	0	0	0	50	2.10
ENE	23	22	3	1	0	0	49	1.71
E	26	32	8	0	1	0	67	1.94
ESE	36	69	31	0	0	0	136	2.18
SE	44	161	116	14	0	0	335	2.75
SSE	31	133	182	66	4	0	416	3.61
S	17	80	137	102	20	2	358	4.42
SSW	8	23	31	39	11	1	113	4.73
SW	7	12	9	16	8	0	52	4.43
WSW	9	10	11	7	1	0	38	3.36
W	6	7	6	6	3	0	28	4.00
WNW	5	11	25	9	3	0	53	3.89
NW	13	36	46	26	8	4	133	4.13
NNW	4	33	76	34	16	7	170	4.70
CALM							51	
TOTAL	274	725	762	360	102	18	2292	3.57

TABLE 2.6-5 (Continued)

Joint Wind Frequency Distribution - 9.14-Meter Level
Stability Class: Pasquill F
Data Period: 72051511 to 73030111

Comanche Peak Steam Electric Station

Wind Sector	Wind Speed Categories (Meters per Second) 0.5-1.5	1.6-3.0	3.1-5.0	5.1-7.5	7.6-10.0	>10.0	Total	Mean Speed
N	12	8	12	0	0	0	32	2.26
NNE	8	7	2	0	0	0	17	1.71
NE	14	4	1	0	0	0	19	1.30
ENE	14	5	1	0	0	0	20	1.31
E	19	34	0	0	0	0	53	1.64
ESE	46	53	1	0	0	0	100	1.56
SE	48	115	17	3	0	0	183	2.10
SSE	44	111	47	5	0	0	207	2.41
S	21	75	74	24	5	1	200	3.60
SSW	8	19	36	20	2	0	85	3.86
SW	16	13	17	11	1	0	58	3.31
WSW	15	18	6	4	1	0	44	2.39
W	6	9	6	1	0	0	22	2.54
WNW	10	27	12	0	0	0	49	2.32
NW	8	40	20	1	0	0	69	2.58
NNW	13	31	10	1	0	0	55	2.32
CALM							85	
TOTAL	302	569	262	70	9	1	1298	2.40

TABLE 2.6-5 (Continued)

Joint Wind Frequency Distribution - 9.14-Meter Level
Stability Class: Pasquill G
Data Period: 72051511 to 73030111

Comanche Peak Steam Electric Station

Wind Sector	Wind Speed Categories (Meters per Second) 0.5-1.5	1.6-3.0	3.1-5.0	5.1-7.5	7.6-10.0	>10.0	Total	Mean Speed
N	1	0	0	0	0	0	1	.67
NNE	1	0	0	0	0	0	1	.89
NE	1	0	0	0	0	0	1	.51
ENE	4	0	0	0	0	0	4	.98
E	5	0	0	0	0	0	5	1.11
ESE	15	5	0	0	0	0	20	1.19
SE	33	34	1	0	0	0	68	1.62
SSE	18	41	3	0	0	0	62	1.87
S	18	27	13	0	0	0	58	2.24
SSW	13	12	5	0	0	0	30	1.91
SW	11	15	2	0	0	0	28	1.76
WSW	13	16	5	0	0	0	34	1.87
W	17	14	2	0	0	0	33	1.63
WNW	11	19	5	0	0	0	35	1.95
NW	16	24	6	0	0	0	46	1.92
NNW	8	6	2	0	0	0	16	1.58
CALM							64	
TOTAL	185	213	44	0	0	0	506	1.60

TABLE 2.6-5 (Continued)

Joint Wind Frequency Distribution - 9.14-Meter Level
Stability Class: All Classes
Data Period: 72051511 to 73030111

Comanche Peak Steam Electric Station

Wind Sector	Wind Speed Categories (Meters per Second) 0.5-1.5	1.6-3.0	3.1-5.0	5.1-7.5	7.6-10.0	>10.0	Total	Mean Speed
N	33	86	140	89	44	6	398	4.42
NNE	40	92	84	7	2	0	225	2.75
NE	45	89	42	1	0	0	177	2.28
ENE	58	52	29	1	0	0	140	2.01
E	61	116	39	0	1	0	217	2.11
ESE	110	218	127	15	0	0	470	2.45
SE	141	422	236	37	0	0	836	2.64
SSE	110	370	437	138	4	0	1059	3.35
S	69	245	412	203	30	4	963	4.03
SSW	36	84	150	94	23	1	388	4.09
SW	42	66	60	49	18	0	235	3.71
WSW	46	63	35	14	5	0	163	2.74
W	32	41	24	10	6	2	115	3.07
WNW	29	74	53	15	8	0	179	3.07
NW	42	117	97	56	12	5	329	3.58
NNW	29	96	181	118	39	22	485	4.75
CALM							212	
TOTAL	924	2231	2146	847	192	40	6591	3.28

TABLE 2.6-6

PASQUILL STABILITY CLASSES

Pasquill Stability Class	Identified in Table as	Definition
1	A	Extremely Unstable
2	B	Unstable
3	C	Slightly Unstable
4	D	Neutral
5	E	Slightly Stable
6, 7	F	Moderately to Extremely Stable

TABLE 2.6-7

MONTHLY PRECIPITATION EXTREMES (INCHES) AT SELECTED STATIONS

Month	Fort Worth (1954-1971)		Cleburne (1951-1960)		Dublin (1951-1960)	
	Maximum*	Minimum*	Maximum*	Minimum*	Maximum*	Minimum*
January	3.60(1968)	0.19(1971)	2.65(1960)	0.11(1959)	3.34(1960)	0.04(1953)
February	6.20(1965)	0.15(1963)	3.34(1959)	0.78(1954)	2.16(1958)	0.52(1953)
March	6.39(1968)	0.11(1956)	4.50(1957)	0.15(1956)	2.63(1953)	0.12(1956)
April	12.19(1957)	0.92(1959)	12.19(1957)	1.38(1951)	8.42(1957)	1.62(1951)
May	12.64(1957)	1.06(1961)	8.60(1957)	2.50(1954)	10.89(1956)	2.18(1959)
June	6.94(1962)	0.40(1964)	7.55(1951)	0.03(1952)	7.08(1959)	0.10(1952)
July	6.36(1962)	0.09(1965)	3.22(1960)	0.29(1956)	7.88(1959)	0.22(1956)
August	6.85(1970)	0.02(1961)	7.85(1953)	0.02(1957)	2.54(1953)	0.02(1957)
September	9.52(1964)	0.23(1956)	6.71(1958)	0.15(1956)	3.71(1957)	0.07(1956)
October	9.22(1959)	0.20(1959)	9.60(1959)	0.05(1952)	9.42(1959)	.00(1952)
November	6.23(1964)	0.20(1970)	8.73(1952)	0.12(1955)	6.27(1957)	T (1955)
December	6.99(1971)	0.21(1955)	5.85(1960)	.00(1951)	4.11(1960)	0.12(1951)

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* Year of occurrence is given in parentheses

TABLE 2.6-8

MAXIMUM RECORDED POINT RAINFALL FOR SELECTED STATIONS IN THE REGION

	Abilene (1906-1961)		Fort Worth (1899-1961)		Waco (1941-1961)	
Duration	Amount (Inches)	Date	Amount (Inches)	Date	Amount (Inches)	Date
5 min	0.68	5/18/42	0.71	5/20/28[2]	0.75	6/5/61[3]
10 min	1.25	5/18/42	1.04	5/20/28[2]	1.15	6/5/61[3]
15 min	1.76	5/18/42	1.40	8/22/16[2]	1.55	7/18/47[4]
30 min	2.75	5/18/42	1.98	8/22/16[2]	2.35	7/18/47[4]
1 hr	3.47	7/31/11	3.35	9/5/32	3.15	6/19/47
2 hrs	4.42	5/22/08	5.59	9/5/32	4.20	6/19/47
3 hrs	4.53	5/11/28	5.99	9/4/32	4.20	6/19/47
6 hrs	6.26	5/11/28	6.93	9/4/32	4.44	5/12/53
12 hrs	6.56	5/11/28	9.04	9/4/32	4.64	5/12/53
24 hrs	6.78	5/22/08[1]	9.57	9/4/32	7.18	5/11/53[5]

1

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1. Period of record is 1886 through 1961.
2. Period of record is 1903 through 1961.
3. Period of record is 1953 through 1961.
4. Period of record is 1947 through 1961.
5. Period of record is 1894 through 1961.

TABLE 2.6-9

EXTREMES OF SNOWFALL AT SELECTED STATIONS

	Dallas (1914-1970)		Fort Worth (1898-1970)		Waco (1899-1970)	
Duration	Amount (Inches)	Date	Amount (Inches)	Date	Amount (Inches)	Date
24 Hours	7.4	1/15/64 1/16/64	12.1	1/15/64 1/16/64	13.0	2/26/24
Single Storm	7.4	1/15/64 1/16/64	12.1	1/15/64 1/16/64	13.0	2/26/24
Calendar Month	9.0	1/18	12.1	1/64	13.0	12/29*
Season	9.9	1963-64	15.3	1963-64	15.0	1929-30
Maximum Depth	7.4	1/16/64	8.2	1/16/64	13.0	2/26/24

1

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* Amount also occurred on earlier data(s).

TABLE 2.6-10

TORNADO POINT PROBABILITY WITHIN A GIVEN YEAR AT SELECTED LOCATIONS (1955-1967)

Square Location	Significance	Annual Frequency, $\bar{t}$	Probability P	Return Period (Years)
Plant Site		4.46	0.00313	320
Adjacent (East)	Area Comparison	3.54	0.00248	403
Adjacent (South)	Area Comparison	3.23	0.00241	446
Adjacent (West)	Area Comparison	2.08	0.00146	685
Adjacent (Northwest)	Maximum in Texas	5.23	0.00371	269
North of Oklahoma City	Maximum in U. S.	8.00	0.00588	170

3

TABLE 2.6-11

MEDIAN PRECIPITATION (INCHES) WITH AND WITHOUT TROPICAL CYCLONE EFFECTS AT SELECTED STATIONS IN THE REGION

	Carrollton		Corsicana		Valley Junction	
Month	With	Without	With	Without	With	Without
June	2.98	2.93	2.31	2.20	2.35	2.15
July	1.55	1.48	1.55	1.49	2.02	1.95
August	1.14	1.09	1.55	1.39	1.86	1.55
September	1.95	1.90	2.04	1.90	2.06	2.01
October	2.30	2.26	2.20	2.15	2.03	2.01

TABLE 2.6-12

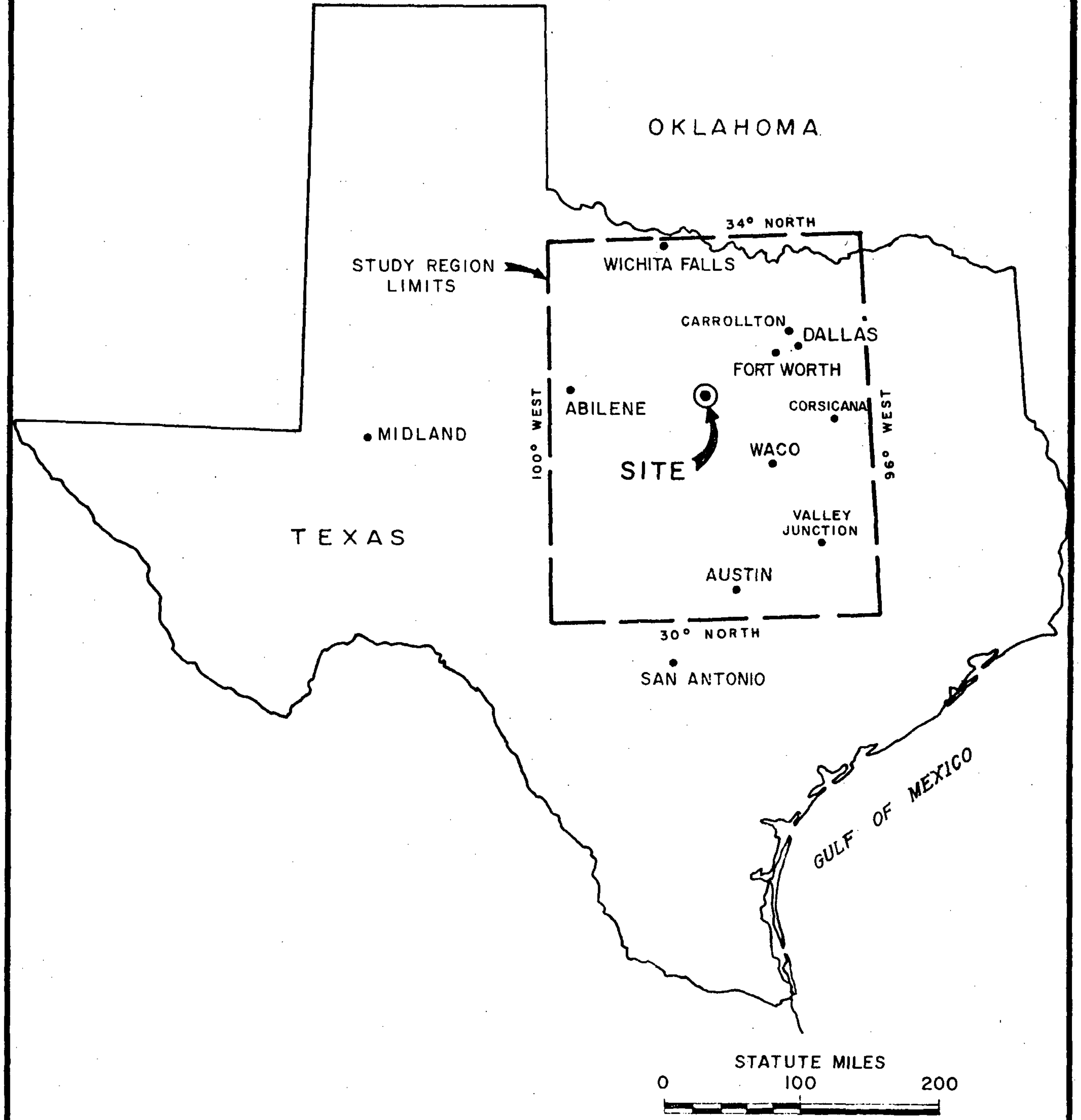
ANNUAL HIGHEST SUSTAINED WIND SPEED (FASTEST MILE) ESTIMATED FOR THE SITE AREA

Return Period (Years)	Wind Speed (Miles per Hour)
200	81
100	76
50	71
20	65
10	61
5	56
2	51

TABLE 2.6-13

MONTHLY VARIATION OF EXTREME "FASTEST MILE" WINDS (MILES PER HOUR) FOR FORT WORTH AND DALLAS

Month	Fort Worth (38 Years)	Dallas (48 Years)
January	SW 61	SW 66
February	W 61	SW 61
March	W 59	W 59
April	NW 53	N 58
May	W 68	S 65
June	NW 57	N 65
July	NW 56	N 77
August	N 49	NW 56
September	N 49	W 48
October	W 56	NW 61
November	NW 53	W 56
December	N 53	S 47
Year	W 68	N 77

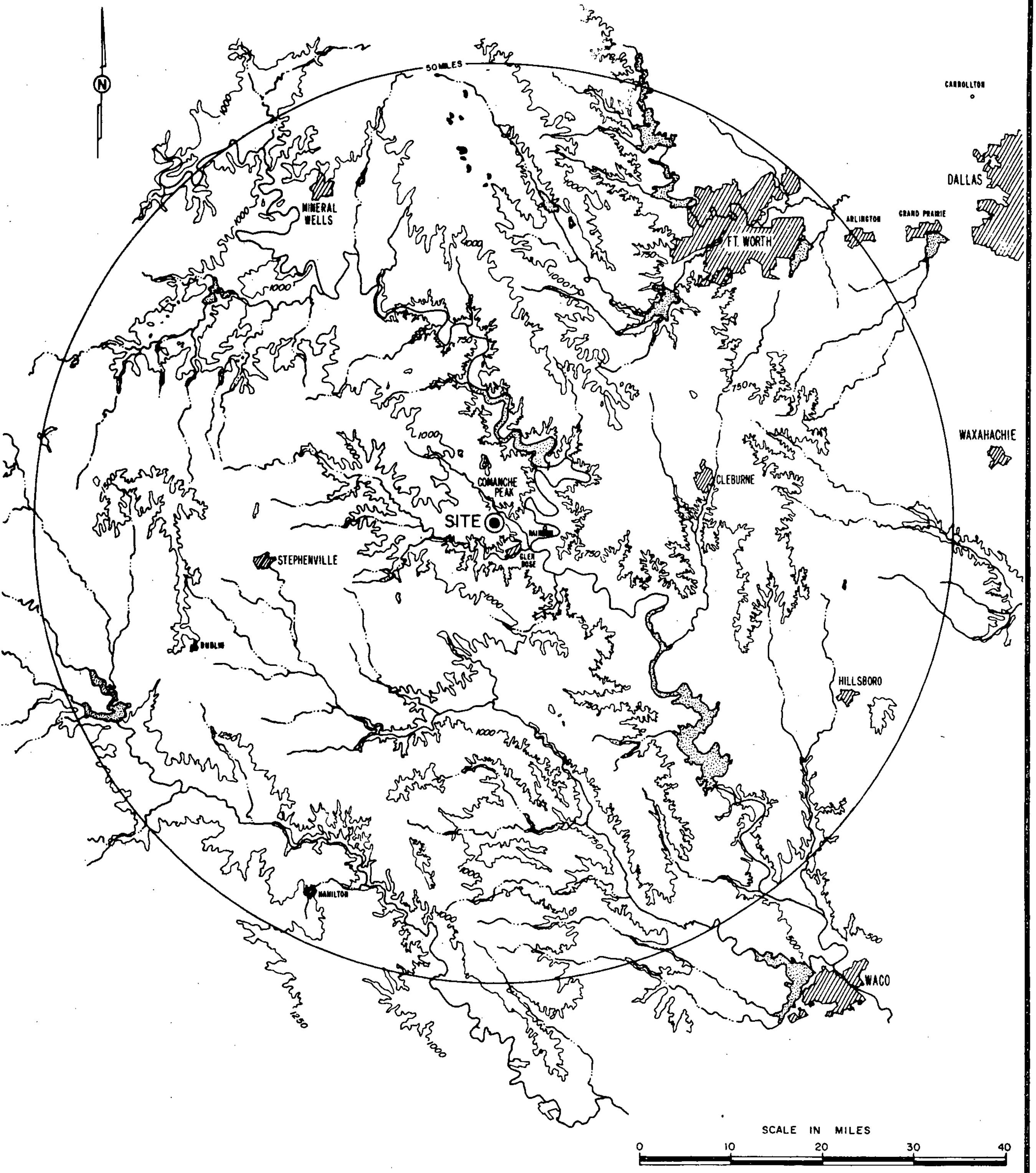


9/28/73 Amendment 1

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

CLIMATOLOGICAL STATIONS
AND REGION

FIGURE 2.6-1



COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

GENERAL TOPOGRAPHIC
FEATURES TO 50 MILES

FIGURE 2.6-2

2.7 ECOLOGY

The following information is descriptive of aquatic and vegetative communities and wildlife habitats occurring within the Squaw Creek Area. Identification of local plant, animal, and aquatic communities will be made and habitats described. Distribution of the principal components of each of the terrestrial and aquatic communities will be discussed along with the interrelationship of the individual species and their environment. Area usage, as it affects the terrestrial and aquatic community, will be considered. The relationship of food chains and the importance of particular organisms and consumer classes will also be considered. Pre-existing environmental stresses on the site area will be analyzed as they pertain to a baseline consideration of environmental impact. Succession will be analyzed from the standpoint of pre-existing environmental stresses as well as pre-history of the area, which serves to determine and shape the general trend of successional patterns. Infestations will be analyzed, as will pathogenic organisms occurring within the site area which serve to affect succession and stress occurring within the community.

2.7.1 VEGETATION

2.7.1.1 Regional Vegetational Background

Within approximately fifty miles surrounding the CPSES site, there is a preponderance of naturally occurring vegetation which groups itself into three distinct regional vegetation forms: Blackland Prairie; Cross Timbers; and Juniper-Oak Savanna. The vegetation regions of Texas and the CPSES site vicinity are shown in Figure 2.7-1.

2.7.1.1.1 Blackland Prairie

The Blackland Prairie is characterized by medium-tall dense grassland. The tall to medium-tall grass prairie can be found principally in areas where soil moisture extends to greater depths in the soil profile than can be found in the short-grass prairie. Regionally, many remnants of Blackland Prairie exist, but as the result of competition from short-grass prairies and savannas, its range has become quite restricted [1]. Some restriction in the form of human development of land for agricultural purposes has also served to greatly reduce the amount of land devoted to Blackland Prairie.

The Blackland Prairie in Texas is situated in a humid climatic region. The soils have developed from chalk, marl, or other calcareous components. The dominance of the grasses in this area is, in part, explained by the fact that deciduous trees are less tolerant of salts than are the grass species.

The grassland of the Blackland Prairie is in large measure a climatic-edaphic climax vegetation type. The dominant vegetational characteristics which make the Blackland Prairie distinct from any other vegetational form are basically the grass species that are found there. Kuchler (2) has discussed the Blackland Prairie to some extent and considers it to be composed principally of andropogon and stipa species. Another interpretation, by Tharp (3), considers the prairie to be principally composed of Andropogon-Stipa-Aristida. Yet another, Carpenter (4), thinks it is composed principally of Sorghastrum nutans, which he considers to be the binding dominant.

In any case, the Blackland Prairie is composed principally of the Andropogon-Stipa community. Perhaps some of the disparity in the descriptions of it can be explained by considering that regional variations are found to occur generally east of the 98th meridian.

The dominant and subordinate species that occur in the Blackland Prairie close to the Squaw Creek site, are made up of the following components.

Dominant species of the Blackland Prairie are:

Little bluestem	(Andropogon scoprius)
Texas needlegrass	(Stipa leucotricha)

Plants found generally in the supportive community of the Blackland Prairie within the study area include (5):

Big bluestem	(Andropogon gerardi)
Silver bluestem	(Andropogon-saccharoides)
Purple threeawn	(Aristida purpurea)
Sideoats grama	(Bouteloua curtipendula)
Hairy grama	(Bouteloua hirsuta)
Grama	(Bouteloua rigidiseta)
Buffalograss	(Buchloe dactyloides)
Switchgrass	(Panicum virgatum)
Indiangrass	(Sorghastrum nutans)
Meadow dropseed	(Sporobolus asper)

2.7.1.1.2 Cross Timbers Community

The second major vegetational component of the regional vegetation profile is best described as the Cross Timbers (Quercus-Andropogon) community type, which is composed of medium-tall grass usually found with broad leaf deciduous trees scattered in clumps throughout the community. Edaphically, the Cross Timbers vegetational community is found on sandy soils and usually in relatively small patches. At one time, the Cross Timbers community extended over most of eastern Texas.

However, as a result of agricultural development and grazing in the area, the restriction of the short grass prairies has caused this type of development to be less than it would otherwise have been under natural succession.

Located in a generally humid climatic situation, Cross Timbers vegetation is characterized by grove formations of mixed deciduous trees. The greatest densities of any woodland type in the site area are usually found to be the Cross Timbers type vegetation.

Overstory is usually dominanted by blackjack oak (Quercus marilandica) and post oak (Quercus stellata). The dominant grassland species found within the Cross Timbers is again the little bluestem (Andropogon scorpius).

The following species serve as the supportive community for the Cross Timbers vegetational type [5]:

Big bluestem	(Andropogon gerardi)
Sideoats grama	(Bouteloua curtipendula)
Hairy grama	(Bouteloua hirsuta)
Texas hickory	(Carya texana)
Hackberry	(Celtis laevigata) (also known as Texas sugarberry)
Canada wild-rye	(Elymus canadensis)
Purple lovegrass	(Eragrostis spectabilis)
Lovegrass	(Eragrostis trichodes)
Panicum	(Panicum scribnerianum)
Panicum	(Panicum virgatum)
Indiangrass	(Sorghastrum nutans)
Meadow dropseed	(Sporobolus asper)
Texas needlegrass	(Stipa leucotricha)
Elm-cedar	(Ulmus crassifolia)

2.7.1.1.3 Juniper-Oak Savanna

The Juniper-Oak Savanna (Juniperus-Quercus-Andropogon) is characterized by a dense to very open synusia, generally composed of deciduous broad-leaf trees and diminutive evergreens and shrubs, including needle-leaf evergreens, low trees and characteristic shrubs of the savanna-stand type. Savannas in general are the great grasslands of the tropics. They usually exceed in area the tall grass prairies of the temperate zone and are nearly equal to the short grasses in area. They cover large expanses of the interior of Africa and Brazil.

Savannas are characteristically found in humid climate regimes, but often they are subject to extensive dry periods. The dry periods, together with high temperatures and evaporation rates typical of tropical regions, usually hinder the development of forests; thus, the savanna maintains climatic and somewhat edaphic climax succession.

Scattered trees, usually small and scrubby, growing singly or in small groves, are characteristic of savannas found in the site area. The predominant vegetation is grass. Where the rainfall is greater or the soil conditions are such that water collection and moisture retention are greater, trees grow close enough together to form a woodland canopy. A savanna can be discerned with respect to its moisture requirements on the basis of whether tall grass or short grass predominates. In areas where tall grass is found, usually soil moisture is considerably above that noted in areas where short grasses are found.

Soil building properties of the savannas are generally considered to be not as highly highly evolved as that of the tall grass and short grass prairies. Edaphically, the savannas are far less fertile than the prairies and short grasslands and have been severely restricted in the site area as the result of agricultural development and livestock grazing. Some remnant swards, however, can be found in the site area.

Savannas become dormant during arid periods, and the scattered trees lose their leaves. As a result, fire burn over much of the grassland in these periods hinders the spread of woodlands.

The dominant vegetation found in the Juniper-Oak savanna includes [5]:

Little bluestems	(Andropogon scoprius)
Ashe juniper	(Juniperus ashei)
Live oak	(Quercus virginiana)

The plants characteristic in the supportive community of the savanna include [5]:

Big blue stem	(Andropogon gerardi)
Reverchon threeawn	(Aristida glauca)
Intermediate threeawn	(Aristida intermedia)
Purple threeawn	(Aristida purpurea)
Sideoats grama	(Bouteloua curtipendula)
Hairy grama	(Bouteloua hirsuta)
Buffalograss	(Buchloe dactyloides)
Redbud	(Cercis canadensis)
Texas ash	(Fraxinus texensis)
Curleymesquite	(Hilaria belangeri)
Red sprangletop	(Leptochloa filiformis)
Vine-mesquite	(Panicum obtusum)
Burr oak	(Quercus macrocarpa)

Texas oak	(Quercus shumardii)
Indiangrass	(Sorghastrum nutans)
Meadow dropseed	(Sporobolus asper)
Hairy tridens	(Tridens pilosus)
Prickly pear	(Opuntia rafinesquei)

The extent of the Juniper-Oak savanna within the site area is limited.

2.7.1.2 Vegetational Components of the Squaw Creek Reservoir Area

An environmental profile of the site area is presented in Figure 2.7-2.

Vegetation in the Squaw Creek Reservoir area is a direct reflection of the dominant regional vegetative types previously discussed. However, local phenomena of topography, soil moisture, soil fertility, and drainage patterns as well as external stresses introduced to the community have somewhat modified the overall vegetational pattern.

Texas A&M University was engaged to conduct a terrestrial ecological study of the site area [5]. Data from this study serves as a basis for the following discussion of the characteristic flora of the area. The report presenting the findings of this study is attached as Appendix C. The field studies were completed in December 1973 and a final report was prepared for the Applicant [190]. 2

Six predominant vegetation types were identified and are discussed below. Each vegetational type will be related to the soil in which it is found to predominate, as well as to other characteristics associated with it which make it distinct from the other vegetative types within the site.

2.7.1.2.1 Cross Timbers

The first vegetative type to be considered is the Cross Timbers type which is found to predominate essentially on sandy soils. Not a great deal of sandy soils remain out of agricultural development in the site area, so this particular vegetational group does not constitute a large proportion of the overall vegetative community.

In the western portion of the reservoir, a small stand of the Cross Timbers type was sampled and found to have a preponderance of Quercus stellata, post oak, and a large, though lesser amount, of blackjack oak (Quercus marilandica). The gum elastic (Bumelia lanuginois) was also found, although the relative frequency of this species was only four percent. Of the woody species, post oak is predominant. Rusty blackhaw is found to predominate in the understory. The ground cover was determined to be quite sparse, predominantly composed or organic litter where the overstory canopy of trees was extensive. Within what might be called meadow openings, the species found in greatest frequency include little bluestem, sand lovegrass, purple lovegrass and purple top. Simspike, threeawn and St. Andrew's cross occurred very sparsely in the sampled area. Greenbriar in Lianas as well as ground cover form was fairly widely distributed within the meadow area.

2.7.1.2.2 Cross Timbers Savanna

The Cross Timbers savanna is found to predominate on sandy soils. It is merely an extension of the Cross Timber vegetation type, with the addition of some grassland species and a little greater diversity within the tree species. The Cross Timber savanna occurs principally along the south-central fringe of the reservoir and, topographically, at contour elevations greater than 820 feet above mean sea level. The main deciduous species include blackjack oak and post oak, as well as cedar-elm. Of lesser importance, but nevertheless distributed throughout the area, are mesquite, hercules club, ash-juniper and prickly pear. There is evidence of juniper invasion as the result of cattle grazing in the area. This is especially true in the areas where cattle are found to graze under larger tree species. (Generally, juniper is an indicator of over-grazing or of the diminished carrying capacity of a particular area of land.) Important grass species found in the Cross Timber savanna include the King Ranch bluestem, which occurred in 100 percent of the plots and usually had a cover percentage of roughly 72 percent. Little bluestem, oldfield threeawn and red lovegrass were found to be important in the second sampling stand, and these are the major dominant grass species. The one dominant forb in both stands appeared to be camphorweed, a perennial composite. Another forb found was St. John's wort, fairly widely in one area, but of very little cover importance.

2.7.1.2.3 Juniper-Threeawn Uplands Cleared

The juniper-threeawn uplands vegetational form is found to predominate entirely on limestone soils. Two sampling plots were used in the study by Guthery and Synatzske [5]. The first sampling area showed evidence of having been cleared within the past twenty years, and stocked with an average of one cow for every nine acres. Junipers, including redberry and ash, as well as mesquite were found to show equal dominance in the first stand, with roughly equivalent coverage value. The frequency of these types was found to be in excess of 70 percent.

In the second stand, junipers showed greater distribution. Their frequency was 90 percent and their cover by percentage was 25.8 percent. Interesting to note here is the fact that mesquite and hackberry were of little importance in the second sampling stand. An inverse relationship between the soil horizon and the coverage by brush seems to exist throughout the vegetational type, all else being equal. That is, where there is a greater horizon of soil there is less brush coverage; where a more shallow soil, greater brush coverage.

With respect to grassland species, the perennial threeawn was dominant in the first sample, having coverage of 16.1 percent and a frequency of 80 percent. Hairy tridens, as a result of the shallower soil horizons, was distributed quite sidely in the second stand, with a frequency of 71 percent and a cover percentage of 22.4 percent. Sideoats grama was important in both of the sampled areas.

Grass species that were important in the first sample area were annual dropseed and fall witchgrass. In the second sample, silver bluestem, Texas grama, fall witchgrass, and Texas wintergrass were found to predominate and to be important. The broomweed was the dominant forb, with coverage of 15.6 and 7.2 percent in the first and second stands, respectively. Its cover percentage was 60 in both of the stands.

Within the juniper threeawn uplands, some uncleared areas are scattered throughout the reservoir area. While they are found to predominate on fairly steep slopes, they can also be found widely ranging in gangly masses on some sections of land, irrespective of topographic relief.

Forbs in uncleared areas were of little importance. The high frequency of litter in the uncleared juniper threeawn uplands is a result of the deposition of large numbers of juniper leaves.

2.7.1.2.4 Broomweed Benches

A third major vegetational type are broomweed benches, which are found to grow predominantly on hillsides in limestone soil or in limestone layers weathered out into shallow, pan-like surfaces. The dominant woody species found in the broomweed benches is the mesquite, occurring on roughly 80 percent of the transects, and generally having about 11 percent ground surface cover. It is interesting to note that roughly 86 percent of the land was open ground. Plant species for which the area was sampled include common broomweed, the main species for the vegetational type, and the narrow leaf sumpweed. The broomweed had an average cover of 28 percent and a frequency of 69 percent, while the sumpweed had coverage of 26 percent and a frequency of 84 percent. Guthery [5] noted that the composition and dominance of grass species was quite variable on broomweed benches; however, the common broomweed is always an endemic high-cover value species.

2.7.1.2.5 Juniper-Hair Grama Slopes

Juniper-hairy grama slopes, the fourth major vegetative type, is found to occur throughout the reservoir area on limestone-marl formations. Usually located below the broomweed benches topographically, the soil characteristic of the juniper-hairy grama slopes is thin and rocky. Shrub species that were found in great dominance were the ash and redberry junipers, with a frequency of 100 percent and cover value of 32.2 percent. Mesquite was rare on juniper-hairy grama slopes and was represented by somewhat dwarfed individuals. Juniper is considered to be a sub-climax stand type, though it may be a climax stand type as a result of topo-edaphic characteristics.

In this area, roughly 70 percent of the ground was exposed, having no vegetative cover. The hairy grama was found to be the dominant grass, and had an average cover of 8 percent and frequency of 49 percent. Perennial threeawn and tall grama were also found to be important. However, no forbs formed a significant portion of the vegetative community.

2.7.1.2.6 Riparian Vegetation

Riparian vegetation types were found to occur in the reservoir site, principally on alluvial soils. They may be subdivided into two classes: lower and upper riparian types.

Lower Riparian: The lower riparian community occurs along Squaw Creek at elevations less than 725 feet. The alluvial soil, a mixture of limestone and sand components, is generally considered to be a sandy loam.

Two sample plots were established [5]: the most important shrub or overstory tree was cedar-elm in the lower riparian. Burr oak was found to occur in the first sampled plot, but was absent in the second. Important species in the overstory, in addition to burr oak and cedar-elm, were the junipers, pecan, American elm and various ashes. Twenty-eight species occurred in the understory. In descending order of importance these include juniper, cedar-elm, American beautyberry, pecan, hackberry, soapberry and roughleaf dogwood. Lianas in the form of Virginia creeper, poison oak, and wild grape were found to occur on one-quarter of the trees encountered in the first sampling area. The ground cover vegetation of the lower riparian is distinctive in that it exhibits the greatest degree of diversity of floristic elements. While the diversity is extremely high, the density is quite variable for plots along the lower riparian section.

Upper Riparian: The second major component of the riparian is the upper riparian vegetational type. A gradual change from the high density lower riparian stands to the moderate and less dense upper riaprian stands is characteristic. The density of trees and shrubs decreases, composition changes extensively, and the range of certain species is exceeded as a result of decreased water availability. Densities of individual types within the upper riparian were the lowest of any woodland community on the study site. The overstory and understory were dominated principally by cedar-elm. Junipers, burr oak, pecan, and soapberry were important in Stratum A. Mesquite was secondarily important in Stratum B. Lianas included grapes, Virginia creeper, poison oak, and ivy treebine occurring on roughly 30 percent of the trees found within the sample area. Mesquite was found to have a relatively unimportant value in some of the sites in the lower riparian, though in some sites mesquite provided both overstory and understory vegetation. Mesquite had major stand importance in the upper riparian.

2.7.1.2.7 Disturbed Sites

Certain species within the proposed reservoir environs are characteristic and were found to predominate in disturbed areas. They occur irrespective of soil, time, profile, or moisture conditions. Within this particular area Texas bull-nettle is usually the first species to become abundant following disturbance. It is an invader species. Others found in common association with Texas bull-nettle include devilsclaw, snow-on-the-mountain, one seed croton, Buffalo-burr, Texas croton, Leavenworth eryngo, euphorbias, and western ragweed.

Knotroot bristlegrass was the most abundant species, occurring in 100 percent of the disturbed area sample plots, covering on the average 50 percent of the ground surface. One seed croton was the predominant forb, followed in importance by Texas bull-nettle, common sunflower, and western horse-nettle.

2.7.1.3 Pre-existing Environmental Stresses

Stresses to the environment which have long been a part of the ecology of the Squaw Creek area can be grouped into two main types:

1) Naturally occurring stresses: these include meteorological phenomena, grazing pressure from wildlife and non-domesticated animals, infestations of disease, insects, fire, and other factors.

2) Man-made stresses: these include grazing pressure from domestic cattle maintained in enclosures, road building and urban construction together with agricultural tillage, the use of chemical agents (herbicides and pesticides), and clear-cutting of pipeline corridors.

These pre-existing environmental stresses tend to alter the environment and given an indication of the baseline condition from which the species-environment interrelationship is determined.

2.7.1.3.1 Natural Stresses

Meteorological Phenomena: Air and soil moisture fluctuations are an ever-present stress, both regionally and at the CPSES site. The availability of water plays a dominant role in controlling distribution of shrub species. Hardy wood shrubs are able to survive even though the available water quality is low. Because the water supply controls the establishment, survival, and productivity of shrubs in this arid region, the boundaries of prairies and the deserts change frequently. In zones where rainfall is limited, and widely variable in distribution, the boundaries between arid and semi-arid areas are transition zones rather than distinct lines marking abrupt changes in species or plant associations. The successional pattern dictated by water distribution in the area will be considered in Section 2.7.1.4

Solar radiation and insulation also play a role in the effect of meteorological phenomena on naturally-occurring stresses. The availability of solar energy in large measure dictates the amount of vegetation that develops in a particular area. The CPSES site is subject to fluctuations of solar radiation intensity from a low of 250 langleys in January to a high, in July, of 600 langleys. This fluctuation in solar radiation intensity serves, in large measure, to bring about the diversity of vegetation that occurs seasonally throughout the site area. Thus, two elements combine: water availability and solar radiation. These, playing their part on the environment, essentially dictate certain plant species.

A third, and somewhat more subtle, stress of a meteorological nature occurring as a natural stress to the environment is the effect of wind. Wind ablation on the site area serves to dessicate the land even during periods when water is plentiful. Thus, wind tends to reduce available moisture at the site, thus limiting some vegetational types occurring on buttes and summits of steep hills and slopes.

These meteorological phenomena work together to shape the general character of the vegetation found at the CPSES site.

Grazing Pressure: A second major category of naturally occurring environmental stress is that of grazing pressure by non-domestic animals. Sometimes overlooked, this stress plays a subtle role in the shaping of the various plant communities in particular locales. There are some indications that the carrying capacity of the area may be more extensive than would at first seem to be the case. Specifically, the most important single use of vegetation, and in particular shrubs, is as a food or fodder for grazing animals. Although some products from shrubs are used by humans directly, most are available to man through direct animal production, whether domestic or non-domestic.

It is well known that range sites strongly influence the species of plants that grow in a particular region. This is a characteristic feature of the Squaw Creek area. The palatability of one plant species is strongly influenced by the availability of other palatable species growing next to it or in association with it.

Such factors as rainfall, temperature, plant composition and past grazing practices influence vegetation composition. These same factors and developmental stages influence consumption of various species. Table 2.7-1 includes specific species occurring within the various vegetative zones; outlines the nutritive value, or source of nutrition, from the individual species; and notes the grazing potential and other information with respect to projected carrying capacity of the individual species. The characteristic grazing practice needs to be considered in the forage value table so that an approximation of particular animal species utilizing the forage can be determined. Wildlife habits are important too, in determining the use by a particular species in a specific locale at the site area. The consumer class, that is, the animal species which utilize the forage located in the particular vegetative zones of the area, are also noted in the table. The palatability criteria with respect to the forage value are included for each vegetative zone. Particular emphasis has been given to each species type and its individual palatability and nutrient, or forage providing, capabilities.

An index may be determined of the "worth" of the CPSES site from the standpoint of its carrying capacity when considering the forage value afforded by the various vegetative zones. When a comparison is made of the Cross Timbers vegetation zone and the disturbed site vegetation zone, it can be observed that the former has a much higher forage value than does the latter, purely on the basis of palatability and nutritive value. The disturbed site zone contains five poisonous range plant types and has four other species of plants which afford no nutritive value. In contrast, the Cross Timbers vegetation zone contains only one species that offers no nutritive value and no poisonous range plant species.

The interrelationship of the wildlife with the forage value of each vegetation or habitat zone will be discussed in Section 2.7.2.

<u>Infestations</u>: Infestations of disease pathogens and insects are an ever-present stress to the vegetative community. Disease pathogens, in particular, serve to lower the productivity of an area as well as to diminish the general biomass output of any particular range of vegetation on which they are found to occur. In a similar manner, insects can cause massive damage in a relatively short time to the vegetational communities which they find as host organisms.

As a secondary effect, infestations of pathogens and insects serve to reduce the forage output of the vegetative zones. This reduces the carrying capacity of the area, by eliminating some nutritive value which would otherwise be available to wildlife, and makes the area less inviting to wildlife species. As an example of the widespread diversification of pathogen and insects on species in the area, a table has been made showing infestations on the dominant tree species of Hood and Somervell Counties (Table 2.7-2). In this table, six predominant tree species in the CPSES site area have been selected for critical analysis. The analysis takes the form of a determination of the particular insect pests to the individual tree species, as well as the individual pathogens which are found to hinder the development of these tree species. Table 2.7-2 shows the far-reaching scope of the insects and pathogens that are likely, or are at present occurring, in the Squaw Creek area. Essentially, the dominant forage species in the area and the insect pests and pathogens associated with those forage species are co-existing at all times.

Another infestation of a rather specialized nature is naturally occurring fire. Historically, fires are thought to have an important role in suppressing deciduous vegetation on native grasslands. Some proponents argue that fire does not play a particularly important role but that climate has the major role in controlling brush and other forms of deciduous vegetation. In the site region, if fire has influenced the make-up of brush and shrubs, it has been a relatively minor factor. During the past 50 years, with overgrazing, its effect has been somewhat masked by the climate and the attenuated successional patterns in brush communities. Thus fire, of itself, is not a particularly potent agent in the regional succession pattern.

Fire, however, is a naturally occurring pre-existing environmental stress and can have a significant influence on local development patterns. In particular, studies of the effects of fire have been made on several species found within the CPSES area.

The effects of fire on young mesquite have been studied by Fisher [47], who found that it was effective in controlling seedlings of mesquite of less than one year old. Mortality of 31 percent of the young plants was noted, though no plants older than one year were killed by burning. Tree dating indicates that fire density will affect mortality and that plants older than seedlings can be killed by high temperature fires. Nevertheless, young mesquite are found to sprout vigorously after fire. On the other hand, drought can have a devastating impact on trees and shrubs. Albertson & Weaver [23] have seen many mesquite trees, in a particular study area, believed to have been killed by the drought of the 1950s. More recently, work on sprouted trees indicate that fire and drought in combination may be quite effective in killing mesquite trees. The interaction of fire and climate is thus quite important. Fire and climate, along with good competition from grasses, appear to have a complex role in controlling mesquite.

Cactus species in Texas are not as well adapted to fire as most woody plants. Tasajillo (opuntia leptocaulis) is easily killed by fire, suffering 85 to 90 percent fire mortality. Prickly pear and Cholla are moderately harmed by fire. Heirman [26] found that, following "chaining" (removal of vegetation by dragging chains between two tractors), fire killed 40 percent of the prickly pear plants during the first growing season subsequent to burning. In an unchained area, fire killed only 22 percent of the prickly pear plants. One of the major effects of fire on prickly pear was the reduction in pad numbers; pads increased 83 percent under non-fire control conditions.

The ash juniper is especially difficult to maintain in grassland if fires occur frequently [27]. That these species are invading grasslands as the result of over-grazing, lack of fires, and competition from grasses is well documented: Bray[7], Foster[18], Miller[28], Leopold[29], Emerson[30], Parker[31], Allred[32], Humphrey[33], Jameson[34], Johnson[27], Arnold et al.[35], Blackburn & Teuller[36]. Since junipers are not fire-tolerant plants, non-sprouting junipers and shrub species generally occupy escarpments and other topographic breaks surrounded by grasslands. This is true of the reservoir site. Junipers less than four feet tall can usually be killed by fire. However, in instances where wild fires have been seen, trees in excess of twelve feet have been killed by crown fires.

Experience with communities of ash juniper indicates that a second fire within a 10-year interval will keep a grassland relatively free of juniper trees and shrubs for at least 20 to 30 years. On the other hand, redberry junipers and other sprouting species are very difficult to kill by fire. However, fires do reduce the sphere of influence of these trees. Once a tree has become established it dominates the area around it and very few forbs grow under the tree. When trees are burned but not killed, their canopy area is reduced and they dominate less area allowing grasses and forbs to take over.

Fire is a major force controlling the distribution of juniper, though drought and competition from grasses also affect its establishment. Sometimes these factors are so closely related that it is difficult to discern which is the most important.

2.7.1.3.2 Man-Made Stresses

Activities of man represent a pre-existing environmental stress which is very important to CPSES environs. The influence of man in this area has been felt since the early days of homesteading in the state of Texas. Man has molded the environment in many ways to suit his own requirements.

Environmental stress existing prior to construction of the CPSES are important because of their influence on the regional vegetation composition. This influence can be felt in the carrying capacity and nutritive value of forage, as well as in the nature of the vegetation found in any particular region. Indications of domestic over-grazing in the site are numerous. Road building and urban construction, as well as agricultural tillage within the area are very evident from aerial photographs. Chemical applications in the form of herbicides, pesticides, and fertilizers are being identified and studied as an integral part of the baseline ecological survey and monitoring programs (Section 6.1).

Grazing Pressures: Domestic cattle corralled in enclosures and allowed to graze on the open range have exerted grazing pressure on the vegetation. Grazing pressure may be seen as a pervasive influence on the site area by referring to the forage values in Table 2.7-1. An ungrazed site in the Cross Timbers may be compared with a disturbed site characterized by overgrazing. In the latter, invader species are found to occupy the area after all useful and nutritious forage has been removed by intensive grazing. The construction of enclosures for cattle grazing has relegated particular parcels of land to intensive increaser species, which are those found to develop as the result of over-grazing by cattle. They are usually considered to be low in forage value.

Mismanagement in the form of grazing pressure over many decades has drastically altered the composition of the flora. Overgrazing affects the entire ecosystem in many subtle ways. One example, cited by Guthery and Synatzske [5], includes growth of tall grass cover with the attending soil development which discourages the establishment of brush, shrub, and tree seedlings. A good cover, vegetatively speaking, burns with an intense heat and eliminates associated woody species. However, if stocking rates of livestock are kept high for too long a time the dominant grasses are the first ones to disappear and the woody species, which are not as foragable by the livestock, are the ones that remain. As a result, a grassland of relatively high productivity can be turned into a shrub-meadow vegetation type, of relatively low productivity, in a short time.

Over-grazing of the land during the last 20 to 30 years is evident by areas of extensive juniper or ash-juniper development. Overgrazing excludes some of the grassland species which would otherwise prevent the juniper invasion.

Construction & Agricultural Tillage: A second major man-made environmental stress that affects the area is that of road building, urban construction, and agricultural tillage. Road construction and road improvement exert a stress on the ecosystem by removal of productive land. Urban development and intensive use of land for housing tracts has constituted another threat to the ecosystem of the area by elimination of some of the dominant plant species found. Such an area is located near the second Brazos River bend along the transmission right-of-way.

Agricultural development of the land within the area has had far-reaching consequences. Pecan groves, and peanut, cotton and cereal grain fields have infringed on the various grassland and savanna communities that once existed in this region.

Chemical Agents: The third major man-made environmental pre-stress is that due to the use of chemical agents such as herbicides, pesticides, and agricultural fertilizers. These chemicals have a direct effect, which is elimination of the plant or insect pest for which they were designed. However, they also exert a more subtle effect on the ecosystem into which they are added. Usually herbicides and pesticides are applied to the soil and their primary effect, tailored to a particular organism, takes place. At some later time, though, the chemicals are moistened by rain or snow and the compounds then percolate through permeable soils down to the water table and may migrate to streams and rivers. Dissolved chemicals also enter the aquatic environment in the form of simple run-off which carries both soluble and insoluble herbicides and pesticides into the regional drainage pattern.

Table 2.7-3 lists the major pesticides used in Hood and Somervell Counties and indicates the nature of that use: amounts, frequencies of application, purposes, and formulations.

Table 2.7-4 lists the major herbicides used in Hood and Somervell Counties in a form similar to that presented for pesticides. The herbicides are considered for formulation, amount used, nature, and frequency of application, and the purpose of the herbicide.

The use of herbicides for weed elimination is primarily for species harmful to agricultural development, but the herbicide also tends to eliminate the possibility of growing useful forage vegetation.

Clear-Cutting of Corridors: A final pre-existing environmental stress to the vegetative community is that of clear-cutting land for corridor access. Corridors for high-pressure gas pipelines, transmission lines, oil pipelines, and water lines are examples. The successional pattern of revegetation in the area is extremely slow: for grass species, four to five years[48,49,50,51,55], and for woody species, fifteen to thirty years[52,53,54,56]. A high-pressure gas pipeline route cleared through the area some time ago is still very evident. Noted from ground observation, the vegetational cover developed over this gas pipeline is still fairly sparse.

2.7.1.4 Succession

The general pattern of succession (specifically considering each vegetational stand type in the Squaw Creek area) is an integration of natural and man-made stresses brought to bear on each plant community and reflects that community's response to those stresses.

In the case of the Cross Timbers and Cross Timber Savanna vegetation, some of the grass species are indicators of the quality and character of succession which has occurred. Little bluestem, sand lovegrass, purple lovegrass, and red lovegrass are all decreaser species. That is, these grasses were endemic and developed as the predominant prairie grasses of the site at a time prior to man's development of the area. Species of an increaser or invader nature are slim spike threeawn, oldfield threeawn, and King Ranch bluestem. These three invader species have no profitable forage value and are now occupying an ecological niche that was once delegated to productive sod-building forage grasses. This invasion of poor grazing quality grass, together with the loss of good quality grass, is a characteristic of the ingress of grazing pressures and agricultural usage of native prairie and savanna types.

Another indicator of the successional trend within the area is the development of woody, herbacious vegetation. In a pristine prairie, wide expanses of grassland are interrupted only intermittently by tree canopy covers. Characteristically, the tree canopies are found near watercourses where the available moisture supports their development. In the Squaw Creek area, the development of herbacious woody vegetation, in the forms of shrubs and trees, has taken a path such that this vegetation dots most of the area; grassland has been broken up by the woody vegetation, a direct result of increased grazing pressures. Removal of productive prairie grasses by livestock and wildlife has allowed herbacious seedlings and shrubs to establish themselves in the once continuous prairie grassland ecosystem.

A further illustration of successional development resulting from over-grazing is a comparison of the disturbed site vegetation type with that of the Cross Timbers and Cross Timber Savanna types. On the disturbed site, under intensive grazing pressure, useful forage grasses have been removed and large numbers of relatively unproductive, non-nutritious, and in some cases poisonous, range plant species now thrive. Such vegetation as Texas bullnettle, western horsenettle, buffalo burr, devil's claw, and snow-on-the-mountain, are species that serve no useful purpose and are merely occupying the ecological niche that at one time was devoted solely to prairie type vegetation.

It must be considered, however, when viewing the successional pattern of the region, that the Squaw Creek area is within a transitional zone between the Oak Juniper Savanna, the Blackland Prairie, and the Cross Timbers grassland type. The vegetational composition of the area is therefore, somewhat unstable and tenuous. It is expected that subsequent successional patterns within the area will develop on the following order: Cross Timbers and Cross Timbers Savanna vegetation stands will gradually diminish on the site as a direct result of grazing pressure and urban development. In place of the Blackland Prairie and Cross Timbers vegetation, oak juniper vegetation will take a foothold. The juniper and redberry, in addition to the cedar-elm stand types, are found to predominate and have well established stands in the Squaw Creek area.

Plant communities usually adapt to an environment on two bases: time and area of coverage. The plant communities of the Squaw Creek Reservoir are quite different from the native vegetation types previously occurring on this site in recent as well as distant successional history. Most of the uplands, with a sandy soil, and the bottomlands, with alluvial soils, have been cleared and put into crop production. Eleven distinct plants have been introduced in the site area. King Ranch bluestem, as mentioned above, which was dominant in certain relatively abundant communities throughout the area, is a prime example of an introduced species. The common hoarhound is associated with disturbed soil in limestone upland and marl areas. Bermuda grass also occurs in patches along Squaw Creek; this grass is agriculturally cultivated in the area, and it is likely that the patches established along the creek are a result of seeds carried down one of the intermittent streams or estuaries. Bermuda grass is cultivated quite extensively in the reservoir area, as determined from on-site observation and is being used fairly extensively as a forage for livestock in the area.

The generalized successional pattern occurring in the reservoir area is in the perennial threeawn stage. That is, indicator species are threeawn, Texas grama, hairy tridents, buffalo grass or curling mesquite, and forbs (including Texas croton and prairie verbenia). This is a retrogressional stage from the first period of vegetational succession, which is a climax of tall grass prairie. The low point in the retrogressional state is bare ground. Generally, vegetation within the Squaw Creek area is currently about two-thirds of the way towards the bare ground stage and the productivity of the area has suffered considerably. The prairie becomes brushland and erosion problems develop, particularly on more severe slopes and crests.

Common broomweed is also found in the area and serves as another indicator species of the lack of productivity characteristic of the region. Common broomweed is an invader species on over-grazed land, just as is the Texas bullnettle.

Generally, those sites having a high incidence of nutritious grassland species are more closely akin to the natural vegetation that occurred on the prairie (both the Cross Timbers and Blackland) than are the sites with a large ingress of introduced species and nongrass species. Those areas which are occupied by native tree species (that is, by post oak, burr oak, Texas oak, as well as the juniper species) are indicators of the margins of the Oak-Juniper Savanna type vegetation. This successional vegetation type is less close to being the climax type vegetation characteristic of the grassland prairie ecosystem. On sites where there are large numbers of introduced or invader species, the successional pattern has depreciated to the extent that there is no longer climax vegetation on the site and to the extent that the site has been degraded or relegated to the unimportant, unproductive species affording neither good soil building capabilities nor forage value.

2.7.2 WILDLIFE

The variety of plant communities present on the CPSES site is a function of local physiography, soils, moisture and management techniques designed to increase the utilization of land for agriculture or improved rangeland or pasture. The diversity of conditions provides an environment for a variety of wildlife.

During a study of animal populations in the Squaw Creek Reservoir (SCR) area, a dramatic variation in animal speciation was observed between upland and bottomlands. Distinct habitat types of the area are the upland vegetation associated with limestone soils (juniper-threeawn uplands, broomwood benches, and juniper-hairy grama slopes), while bottomland vegetation includes those types associated with alluvium (lower and upper riparian) (Figure 2.7-1). Animal populations in upland vegetation on sandy soil (Cross Timbers and Cross Timbers Savanna) were investigated to a lesser extent because this vegetation-soil association occupies only 110 acres, approximately two percent of the entire SCR area. Analysis of mammal populations were conducted in specific representative vegetational communities [57].

"Important" wildlife species are those that have some recreational value for man, are hunted for sport, are considered rare and/or endangered, or are vital to the survival of other "important" wildlife. Each important species or taxonomic group will be identified and their inter-relationship with the environment will be discussed.

2.7.2.1 Avifauna

All birds are important as a recreational resource for bird watching enthusiasts. Birds hunted for sport include: waterfowl, bobwhite quail, mourning doves, and white-winged doves. The wild turkey has been restocked in areas of Bosque and Somervell Counties but the populations are not high enough to support a harvest. The adjacent counties of Johnson, Tarrant, Parker, and Palo Pinto permit wild turkey hunting.

Rare and/or endangered species that may include Hood and Somervell Counties in their continental range are the peregrine falcon, prairie falcon, southern bald eagle, and golden-cheeked warbler.

It is estimated that 118 species of birds are likely to derive ecological requirements from the SCR area (Table 2.7-5). The list of species in the table was derived through a review of literature on habitat requirements and distribution [58, 59, 60] and field observations [57].

A total of 118 species was observed on the study area from August to December, 1972. This includes 43 resident and 75 migratory birds [57]. The more common species were mourning doves, mocking birds, scissor-tailed flycatchers, cardinals and lark sparrows. Sandhill cranes (Gus canadensis), snow geese (Chen hyperborea), double-crested cormorants (Phalacrocorax auritus), and white pelicans (Pelacanus erythrorhynchos), were observed in migratory flights across the area.

The quantitative estimate of bird densities presented in Table 2.7-6 represent the average of a small number of censuses conducted in early November. The flocking characteristics of many species resulted in highly variable data. Confidence limits on the average number/100 acres would be high but the estimates are perhaps not meaningful in an absolute sense. They are, however, indicative of relative abundance [57]. It should be noted that in southern climes, avian density is often greatest during the winter [61] when birds are flocked together. The high density of birds, especially robins, in the bottomlands is evidence of flocking behavior.

As Table 2.7-6 indicates, robins and fringillids were the most abundant species. The high density of robins (605/100 acres) in bottomlands may be attributed to the time of census and to the habitat provided along Squaw Creek. Large flocks roosted in riparian vegetation and began flights to feeding grounds approximately one-half hour after sunrise. Some feeding flocks congregated in alluvial vegetation (Riparian and agricultural) while others continued to the uplands. Hence, the period of maximum robin activity in bottomlands and the time of census coincided. If afternoon censuses had been conducted, the density of robins in the uplands would have increased because large aggregations sought flame-leaf sumac, mistletoe, and juniper berries in this habitat type [57].

The density estimates of birds vary within habitat types and between habitat types. This difference in species density in habitat types is the result of the service supplied by the habitat to a species. Specific habitat types that were found to be important to birds include: mesquite flats, rimrock coppices, and fencelines. These habitat types are described in the following paragraphs.

Mesquite Flats. Comparatively dense stands of mesquite occur on the reservoir area where soil is relatively deep but topographic position precludes moisture accumulation. Mesquite flats are coextensive with the Upper Riparian vegetation type and are occasionally found on hilltops where soil is relatively deep and stoneless. They are also ecotonal between the vegetation of limestone and sandy sites. Texas wintergrass and common broomweed are often the dominant grass and forb [57]. Myrtle warblers, ruby-crowned kinglets, slate-colored juncos, Carolina wrens, Eastern bluebirds, Harris sparrows, and other feeding birds were frequently observed in mesquite flats. Sites with a few large pecan or live oak trees along dry ravines were consistently popular with a diversity of birds.

Rimrock Coppices. Limestone outcrops on the reservoir area are often situated so that brush clearing is impossible. Hence, outcrop vegetation is a heterogeneous mixture of woody species (live oak, gum elastic, skunkbush, elbowbush, flame-leaf sumac, and juniper) which grows in narrow bands along contour lines. Birds such as rufous-sided towhees and song sparrows, which are typically encountered in the dense brush of the Lower Riparian type, are also found in rimrock coppices. Flocks feeding in Broomweed Benches sought refuge in these coppices when disturbed [57].

Fencelines. Fenceline vegetation is an important edge habitat since it often demarks changes in vegetational usage on the reservoir area. Thick growths of juniper, shrubs, and herbaceous vegetation are usually found there. Many of the plants began from seeds brought to the fenceline by perching birds and feeding animals that disperse the seeds intact through their digestive systems. Birds that commonly associate with the fenceline vegetation are the mockingbird, slate-colored junco, cardinal, white-crowned sparrow, rufous-sided towhee, Harris sparrow, and bobwhite quail.

The principal foods of the more common birds provide a clue to their role in the food web and flow of energy. Birds of prey (hawks, eagles, and owls) are secondary or tertiary consumers that feed on macro-invertebrates, reptiles, amphibians, small birds and small mammals. In some parts of its range, the southern bald eagle feeds primarily on fish and, hence, is principally a tertiary consumer. Carrion feeders include the turkey vulture and raptores. Birds that are secondary consumers feeding almost exclusively on invertebrates include some shorebirds, cuckoos, whip-poor-wills, nighthawks, swifts, flycatchers, wrens, kingbirds, phoebes, swallows, gnatcatchers, kinglets, and some of the vireos and wood warblers. Besides invertebrates, the roadrunner feeds on reptiles, small birds, and mammals. Most other birds are primary and secondary consumers with plant and animal food in their diet. Examples include: waterfowl, quail, turkey, shorebirds, woodpeckers, larks, blue jays, crows, chickadees, tit-mice, nuthatches, creepers, thrashers, thrushes, pipits, waxwings, starlings, some vireos, some wood warblers, meadowlarks, blackbirds, orioles, tanagers, grosbeaks, finches, and sparrows [62].

In the SCR area, many plants produce fruits that serve as food for birds. These include: grape, gum elastic, juniper, hackberry, American beautyberry, roughleaf dogwood, greenbrier, elbowbush, agarito, mistletoe, flame-leaf sumac, and rusty blackhaw. Juniper berries and hackberries are relished, as indicated by their frequent presence in bird droppings [57]. The mast produced by oaks and pecan is also important in the diet of avifauna.

2.7.2.1.1 Waterfowl

Waterfowl as winter residents are not common to the Squaw Creek area. However, many waterfowl following the Central Waterfowl Flyway may pass near, as well as over, the Squaw Creek watershed. The flyway has been subdivided into corridors by Bellrose [63]. The migratory pathways over the SCR area are described below.

The mid-plains corridor is used by about 700,000 dabbling ducks annually and extends from western Saskatchewan to the Texas Gulf Coast between Galveston Bay and Corpus Christi. An approximate estimate of 43,000 mallards winter in the northern part of Texas, though most of the other species of dabbling ducks winter along the Texas coast. The diving ducks use a corridor passing over SCR and extending "...from western Manitoba and eastern Saskatchewan to the Texas coast below Matagorda Bay" [63]. Ninety-five percent of the approximate 450,000 divers using this corridor are redheads. Canvasbacks and lesser scaup ducks represent most of the remaining five percent of the diving ducks that reach their wintering grounds along the Gulf Coast via this corridor. Canada geese may follow a very narrow corridor extending through Texas' Cook County, in the north, to the Gulf Coast above and below Corpus Christi.

Squaw Creek and stock ponds nearby are used by waterfowl, primarily dabbling ducks like the mallard, pintail, and shoveler (Table 2.7-5). Migratory flights of snow geese were recorded traversing the SCR area in the fall of 1972 [57].

2.7.2.1.2 Bobwhite Quail

The bobwhite quail is an important species from which economic, sport, and recreational values are dervied by many people. Ranch owners may obtain economic benefits by leasing hunting rights. Stores, restaurants, and motels may receive economic benefits when ammunition, clothing, food or lodging is purchased by the hunter.

The bobwhite quail is presently distributed in Texas east of an imaginary line following the west Texas Panhandle-New Mexico border south to the Rio Grande River. Populations of quail do exist west of this line, but limited rainfall is an inhibitive factor [64].

The density of bobwhite quail was estimated in the SCR area by plotting on a large-scale map the locations of all coveys observed [57]. Sixty-six bobwhite conveys were observed during the summer and fall of 1972. The density of bobwhite was estimated to range from 17 birds/100 acres to 40 birds/100 acres on the southern half of the reservoir area. The northern half of the reservoir area was not examined in great detail [57].

Bobwhite quail were counted by Texas Parks and Wildlife Department personnel along chosen roads in numerous counties in Texas. The number of bobwhite quail observed per mile in Hood and Somervell Counties and three adjacent counties (Bosque, Johnson, and Erath) is presented in Table 2.7-7. On the basis of these observations, populations seemed to have declined in Bosque County from 1968 through 1971 and increased from 1967 to 1970 in Erath County. Hood, Somervell, and Johnson County populations fluctuated from year to year. Populations will fluctuate from year to year and season to season with habitat changes, changes in mortality caused by natural and man-made factors (hunting, habitat manipulation), and changes in nesting success caused by favorable or unfavorable climatic conditions. The following example shows the typical annual fluctuation in a bobwhite population during 1966-1967 from the combined counties of Bosque, Hill, Hood, and Johnson [65]. A spring (February, 1966) census of 282 quail was compared to a census of the adult segment (200 quail) of the fall (November, 1966) population to estimate a natural mortality in adults of 29 percent.

A census of 773 bobwhite quail during the fall (November, 1966) resulted in an estimate of 573 (74 percent) young recruited into the population. A comparison of the pre-season (November, 1966) census of 773 total quail, a post-season (February, 1967) census of 480 quail provided an estimate of a 38 percent harvest. The estimate agrees closely with the known harvest of 39.8 percent. Hence, the population of bobwhite quail on the census areas in the four counties fluctuated in numbers from 282 in the spring, to 773 in the fall, to 480 in the following spring.

The values demonstrate the annual adjustment in populations resulting from changes in mortality and natality rates. Recruitment can fluctuate to levels higher and lower than shown in this example.

The age and sex composition of a game population provides information concerning the recruitment of young into the population prior to a hunting season, and the ability of the population to maintain itself. The sex composition of bobwhite quail which were collected in the Squaw Creek Reservoir area was 14 males/ 5 females. In this small sample, juveniles outnumbered adults by an 8:1 ratio, indicating highly produtive quail range. Bobwhite quail wings were gathered from hunters in Bosque, Hill, Hood, and Johnson Counties during the 1964-1965 and 1965-1966 regular hunting seasons [65,66,67]. The wings of 1115 bobwhite in 1964-65 and 1169 in 1965-66 showed that the population contained nearly a 1:1 ratio of adult males to adult females and juvenile males to juvenile females. Juveniles accounted for 73 percent of the 1964-65 sample and 75 percent of the 1965-66 sample. The ratio of male to female quail among the adult and juvenile bobwhite quail shows a sexually stable population. The high percentage of juvenile quail is an indicator of a very productive population. The high productivity often results in a surplus of birds greater than the food supply and habitat can continually support. To maintain this carrying capacity, mortality (either man-induced or natural) will occur and remove some, all, or more than the surplus.

Weather is an important factor affecting the annual and daily biological cycles of many animal populations, including the bobwhite quail. The climate of Texas varies considerably from east to west and from north to south (refer to Section 2.6). The variability of precipitation from year to year in Hood and Somervell Counties can cause fluctuations in quail numbers by affecting nesting success, food supplies, and protective cover.

Conditions of drought or excessive rainfall during nesting and/or incubation periods (from late May to late June) can cause mortality in the clutch or early broods [68]. Drought and high temperatures in Texas in 1971 prevented normal nesting, egg hatching and brood survival until vegetation responded to mid-summer rains [69]. Excessive rain during nesting can cause "...either nest destruction, nest abandonment at hatching, or chick mortality" [68]. Too much rain during the 1970 nesting period caused nest abandonment and brood mortality in many areas of south Texas [69]. The ability of soils to drain well during excessive rains plays an important part in the survival of nests and newly hatched broods. When unsuitable weather exists during the normal nesting period, quail will nest or re-nest in mid- or late- summer when the combined factors of weather, food, and cover become more favorable.

Cover needs of the bobwhite quail vary seasonally and daily. The level of change at which cover becomes too dense or too sparse is seldom definable. However, general statements can be made concerning the quality of needed cover. "Bobwhites need these types of cover: screening overhead for concealment while feeding and moving around; tangled woody thickets, or dense patches of coarse weeds and grasses which can easily be reached when quick escape from an enemy is essential; ...cover fairly open near the ground... for resting, dusting, and the mid-day inactive period; and nesting and roosting cover" [64]. Overgrazing by livestock can have a detrimental effect on all forms of cover for the bobwhite quail. Large areas of nesting cover are required for nest dispersion and protection from predators.

Where cover is present, food must also be present to insure the existence and success of the bobwhite. Food is often most abundant where an edge exists between two or more plant communities. A high diversity of vegetation is usually present at such an edge.

Food habit studies of bobwhite quail were conducted by the Texas Parks and Wildlife Department by inspection of crop contents from 227 bobwhite killed by hunters in Wise and Hill Counties during the regular hunting season (1 December 1957 - 16 January 1958)[70]. A total of 346 quail crops was collected from hunters throughout a 29-county area (Possum Kingdom Game Management Area) during the 1958-1959 season [71]. Both Wise and Hill Counties are in the Cross Timbers and Prairie biotic provinces of Texas, whereas the entire Possum Kingdom Management Area includes portions of the Cross Timbers and Rolling Plains biotic provinces. The percent volume and frequency of occurrence of each species found in over five percent of the crops is summarized in Table 2.7-9. The most frequently found food species include: croton, Spanish clover, vetch, snakeweed, wooly croton, woolybucket burmelia, western ragweed, partridge pea, wild bean (Strophostyles spp.), gromwell, acorns, tickclover and unidentified green vegetation. Seventy-four percent of the genera of plants noted on the site area are included in Table 2.7-9. Western ragweed, acorns, and croton (Croton spp.) were common plant items in quail crops examined by all three investigators. Insects, although in trace amounts, were common in crops examined on the site [57] and in Wise and Hill Counties [70] (Table 2.7-9).

Table 2.7-10 shows an analysis of the percent nutritional content of total protein, fat, calcium, phosphorous, ash fiber, and nitrogen-free extract (carbohydrates) in items found in the diet that were represented by a large volume in the crops [70].

Mimosa and bundleflower were high in protein, snakeweed, grasshopper eggs, and western ragweed were high in fat, and western ragweed was very high in carbohydrates.

Crops and gizzards from bobwhite quail collected in the Post Oak Region in Eastern Texas have been collected and analyzed. By volume, the most important winter (February) foods were oak (Quercus spp.) and croton (Croton spp.). Oak, croton and panic grasses (Panicum spp.) were important foods in the spring, (March, April, May) with animal matter high on the list in May. The two major summer foods included animal matter and panic grasses. The number of crops or gizzards, however, varied from three to nine per month. Crops were not obtained for December and January [72]. The winter feeding habits of bobwhite in the West Cross Timbers region of Texas and Oklahoma were recorded from an examination of 25 crops [73]. The major plant species identified in the 25 crops (in descending order of percent by volume) include: post-oak acorns, wild-bean, panic grass and tick trefoil.

Invertebrates recorded were little red-legged grasshoppers, blue grasshoppers, and parts of beetles.

Foods of bobwhite quail collected in the reservoir area included at least nineteen plants, five insect orders, spiders, and snails (Table 2.7-8). Western ragweed. cedar-elm mast, common broomweed, acorns, and annual dropseed were volumetrically important in the quail diet. Green vegetation (primarily sprouting dicotyledons) was present in 84 percent of the crops. Plant and animal matter comprised approximately 97 and three percent of the diet, respectively [57].

2.7.2.1.3 Turkey

The SCR area was part of the ancestral range of the wild turkey. The increase in grazing pressure and agricultural cultivation, coupled with a decline in the forested areas were factors contributing to the decrease in native populations of turkeys. Human disturbance was another factor [74]. The possibility of restoration of the wild turkey near the confluence of the Brazos River, Paluxy River and Squaw Creek will be restricted in range by increased land development.

The wild turkey best survives where the annual rainfall ranges between 16 to 32 inches and human activity is low. Brush and timber, such as oak and pecan provide important annual foods and winter roosts. Open rangeland provides needed nesting habitat where little to moderate grazing from domestic animals occurs. A study in the Post Oak region suggests that 50 percent of a turkey's range should be open well-spaced terrain [74].

Wild turkey has the wide-ranging mobility of some mammals. They will utilize 20,000 acres or more during a year to obtain nesting cover, occasional roost sites, surface water, and other necessities [74]. Densities of wild turkey will oscillate from year to year as well as over a series of years. A decline in turkey numbers has been associated with years of drought followed by an increase in numbers with years of normal precipitation [74].

2.7.2.1.4 Mourning Dove

Mourning doves are a game bird and a permanent resident in Texas and are commercially and recreationally important. The fall season is accompanied by an immigration of mourning doves from the northern states. During the spring, migrant doves emigrate back to their nesting areas in the northern states. Hence, mourning doves increase in numbers during the fall and winter on croplands and pastures where they feed during the day and in trees where they roost at night.

The number of mourning doves observed per mile by the Texas Parks and Wildlife Department in Hood and Somervell Counties and three adjacent counties is presented in Table 2.7-11. Based on this index, fall populations declined from 1967 to 1969 and increased from 1969 to 1970 in Bosque, Johnson and Erath counties. Mourning doves increased along the Hood and Somervell County census route between 1968 and 1969, when other counties showed a decline and decreased from 1969 to 1970, when the other counties showed an increase. Although census values will vary according to climatic conditions during the census, and the period of maximum immigration from northern states, the values demonstrate the fluctuation in numbers of mourning doves from one county to another during the fall. As previously noted, mourning doves often form large flocks during the winter which can influence census values from county to county and year to year. The fall migrants respond to roosting sites and the abundance of food.

A breeding census of mourning doves by a roadside census or call counts has not been conducted by the Texas Parks and Wildlife Department. The abundance of mourning doves in the SCR area is highly variable because of the species migratory behavior. As shown in Table 2.7-6, late fall densities ranged from 12 to 19 birds per 100 acres in uplands and bottomlands, respectively. During late August, over 400 birds were observed on a 780 acre property located centrally in the study area. The vast majority of these birds were feeding in fallow farm fields adjacent to Squaw Creek. Flocks of 150 to 200 doves were occasionally seen in dense stands of western ragweed during November and December [57].

Mourning doves consumed the seeds of 14 different plants (about 99 percent of the diet) and very small quantities of insects (Table 2.7-12). The most important foods volumetrically were western ragweed, sorghum, white prickly-poppy, and oneseed croton, comprising 36.3, 13.2, and 10.0 percent of the volume, respectively. Western ragweed was present in 90 percent of the crops [57]. It is possible that the birds are selective toward plant material that is seasonally high in nutritional quality, such as western ragweed (see Table 2.7-10).

2.7.2.1.5 White-winged Doves

Three white-winged doves were observed on Panther Branch during mid-July 1972. These birds remained on the reservoir area until mid-August. The white-winged dove is a game bird important in the Rio Grande Valley of Texas, but those observed on the study area were out of their normal range [57].

2.7.2.1.6 Threatened and Important Avian Species

Table 2.7-12a lists avian species which are of special concern because they are either (i) included in <u>Threatened Wildlife of the United States</u> [75], or (ii) top carnivores. The top carnivore as used here means predators or other vertebrates, and 2 includes the vultures; it excludes such strictly insectivorous birds as nighthawks and vireos, but includes shrikes because their diet include vertebrates.

2 The birds listed in Table 2.7-12a are in many cases migrants, or move from considerable distances to forage on the affected area; consequently, it is not practicable to present meaningful data on the recruitment and/or turnover of their populations. Moreover, many are of conjectural occurrence, and listed solely because it is conceivable that they might occur. Information amplifying the table, based on the results of current investigations, is incorporated in the following paragraphs.

2.7.2.1.6.1 Prairie Falcon

2 The U.S. Department of the Interior has classified the prairie falcon as a threatened species [75]. It is an infrequent visitor throughout northern and central Texas according to Peterson [58] but none have been observed in the SCR area [57].

2.7.2.1.6.2 Peregrine Falcon

The peregrine falcon is classified as an endangered species [75]. It is a spring and fall migrant throughout Texas [58]. According to Vincent [76], the peregrine falcon breeds from non-Arctic Alaska and Canada south to Baja California, Arizona, and southwestern Texas. Reasons for the decline throughout its range include some shooting and destruction of nests, breeding failure resulting from the cumulative effects of toxic pesticides, and direct poisoning from eating prey that has assimilated excess chlorinated hydrocarbon residues [76]. This species has not been observed in the Squaw Creek area.

2 2.7.2.1.6.3 Southern Bald Eagle

According to Peterson [58] the bald eagle formerly nested (and occasionally still do so) along waterways of east and central Texas. They are a winter visitor to north Texas and the Texas Panhandle, a casual visitor to the Trans-Pecos region, and rare in the Rio Grande deltas. The diet of the bald eagle includes fish, songbirds, water-birds, small and medium-sized animals, and a few reptiles and amphibians [78].

2.7.2.1.6.4 Other Important Tertiary Consumers

2 Sparrow hawks preferred upland savanna habitat. They were present in greatest abundance as wintering and migrant birds although some are resident.

Red-tailed hawks occurred predominantly in upland situations. Nesting habitat is available in large trees of the riparian type. One red-tailed hawk nest has been observed in the uplands but its success was not monitored. The density of these birds throughout the area probably does not exceed two individuals per square mile and a realistic estimate might be less than one individual per square mile.

About four migrant rough-legged hawks were observed during March 1973. All were in upland situations.

One osprey was observed about a mile from the CPSES site during March 1973.

Owls were not encountered in abundance during the censuses but this was expected since they are nocturnal species. Great horned and screech owls have been observed in both upland and bottomland habitat. Great horned owls nested in live oak associated with limestone outcrops in the uplands. One great horned owl nest was located and the results of the monitoring of its success will be made available at a later date.

The data presented in Table 2.7-12a for black and turkey vultures have little meaning because these birds cruised throughout the area in search of carrion. It is apparent that wintering vultures outnumber resident birds. 2

Aquatic birds (kingfishers and herons) will have increased feeding habitat after the SCR is constructed. These birds were encountered along Squaw Creek and at stock ponds in the uplands. A kingfisher nest was discovered in a dirt bank along Panther Branch but it could not be monitored.

Marsh hawks were observed only in upland savanna habitat during winter and early spring. They probably do not nest on the area.

A small number of accipiters (sharp-shinned and/or Cooper's hawks) winter on and migrate through the reservoir area. They were observed in both upland and bottomland habitat with a slightly greater number in bottomlands.

Trapping results demonstrated that small-mammal abundance was about two times higher in uplands than in bottomlands. This might explain, in part, the fact that raptors were encountered in greater numbers in the uplands.

2.7.2.1.6.5 Golden-cheeked Warbler

The golden-cheeked warbler (*Dendroica chrysoparia*) is classified as threatened [75]. Its summer range is restricted to 32 counties in central Texas (K. A. Arnold, *personal communication*). This limited area includes Hood and Somervell counties. Both of these counties will be affected by development of the proposed CPSES. The warbler travels south for the winter to Southern Mexico and Guatemala [77].

A field investigation was conducted during the period 26-28 July 1973. The goal of this study was to evaluate the availability of habitat for this warbler that would be affected by construction of the CPSES. The continuing decline in numbers of this species is attributed to reduction of its breeding habitat. This bird is dependent upon areas of mature Ashe-juniper from 25 to 40 feet tall. The nest is usually constructed in the Ashe-juniper with bark from this tree interwoven on the outside. Young hatch from three to four eggs between late April and early in May and are fed a diet of insects [77].

Resident warblers were not expected on any areas studied, because the breeding population has largely dispersed by mid-July. Not even stragglers were encountered at the time of the survey. The investigation began with an intensive search of the area in Meridian State Park where golden-cheeked warblers are known to breed [180]. One nest, possibly of the golden-cheeked warbler [101,77,182], was located in a situation predicted from the literature, but no others could be found. The environment of this nest was accepted as the best representative of breeding habitat available. An attempt was made to identify unique characteristics of the warblers breeding habitat by both objective measurements and subjective impressions. The field experiences permitted a refinement to be made of the sometime contradictory descriptions of the habitat which were available in the limited literature.

Conferences with TUC personnel, and inspections of aerial photographs, led to the identification of several areas on the project site, subject to potential disruption by the CPSES, which were possibly suitable as breeding habitat for golden-cheeked
2 warblers. On visiting several of these areas, it was found
that only some met the criteria of suitability.

At this time, it is predicted that the CPSES with associated facilities such as the Squaw Creek Reservoir, transmission and rail line rights-of-way, will probably reduce the potential breeding habitat available. However, the results of the planned field surveys are required before sensitive habitat areas can be identified and possible losses estimated reliably (Section 6.1.4.3.2.2).

The transmission lines associated with the CPSES will affect directly an area of approximately 3 hectares (6 acres) which is judged to be suitable habitat for the golden-cheeked warbler.

The Squaw Creek Reservoir will have a surface (at maximum) of 3,228 acres (1,595 ha). Of this, 51 percent or about 80 ha, may be suitable as breeding habitat for the golden-cheeked warbler. However, this estimate may be lower than is actually appropriate because it is not certain to what degree other trees are accepted by the warbler and how far the warblers will nest from stands of Ashe-juniper trees. The warbler is known to nest in five species of trees other than junipers [181]. It would appear that the riparian vegetation along Squaw Creek which is scheduled to be inundated by the SCR would not be attractive to the golden-cheeked warbler [77]. 2

2.7.2.2 Mammals

Mammals occurring in the SCR area, based on literature reviews [79,80] and field observations [57] are presented in Table 2.7-13. The checklist includes 18 families comprised of 37 species. Twenty-six species have been observed on the area from August to December 1972 [57].

All mammals are important to an ecosystem by transporting energy both directly as a primary consumer and by death, and/or indirectly as prey. Mammals considered by man to be important are those useful for sport or recreation (white-tailed deer, fox squirrel, collared peccary) and those classified as endangered or rare (Texas red wolf). The Texas kangaroo rat has been under consideration for inclusion with the endangered and rare species of the United States by the U.S.D.I. pending additional information determining their status (75). In addition to those mammals classified as game species, meat of the opossum, raccoon and armadillo is occassionally eaten by man. The frequency of this, however, is not known.

Medium-sized mammals and small mammals were censused with traps in both the upland and lowland (riparian) habitats along Squaw Creek. The trapping methods and data analysis are described in Appendix B.

The food eaten by mammals provides a clue to their role in the food web and energy flow. "Mammals are primary, secondary, and mixed consumers. Certain small rodents, rabbits, deer and gophers are herbivorous. Bats and coyotes, among others, may be considered secondary consumers. Mixed consumers include foxes, ringtail cats, raccoons, skunks, cotton rats, and others" (62,80). Mammals considered important by the definition above are discussed in the following paragraphs.

2.7.2.2.1 White-tailed Deer

Davis (80) reports that the "White-tailed deer occur almost entirely in the hardwood areas within their general range, except for the southeastern section of Texas. . ."

Stevens (81) reported that the carrying capacity for deer (number of deer that the range can support continuously) in 23 counties in the East and West Cross Timbers and the Grand and North Central Prairies vegetative areas is considered to be one deer to 15 to 20 acres (32-42 deer per square mile). Holt (82) suggested that the density of deer on poor range would be near one deer per 75 acres, or 8.5 deer per square mile. The estimate takes into consideration the grazing incurred by livestock and the farm crops available to deer. Although this is an estimate for a broad management area (23 counties) it permits a comparison to deer censuses on the site in Hood and Somervell Counties.

Based on 21 deer observations during five months of field work the density of deer on the southern one-third of the Squaw Creek Reservoir area was estimated to be between two and four deer per square mile (57). The density of white-tailed deer estimated is far below the carrying capacity estimate by Holt (82) for poor range.

Residents of Somervell County indicated that no deer were present on a portion of the property as recently as 20 years ago. The improvement of pasture through the practice of brush clearing was accompanied by an immigration of white-tailed deer [57].

Table 2.7-4 compares the census of white-tailed deer along cruise lines located in Hood and Somervell counties to similar censuses in adjacent counties [83]. In order to compare those figures in the table with the estimate for the SCR site, the following guide is suggested: One deer per 10, 20, 30 and 40 acres is equivalent to 64, 32, 22, and 16 deer per square mile, respectively. Table 2.7-14 shows that deer have increased in Bosque, Johnson, and Somervell counties and decreased in Hood County from 1965 to 1970. Based on these censuses, the Erath County deer population decreased from 1965 to 1967 and then increased in 1970. The deer population in Hood and Somervell counties was near the carrying capacity of the range as established by Steven [81]. Site population estimates of the deer, although considerably lower, are for an exclusively defined population more representative of the SCR.

Mortality among deer results from hunting pressures and natural causes (primarily predation, parasites, disease, and starvation). The Texas Parks and Wildlife Department issues permits that allow a hunter to harvest two deer of either sex from mid-November to January 1 in Hood and Somervell Counties. In addition, there is an October archery season permitting the harvest of one deer of either sex.

Deer "dieoffs" involving the death of a few hundred to several thousand deer have been recorded in 1937, 1938, 1942, 1945, 1947 and 1962 [84]. With the exception of 1962, many of these "dieoffs" "...were restricted to ranches, and even to pastures within ranches..." Long term drought conditions and grazing competition with livestock depleted the available food supplies. High reproduction, and competition among deer for the limited food, caused an increase in malnutrition and subsequent "dieoff". The screwworm (Cochliomyia americana) was speculated to be the additional stress on the weak deer herds that helped cause this high natural mortality. The screwworm infestations seldom show ill-effects on healthy deer.

The density and distribution of white-tailed deer are influenced by factors such as the palatability and nutritional quality of available food, cover, and climate. In the southern states, white-tailed deer are primarily grazers rather than browsers.

Food habit studies were conducted by the Texas Parks and Wildlife Department. The contents of deer stomachs were analyzed from range in Bosque County during the period from November 16 to December 8, 1957 [70].

Studies were continued during the fall of 1958 on 24 stomachs obtained from deer killed in Bosque, Jack, and Stephens Counties [71].

Table 2.7-15 shows the frequency of occurrence of plant species found in deer stomachs in Bosque County according to Clark [70]. Live oak and post oak acorns were found in the highest percentage of the stomachs, followed by oats and browse from live oak, post oak, and Texas oak, and finally unidentified grasses. Winkler [71] reported that "...grass cedar..., and an unidentified species of mallow were the foods most readily taken" by seven deer collected in Bosque County. The deer obtained for food studies by Clark and Winkler may have been harvested from different areas of the county and may account for the difference in major plant components between the two years. Although Bosque County is adjacent to and south of Somervell County, the data presented (Table 2.7-15) may vary somewhat from the food habits of deer in Somervell or Hood counties.

Greenbrier is an outstanding deer browse and prickly pear and juniper occur frequently in the diet of deer, according to Hosley [85]. Hosley reported that other important forage plants are mesquite, hackberry, elbowbush, wildplums, crotons, agarito, possumhaw, grasses and sedges. The fruits of oaks, sumac, American beautyberry, hackberry, greenbrier, grape, possumhaw, and poison oak supplement the diet whenever they are available [86].

Flame-leaf sumac reported growing in the upland areas of Squaw Creek and oaks, grasses, and greenbrier most abundant in the Cross Timbers and riparian vegetation types represent an available food supply for the white-tailed deer [57].

The choice of food items has often been speculated to be in response to nutritional quality as well as availability.

The daily home range of a single white-tailed deer is usually less than one square mile. This range is often shared by others, particularly during the rutting season which extends from September to December [80]. Seven months later, one or two fawns are born of does at least two years of age. When food is abundant, deer often remain in one locality for a year or more. Seasonal shuffles do occur from one area to another, but on the Edwards Plateau of Texas this seldom exceed five miles [80].

Daily activities within a deer's home range includes two peaks of activity, shortly after sunrise and before sunset. Sometimes deer may feed into the night but the nights and days are usually occupied by resting and chewing the cud [80]. In south Texas, feeding and general activity patterns are not affected significantly by weather [87].

2.7.2.2.2 Opossum

The opossum inhabits deciduous woodlands, prairies, marshes, and farmlands. They are most frequently found near riparian habitats in their western range [80]. Thus the high frequency of capture in the riparian zone was expected.

The opossum was over twice as numerous as any other furbearer on the Squaw Creek Reservoir area. Davis [80] reported a high population of opossums in southeastern Texas at one per four acres when compared to an estimate of one per 31 acres in Walker County of east Texas. The opossum has a high reproductive rate and in Texas a litter of up to 14 young may be produced twice a year. Its reproductive capacity, reproductive behavior, and omnivorous feeding habits help insure its ability to outnumber other medium-sized mammals.

The omnivorous feeding habits of the opossum have adapted it to many locations throughout the eastern half of the United States. Martin [62] reports that the opossum is primarily a carnivor feeding on carrion, and consumes only a small amount of plant material. Stomach contents of 28 opossums collected from the reservoir area contained approximately equal volumes of plant and animal matter. Grasshopper fragments, feathers, pecans, and juniper were encountered with the greatest frequency. Small rodents, rabbits, beetles, carrion (domestic cattle), grapes, hackberries, rusty blackhaw berries, Johnsongrass, and oats had also been consumed [57].

Thirty-nine different foods were recorded in 25 digestive tracts and 23 fecal droppings from opossum in the Post-Oak Region of Texas [88]. Major food items throughout the year in order of their importance were: plants (acorns, persimmons, and small amounts of French mulberry, grass, grape, hackberry, and others), insects(generally unidentifiable), mammals (white-footed mouse, cottontail rabbit, cotton rat, opossum as carrion), cold-blooded vertebrates (snakes, lizards, and toads), birds, and non-insect invertebrates (spiders, millipedes, and snails).

2.7.2.2.3 Raccoon

The raccoon is distributed state-wide, and primarily inhabits broadleaf woodlands [80]. Trapping results in the SCR area indicated they were second in abundance and equally distributed between the uplands and lowlands [57]. Raccoons are usually active at night and seek shelter (den) in hollow trees, hollow logs, or crevices in rocky bluffs during the day [80].

Raccoons on the SCR area eat a variety of plant and animal foods. Gum elastic berries and grapes were favored items during late summer and early fall as indicated by their volume at scat stations. Other raccoon foods, determined from scat and stomach analysis, included small birds, grasshoppers, dragonflies (Odonata), beetles, homopterons, hymenopterons, fish, acorns, rusty blackhaw berries, pecans, mesquite beans, hackberries, juniper berries, and elbowbush berries [57].

Wood [88] identified 68 different types of foods from 47 digestive tracts and 164 fecal droppings from raccoons in the Post Oak Region of Texas. This analysis showed the annual diet to "... include 11 mammals; seven birds; three snakes; two lizards; 22 plants; 14 families of insects, ..." other invertebrates; and some unidentifiable material. Fruit of the yaupon, hackberry, grape, and deciduous holly each represented over five percent of the annual volume of food in stomachs examined by Wood. According to Martin [62], plant material represents 62, four, 18 and 42 percent of the winter, spring, summer and fall diet, respectively, of the raccoon throughout its range. Acorns and fruit of the persimmon form a significant part of the raccoon's diet in east Texas [62]. The role of the raccoon in the food web is one of a carnivore as well as a primary consumer.

2.7.2.2.4 Ringtail Cat

The stomachs of two ringtail cats taken on the SCR area contained grasshoppers in the greatest volume, followed by juniper berries, chinaberries, and feathers [57].

Ten scat samples were examined at a ringtail den in early November. Juniper berries, mesquite beans, Texas sophora beans, elbowbush berries, hackberries, prickly pear tunas, grass blades, cedar elm leaves, and persimmons (Diospyros sp.) were present in 10 scat samples collected at a single den in early November. Grasshopper fragments, beetle fragments, and mammalian hair were also found in the scats [57]. The presence of feathers and mammalian hair is indicative of their carnivorous habits.

A seasonal analysis of the food habits of the ringtail cat in the Edwards Plateau Region by Taylor [89] revealed the following: insects had the highest frequency of occurrence during the fall, followed by plant material, mammals, and birds. Mammals were the major food item during the winter followed in order by birds, insects, and plant material. The spring diet, in order of occurrence was mammals, insects, and finally birds. Insects again were of primary importance in the diet of ringtails collected during the summer. Plants, arachnids, and mammals occurred in decreasing order. Plant materials consisted of juniper berries, hackberries, Mexican persimmon, mistletoe, spectacle berry, barberry, with smaller amounts of acorns, cactus (seeds and fruit fragments) and others. Among mammals, cottontails, fox squirrels, ground squirrels, white-footed mice, cotton rats, pocket mice, wood rats, harvest mice, deer (doubtless carrion), bats, domestic sheep (carrion), and skunks (carrion) were utilized [89]. Like the opossum and raccoon, the diet of the ringtail is varied including plant matter (primary consumer) and animal matter (secondary consumer). The habitat supplies the variety of material required by these species.

2.7.2.2.5 Skunks

The spotted skunk and striped skunk were collected through trapping in the SCR area. The striped skunk was the third most abundant furbearer according to trapping results. Both species of skunk inhabitat wooded areas and utilize crevices in rocky outcrops, creek bluffs, or underground burrows [57]. However, Davis [80] also noted that the striped skunk made use of the burrows prepared by fox, armadillos, or other mammals. The striped skunk is typically associated with farmlands [80]. Both species of skunk are primarily nocturnal.

Both species of skunk are beneficial to the agriculturalist during the summer by feeding on insects and rodents. The seasonal diet of the spotted skunk includes small mammals and grain during the winter; small mammals and insects in the spring; insects with some small mammals, fruits, and birds or their eggs in the summer, and primarily insects again with some mice, fruits, and birds in fall. Insects were found to be the major component of the diet of the striped skunk throughout the year. Arachnids, small mammals, birds, reptiles, and vegetation are also seasonally important [80].

2.7.2.2.6 Gray Fox

Seven gray foxes were collected in the SCR area [57]. The density of this predator in the reservoir area was not calculated. The numbers trapped, however, indicate that the environs supply some or all of this mammal's requirements. Most of the gray fox in Texas primarily inhabit wooded areas such as the oak and juniper communities on the Squaw Creek site. The high frequence of capture in the juniper-uplands suggests that they prefer to forage in the uplands rather than the riparian communities. The omnivorous diet of the gray fox varies with the season and the availability of food items [80]. In three gray fox stomachs the following items were found: juniper berries, a deer mouse, pecans, feathers, and grasshoppers [57].

The gray fox is capable of climbing trees and may use cavities above the ground for dens. However, denning in rock crevices, underground burrows, or under rocks is more typical [80]. The breeding season occurs in February and March with the female giving birth to three to six pups in April or May.

2.7.2.2.7 Coyote

The coyote was not trapped or observed on the SCR area; however, its range should include the site. A density of one-half to one coyote per square mile is realistic throughout their range in Texas [90]. According to Davis [80], the removal of timber stands is increasing the range of the coyote in Texas. The coyote has been the subject of extensive trapping throughout its range whether it has been identified as a predator of livestock or not.

The coyote will dig its own den or use that of another mammal, or use crevices in rocky bluffs. The breeding season extends from February through March with five or six young born by April, May or June [80].

The coyote is opportunistic in its feeding habits; its diet includes fresh meat from wild and domestic animals, garbage, carrion, frogs, snakes, and invertebrates. The contents of 1,948 coyote stomachs were examined in Kansas from 1948 to 1962 [91]. Rabbit was identified most frequently (54.3 percent) in the diet, followed in importance by carrion (37.5 percent) rodents(41.5 percent) and chicken (13.8 percent). Invertebrates, reptiles and fruit or seed of some vegetation were also present.

2.7.2.2.8 Bobcat

The bobcat is highly adaptable and occupies a variety of habitats throughout Texas. They prefer rocky canyons but also utilize thickets in the pinon pines, junipers, oak, or chaparral areas of Texas. Crevices in the canyon walls or thickets that provide suitable protection, are used for dens. The breeding season occurs from February to April and two to seven young are usually born between April and May [80].

The diet of the bobcat is principally birds and mammals. Mammals eaten include wood rats, mice, ground squirrels, and rabbits. Deer meat found in the stomachs of bobcats has been carrion.

2.7.2.2.9 Hares and Rabbits

The California jack rabbit, Eastern cottontail, and swamp rabbit were sighted or trapped on the SCR area [57].

The jack rabbit inhabits the western three quarters of Texas. The swamp rabbit occurs in the eastern one quarter of the state and the cottontail rabbit occurs throughout Texas excluding the Texas-Pecos mountain region. Both the jack rabbit and Eastern cottontail should occur within Hood and Somervell Counties. The swamp rabbit, on the other hand, should not [80]. The distribution of these three members of the family Logomopha is, in part, a function of their habitat requirements, tolerance for moisture, and feeding habits.

The following discussion was taken primarily from Davis [80].

The jack rabbit occurs primarily on semi-arid range and is especially common on overgrazed rangeland, where it competes for forage with livestock and other native wildlife. In the SCR area, jack rabbits were present primarily on grazed pasture of the well-drained limestone uplands but sought young sprouts of cultivated oats in fields adjacent to the creek [57]. Both the cottontail and swamp rabbit seek cover under the low canopy of riparian vegetation such as brush along the streamside, and shrubs bordering cultivated fields.

The swamp rabbit has adaptations making it suitable for inhabiting the poorly drained bottom land of marsh or stream flood plain environments. Its dense fur forms a protective barrier that prohibits saturation and water contacting the skin. A census of poorly drained bottom land in Brazos County revealed a density of one swamp rabbit per seven acres of poorly drained stream flood plain [80]. On that occasion, cottontail rabbits were equivalent in number to swamp rabbits. The cottontail inhabits the lowlands with the swamp rabbit and the uplands with the jack rabbit.

Logomorphs are most active in the twilight hours and at night. The breeding season occurs throughout the year for the cottontail; from December to September for the jack rabbit; and from January to September for the swamp rabbit. The quality of food is important in the productivity of logomorphs. For example, the swamp rabbit exhibits a peak in breeding activity associated with the early sprouts of green vegetation in February and March. Multiple litters are common in all three species, with the jack rabbit commonly producing the most, up to six litters in a year.

The food habits of the cottontail and swamp rabbit probably vary little in the riparian zones of the Squaw Creek Reservoir area. A variety of green vegetation, grasses and herbs make up their diet. The cottontail diet will include bark and twigs of shrubs and trees. In contrast, the jack rabbit's inhabitation of more arid sites results in a slightly different diet. They feed on forage crops, cactus, mesquite, and numerous grasses and herbs.

Logomorphs are in the diet of many predators, including the following: coyotes, foxes, bobcats, red-tailed and other hawks, and opossum.

2.7.2.2.10 Armadillo

The nine-banded armadillo is a recent inhabitant of southern coastal, eastern, and northcentral Texas, according to Buchanan [92]. The spread of the armadillo has followed the pattern of alluvial soils, temperate climate, and invertebrate food supply. Theories explaining their extended range have been authored but none have been founded on solid proof. However, it is generally agreed that temperature and the food supply will be the deciding factor inhibiting its further northward invasion toward northern Kansas and Oklahoma and eastward [92, 93].

Alluvial soils in the vicinity of Squaw Creek provide the easiest accommodations for this burrowing animal [57]. The armadillo digs several burrows typically at the base of a tree or shrub [92], but uses only one for its den. Other burrows may offer protection when the armadillo is pursued. Several of these animals have been observed in the Squaw Creek area.

Armadillo burrows also serve a variety of other mammals including the opossum, striped and spotted skunk, and gray fox. Taber [93] recorded the opossum, cottontail, cotton rat, and striped skunk as using these burrows in Chambers County, Texas.

The armadillo is generally active at night during the summer when temperatures are high during the day. When night temperatures become cold in the winter they are frequently seen afield during the afternoon. The armadillo spends most of its active period searching for food and devouring its catch [92, 93].

Armadillos are chiefly insectivorous in their feeding habits. Their claws and snout aid in digging up grubs and larvae located beneath the surface of the soil. According to Taber [92], armadillos probe beneath decomposing piles of cow dung in search of beetle and fly larvae.

2.7.2.2.11 Red Wolf

The Texas red wolf (Canis rufus rufus) formerly occurred throughout northcentral Texas, but is now confined as a remnant population on the Texas Coastal Prairie [80]. The red wolf is considered an endangered species.

The presence of the red wolf in the southeastern counties of Brazoria, Chambers, Jefferson and Liberty was confirmed by Paradiso and Nowak [94] between 1963 and 1969. Records of a hybrid between the coyote and red wolf have been made from east central Texas, where hybridizations began, to southeast Texas. Paradiso and Nowak suggested that the expansion of the hybrid followed the expansion of the coyote eastward as it replaced the red wolf. Habitat changes and metropolitan expansion are slowly decimating the existing red wolf packs in southeastern Texas.

2.7.2.2.12 Fox Squirrel

The eastern fox squirrel has been observed in wooded portions of the site adjacent to Squaw Creek [57]. Abundance estimates were not made on the site but populations are often densest along creek bottomlands where mast-producing trees (oak) are found. Throughout its range, populations vary from one per two acres to six per 2-1/2 acres [79]. In Shakelford, Throckmorton, Eastland, and Coleman Counties, fox squirrel populations are light and occur chiefly along water courses where mast-producing trees are most numerous [95].

2.7.2.2.13 Small Rodents

Trapping results showed that deer-mice, hispid cotton rats, and pygmy mice were the three most abundant species in the reservoir area. Seven different species were trapped in limestone uplands, four in bottomlands, and three in sandy uplands [57]. The white-footed mouse was collected in all three habitats.

The total catch indicated that small rodents in sandy uplands were approximately twice as abundant as those in limestone uplands and over four times as abundant as those in bottomlands. The small number of rodents in bottomlands can partially be attributed to the lack of concealing herbaceous ground cover under the canopies of large trees [57].

Seventeen different sites were trapped in the analysis of rodent populations. Results ranged from no catches in 130 trap nights (trap-night index, TNI = 0.0) to seventeen catches in 518 trap nights (TNI = 32.8) [57]. The abundance and distribution of small mammals is a relative indication of habitat quality. Only four sites were relatively productive.

Traps had been set beside a fenceline on sandy uplands. Twelve deer mice, four fulvous harvest mice, and one white-footed mouse were captured during 518 trap nights (total TNI - 32.8) from December 22 - 29 [57]. In addition to the rodents, at least one shrew and one eastern cottontail rabbit were caught at this site. Oldfield threeawn, red lovegrass, and little bluestem were the dominant grasses with approximate coverage values of 60, 30, and 20 percent, respectively. Horseweed, ragweed, and broomweed were the dominant forbs with coverage values of 50, 30, and 20 percent, respectively. Average height of the ground cover was 30 - 60 cm. Brush was essentially absent but a few scattered post oaks, approximately 5 - 10 m tall, were present [57].

Two southern plains woodrats, two hispid cotton rats, two white-footed mice, and one pygmy mouse, was captured during 300 trap nights (total TNI = 23.4) in an ungrazed pasture of the limestone uplands. King Ranch bluestem was the dominant grass with a coverage of 80 percent and an average height of 30 - 40 cm. Scattered clumps of little bluestem were present. Forbs were notable by their absence. This site has been cleared by pushing brush into piles along contour lines with the plies spaced at about 15 m intervals. Flame-leaf sumac and juniper were abundant.

During 500 trap nights at one site in the limestone uplands, six pygmy mice, two hispid cotton rats, and two brush mice were captured (total TNI = 20.0). King Ranch bluestem, Texas wintergrass, and common broomweed were dominant ground cover with coverage values of approximately 50, 40, and 10 percent, respectively. Ground vegetation ranged from 20 - 40 cm in height. Mature juniper trees, about 3 - 5 m tall, covered 40 percent of the ground surface. A few large live oaks were present. The six pygmy mice, because of their colonial tendencies, were caught in three different traps located in close proximity to each other [57].

Three hundred trap nights at one location in the upper riparian vegetation type yielded five cotton rats and one white-footed mouse (total TNI = 20.0). Texas wintergrass (coverage of 70 percent and average height of 7 - 10 cm) and common broomweed (coverage of 80 percent and average height of 30 - 45 cm) were dominant in the ground cover. This site was representative of the mesquite flats and much juniper and a few live oaks were present [57].

One hispid cotton rat and one white-footed mouse were trapped during 624 trap nights (total TNI = 3.2). The location was the border of a cultivated oat field in the upper riparian vegetative type. Common vegetation included pecan, Texas wintergrass, western ragweed, Bermuda grass, and elbow bush, with 50, 40, 40, 30, and 25 percent coverage, respectively.

A southern plains woodrat was obtained during 441 trap nights (total TNI = 2.3). Texas grama, threeawn, and hairy tridens each covered approximately 70 percent of the ground surface in a pasture. The pasture had a cleared appearance with a 25 percent cover of juniper bushes.

A fenceline in the Lower Riparian vegetative type was trapped for mammals without success. Rough-leaf dogwood, Texas wintergrass, common broomweed, and cedar elm were dominant with a ground coverage of 70, 50, 50, and 50 percent respectively.

2.7.2.2.14 Bats

Bats were seen along Squaw Creek during August but none were collected and identified[57].

2.7.2.3 Amphibians

Fifteen species of amphibians that could occur on the site are listed in Table 2.7-16[96,97]. Three species were observed in the area of Squaw Creek and include the bullfrog, Woodhouse toad, and red-spotted toad. Woodhouse's and red-spotted toads occurred in rocky canyons while green toads inhabit grassy mesquite flats[98]. Stock ponds in the uplands and semi-permanent pools in Squaw Creek held a large number of immature frogs during August and September [57].

Amphibians play an important role in the food web of an ecosystem acting both as prey and as predators. Food consumed varies not only among species but also among age classes. Most larval forms, such as tadpoles, feed on plankton, plants, and small aquatic arthropods, although some are carnivorous and cannibalistic[99]. Adult toads eat ground-dwelling insects, spiders, and other small arthropods, and even small snakes are consumed by mature bullfrogs [57].

Amphibians are sought as prey by small predatory mammals such as the raccoon, opossum, and skunk; by such birds as great blue heron and green heron; and by reptiles like the water snake, coachwhip, and hognosed snake.

2.7.2.4 Reptiles

Fifty-two species of reptiles could occur in the SCR area (Table 2.7-17). Sixteen species were observed [57].

Some reptiles prefer aquatic or semi-aquatic habitat such as that provided by Squaw Creek and portions of the associated bottomlands. Pond sliders and spiny softshell turtles were common in deeper pools from August through November. One common snapping turtle was observed in late October. Plain-bellied water snakes were frequently encountered along the creek bottom. Western ribbon snakes, six lined racerunners, ground skinks, rough green snakes, and copperheads were associated with woodland (Lower Riparian) vegetation [57].

Most reptiles on the reservoir area preferred upland habitat situations. Greater earless lizards, the most abundant reptilian species, were found in dry, rocky creek bottoms and along limestone outcrops. Collared lizard occupied the same habitat but few were observed. Young coachwhips occurred in dry, rocky ravines. Texas spiny and eastern fence lizards were seen along fencelines and in trees throughout the study area. Although landowners reported dense rattlesnake populations, only one western diamondback rattlesnake was observed. The limestone outcrops, cacti, and mesquite of the area provide ideal habitat for a variety of reptiles including Texas horned lizards, bullsnakes, and kingsnakes.

Reptiles play an important role in the food chain of an ecosystem by serving both as predator and prey. Thomas et al [99] placed reptiles in three consumer levels. Fence lizards, box turtles, and mud turtles are primary consumers. Most lizards and snakes are almost entirely carnivorous, feeding on insects, amphibians, reptiles, and rodents. Some snakes feed on birds. The softshell turtles are almost entirely carnivorous whereas most other turtles include plant and animal life in their diet [62]. The greater earless lizard, an abundant species in the Squaw Creek area, is probably an important forage species.

The reptile serves as prey to various mammals (raccoon, opossum, and ringtail cat) and predatory birds (red-tailed hawk, sparrow hawk, roadrunner, and northern shrike).

2.7.2.5 Pre-existing Environmental Stress - Wildlife

Factors that act as stresses on wildlife populations, rather than on individuals, will be discussed in this section. A population is a group of individuals defined within a specific area such as the Squaw Creek Reservoir site. The defined area, however, may be either smaller or larger than the reservoir site. The presence, absence, diversity and abundance of wildlife is strongly dependent on a combination of three factors: soil, vegetation, and meteorology of a site.

Stress on the environment that have long been influencing the wildlife abundance and diversity on the CPSES site are grouped into two basic categories: natural stress and man-made stress.

Natural occurring stress includes meteorological phenomena: physical environmental factors such as soil, vegetation, and fire: such limiting factors that influence the survival of wildlife populations as intra and inter-specific competition, and finally; disease infestations.

Man-made occurring stress is identified in two forms: competition with man, and chemicals and air-borne particulate matter.

The first natural stress to be discussed is meteorology. Meteorological factors influence wildlife indirectly through effects on the vegetative cover and the vegetative and invertebrate food supplies and directly by affecting juvenile and adult survival.

Precipitation is the one meteorological factor that acts as a stress on almost all species of wildlife in northcentral Texas. The role of moisture in determining vegetative species and distribution has been described for the CPSES site in Section 2.7.1. Precipitation during the spring benefits amphibians, promotes vegetative growth, and increases the humidity. The moisture often insures vegetative cover and food for grazing wildlife as well as creating ideal conditions for invertebrate development from the over-wintering egg and pupae into the adult. This provides a high biomass of edible material for insectivorous wildlife.

An excess of precipitation can cause a considerable loss in invertebrates an important item in the diet of many species of wildlife. This will affect the ability of insectivorous birds, mammals, reptiles and amphibians to survive. Excess precipitation can directly cause mortality among juvenile and adult wildlife especially among ground-nesting species during the breeding season. The ability of soil to drain excess water plays an important role for reducing mortality.

Drought in Texas, on the other hand, is an indirect stress on wildlife by inhibiting vegetational development necessary for food and cover as well as inhibiting invertebrate development. A decrease in protective cover will increase the vulnerability of small mammals and ground-nesting birds to be preyed upon by predatory wildlife. Drought would also delay the reproduction in amphibians or the maturation of young amphibians.

The amount of daylight and temperature are major meteorological phenomena that, in part, cause avian migrations southward in the fall and northward in the spring. Birds regularly congregate in Texas during the winter season. For example, robins and meadowlarks were observed in large numbers on the CPSES site. The habitat and diet requirements of various bird species help determine whether they will congregate on the CPSES environs. This inflow of species from the north and outflow of species toward the south is an additional stress on the wildlife populations that remain on the site; birds, mammals, amphibians, and reptiles. Some immigrating populations may be more competitive for food and hence act as one of the many regulatory factors that maintain population levels within broad limits of the land's carrying capacity.

Temperature as well as precipitation can influence invertebrate survival. Low temperatures in late spring following a warm trend can cause mortality among invertebrates that had developed. This in turn can cause some mortality among early broods of juvenile insectivorous animals and reduce the survival of young for any given year during which these conditions exist. In addition, low spring temperatures can increase the hardship on avian nestlings. Nestlings may require additional attentive activity by the parent birds in caring for the young. The parent birds would be required to forage farther for food and spend less time at the nest. These stress factors would increase the probability of nestling mortality.

Wind is the least of the meteorological stresses on wildlife populations. Wildlife, in general, seek shelter during periods when wind velocities are high. The transport of particulate matter is primarily the way in which wind acts as a stress.

Any one factor or a combination of meteorological factors may have drastic effects on wildlife populations during any one season of a year. These factors are partially responsible for the declines and increases that are witnessed in populations from one year to the next. Their effects on wildlife populations are seldom significant during several years of study. However, some populations, such as the endangered golden-cheeked warbler, can be reduced quite significantly if harsh climatic conditions should prevail.

The second major category of natural occurring stress is the physical environment; soil, vegetation, and fire. Soil is one of many factors that influence the carrying capacity of the CPSES site. Vegetation takes up nutrients from the soil and concentrates many of these as compounds (carbohydrates, fats, proteins, etc.) in the growing tips, buds, and seeds. These nutrients are either returned to the soil when the plants die or transferred to wildlife (herbivores, omnivores) that eat the vegetative parts at various stages of growth throughout the year. A diversity of plants and their nutritive values are important in determining the capacity of the area to support herbivores. A loss of vegetation would lower the availability of nutrients in the area and act as a stress by lowering the carrying capacity.

The vegetation itself and precipitation are two important naturally occurring stresses that cause changes in the levels of soil nutrients. Vegetation provides needed protective cover for wildlife during nesting, while traveling, and while resting.

Some species of wildlife survive best in dense cover, other species survive well in open cover, and yet others are equally adaptable. The bobwhite quail is an example of a bird with specific cover needs. It best survives in grassland-brush communities with a light-to-moderate density of ground vegetation. It is seldom found in dense vegetation where travel on the ground is inhibited or in areas of sparse vegetation where it is vulnerable to predation.

Fire is the last of the physical environmental factors to be addressed as a natural stress. Fire is a stress on wildlife directly by causing mortality and indirectly by removing the available vegetative associations which reduces habitat and food. Fire as a stress on vegetation has been discussed in Section 2.7.1. Although fire is destructive, it is often beneficial by removing climax and sub-climax associations so that the area occupied by the burn again passes through successional development. Wildlife inhabitants and numbers change as succession progresses once more toward the climax type. For example, bobwhite quail occur in areas progressing through an early stage of succession and the wild turkey relies on several stages. Fire has been used in range management by man on the CPSES site and will be further discussed in a section describing man-made stress.

The third major category of natural stress identifiable on the wildlife of the CPSES site is a behavior characteristic of all wildlife species known as competition. Two forms of competition will be discussed here; intra and inter-specific competition. Intra-specific forms include the variety of interactions that occur between the members of a population. Inter-specific competition are interactions that occur between different populations of different animals.

Natural stress from intra-specific competition include competition for more mates; competition for space such as nest sites, food sites, and living areas; competition for shelter such as den sites and roost sites; and competition for food and the predation of one member on another member of the population. Under ideal conditions, all adults find mates, have sufficient living space with shelter, and adequate food. However, such ideal conditions are non-existent except under artificially manipulated conditions. All forms of wildlife compete for mates by declaration and the environment will support only a limited number of successful pairs. The pair must compete for living space, shelter, and food with members of their own kind competing for the same requirements for survival. The boundaries of their vegetative domain limit the number of individuals in the population that the land can carry. Competition then operates as a stress whereby the limited resources inhibit population expansion. Where one of these resources is in short supply competition will cause population levels to decline. Both meteorological and physical factors can cause one of these resources to be limited such as the food supply, that would lower reproduction or an overall lower carrying capacity for that population.

Inter-specific competition occurring between different species also include stresses that help regulate population levels. Inter-specific competition occurs for space; for food, either searching for the same foods or as predator and prey; for shelter, such as dens, and; between the host and parasite. Seldom does a single one cause of interaction result in the decline or increase of one or more populations. A decline or increase usually results from the combination of several causes, such as the competition for living space, food, and shelter. The ability of the habitat such as that occurring on the CPSES site to support several browsing species (white-tailed deer, cottontail rabbit) several grazing species (swamp rabbit, jackrabbit, white-tailed deer, small rodents) and several omnivorous species (raccoon, skunk, opossum, ringtail cat) is dependent on the resources available to each species. For example, the hare and rabbits have a different special distribution on the site which reduces the probability of competitive stress. The grazing species have different special requirements and often feed on either different plant species or different portions of a single plant species. Rodents are often competitive for space, food, and shelter. A change in the environmental conditions from drought, fire, or soil erosion can result in the interplay of competitive factors to reduce and/or increase one population of one animal over the population of another animal.

Disease and parasitic infestations are natural occurring stress on wildlife populations. A list of the common disease and parasite organisms in wildlife has not been compiled for the CPSES site. Few parasite infestations directly cause mortality within populations because the death of the host results in death of the parasite. However, a parasite often lowers the threshhold of the animal to become susceptible to disease, or other forms of environmental stress. The combined factors result in death of the organism and if widespread, the death of a proportion of a population.

Man-made stress is the second major category that has had a significant influence on the wildlife diversity and abundance on the CPSES site. The influence of man in this particular area has been felt since the early times of homesteading in the State of Texas. The agricultural practices in the valleys containing organic or alluvial soils and the grazing of domestic stock have been major influences from man. The subject of man-made stress has been conveniently divided into the subjects of competition and chemical releases.

Man has competed with wildlife for space since he became colonial and learned to cultivate fruits, grains, tubers, edible leaves and livestock. Today man continues to compete for space through cultivation; construction of buildings, dams, roadways and transmission corridors. Agriculture replaces an area of low productivity with one of high productivity; it replaces an area of high diversity with one of low diversity; and it replaces an area of higher stability with one of a lower stability. Through agricultural practices, man has used the most productive soils for crop production and removed the most productive native habitat for wildlife. On the CPSES site, native prairie and forest vegetation was replaced by agriculture primarily on alluvial soils. Agriculture is a system with low diversity and consequently provides little cover and a low variety of foods for native wildlife. Mourning doves, horned larks, and killdeers do take advantage of the concentration of grain or bare soil where invertebrates are often found. The hedgerows and fencerows that separate cultivated fields provide another successional stage in vegetative development suitable for a different variety of vertebrates and invertebrates.

The spotty distribution of cultivated fields on the CPSES site has created a patchwork of distribution of cultivation and native vegetation. Overall, the effect is considered to be benefical for a variety of wildlife. However, only remnants of native prairie still occur on the CPSES site and the wildlife associated with these conditions are not abundant. The introduction of livestock on the ecosystem has been a significant factor in reducing native habitat as will be discussed later. Such species as the omnivorous opossum has increased in abundance in response to the low vegetative productivity induced by grazing, the variety of foods from both livestock and agriculture, and the abundance of burrows dug by the armadillo.

The livestock industry has had the most far-reaching consequenses as a stress on the CPSES site as well as elsewhere. Grazing livestock is considered here as a form of spacial competition between man and wildlife. Grazing has had a direct effect on the diversity and density of vegetative species as well as the nutritional value of surviving vegetation. The carrying capacity of the range for native herbivores (white-tailed deer, rodents, hares and rabbits) and the numerous omnivorous species has changed, either increased or decreased, as a result of grazing. A high stocking rate of livestock per unit area results in a decline in the available leads to an increase in the rate of erosion and consequently a loss of soil nutrients and productivity. The reduced ground cover and lower nutritive values of grazing-tolerant plants lowers the carrying capacity for small mammals. The drastic effect overgrazed range can have on bobwhite quail was discussed in Section 2.7.2. Moderate grazing was found to be moderately beneficial to the bobwhite.

The formation of pasture relies on a combination of cutting, burning, and grading methods for clearing shrubs and trees. The trees and shrubs are usually cut, bulldozed into piles or along steep slopes and burned. This removes vertical cover that serves as protection for such species as rabbits, hares, armadillos, opossums, ringtail cats, and white-tailed deer. The removal of trees and shrubs increases the probability of erosion and loss of soil nutrients while decreasing herbaceous vegetation. Fire destroys nutrients which might leach into the soil and become available to other plants. Fire is a tool to remove a later successional stage of vegetative development in favor of an earlier successional stage. Thus, it is detrimental for some groups of wildlife and beneficial for other groups of wildlife.

A third form of spacial competition as a man-made stress is the construction of buildings, roadways, and transmission corridors. The construction of buildings and/or roadways directly removes habitat from productive use by wildlife. An ecotone is often formed along roadside borders, other transportation corridors and fencerows. The diversity of wildlife usually increases whenever there is an increase in the diversity of vegetation.

Man competes with some species of wildlife directly by hunting and in predator control programs. The most important game species on the CPSES site area include the mourning dove, bobwhite quail, and white-tailed deer. Fern fox squirrels and cottontail rabbits were on the site which suggests they were not important. Historically, the predator control programs in Texas were directed against the coyote. In recent years, the coyote has been considered less and less of a problem to the extent that the economic gain from a control program was not sufficient to warrant the continuation of a program in Hood and Somervell Counties.

Transmission line corridors alter the habitat by removing trees and shrubs. This encourages herbaceous vegetation. This result discourages arboreal species of wildlife and encourages grassland species and species associated with the ecotone between the forests and the corridors.

The second major category of man-made stress that occurs on the CPSES site is chemicals and air-borne particulate matter. Smoke, vehicle exhaust, and chemical wastes discharged into the environment are included here. These three forms of chemical and particulate discharges are not considered to be important as pre-existing stresses of the CPSES site environs. Dust and windblown soil particles may be a significant stress on the environment because of the proportion of bare soil exposed from agriculture and overgrazing practices.

Pesticides and herbicides are two of the major chemical stresses that influence the CPSES site environs. Tables 2.7-3 and 2.7-4A list the more common pesticides and herbicides in use in Hood and Somervell Counties. The chlorinated hydrocarbon pesticide compounds (Aldrin, DDT, Lindane, Methoxychlor, Toxaphene) are not biogradable and remain in the environment as a continuous hazard to invertebrates and wildlife. An analysis of pesticide and herbicide residues, and heavy metals in soils and water on the CPSES site is being conducted as part of the baseline ecological survey. The effects of wildlife will be discussed for compounds used in quantities considered to be hazardous to wildlife. The dosage toxity of pesticides and herbicides required to cause 50 percent (LD_{50}) mortality in test animals has been reported [138]. Most pesticides and herbicides are not applied in sufficient concentrations to be immediately lethal to wildlife in the environment. However, many may accumulate in the tissues of living animals ultimately producing physiological effects.

Two pesticides listed in Table 2.7-3 were used on agricultural crops, Aldrin and DDT. Both of these are no longer used but residues are likely present in soils on the CPSES site. The other pesticides listed are used to varying degrees to control insect infestations in cattle. They are applied to cattle in enclosures rather than on the open range. Livestock distribute the pesticides, but notin sufficient concentrations to enter food webs and be hazardous to wildlife populations. Indiscriminant use or discarding unused pesticides may be far more detrimental to the ecology of the Squaw Creek area. Table 2.7-4B is a list of the dosage of pesticides and herbicides that cause 50 percent mortality (LD_{50} or LC_{50}) in test organisms [138].

Aldrin is a chlorinated hydrocarbon that causes mortality at low dosages. Aldrin causes a decrease in the frequency of estrus in rats fed 10 to 20 ppm daily beginning at one month of age. DDT as a long-lasting pesticide has received a considerable amount of study in recent years. DDT is not only toxic but also causes changes in physiology such as lowering clutch size, embryo survival, and chick survival in birds. Synergistic effects have been reported between DDT and increasing spring temperatures [138].

The application of herbicides immediately decreases the carrying capacity of the CPSES site environs by reducing vegetative biomass available for consumers. This also short-circuits the directional movement of a community toward a more stable (climax) community by forcing the system into a less stable (younger) successional stage. The variety and density of populations may change as a direct result of the habitat changes. In cultivated fields, herbicides remove the pioneer species that invade these disturbed (unstable) sites. The herbicides may also have toxic effects on wildlife feeding on the site where application occurred. Treflon and Princep are most frequently used at the present time in Hood and Somervell Counties. Their toxicity to some species of wildlife are given in Table 2.7-4B.

2.7.2.6 Wildlife Succession

Wildlife succession is the natural progression of wildlife forms in parallel with vegetational succession such that each form is suited to an existing seral stage (seral stage is any transitory community during succession). An ecosystem exemplified by several seral stages would also contain a varying diversity and abundance of wildlife associated with each stage. A low diversity, low stability and high abundance is typical of an early development stage (such as a field following a wild fire) whereas a high diversity, high stability and low abundance is typical of a climax seral stage (tall grass prairie). Unless interrupted, early seral stages will gradually progress through successional changes toward the climax. Natural and man-made stress, however, interrupt the progress of succession, or as most often occurs, man replaces it with an earlier stage.

Vegetation on the CPSES site has undergone considerable change as a result of both pre-existing natural and man-made stresses (section 2.7.1). Vegetation is a major factor in determining the successional pattern of wildlife. The man-made stress, especially intensive grazing by domestic livestock and agricultural cultivation had a greater effect on wildlife of the CPSES site than had natural stress.

The endemic vegetation to the CPSES site was tall grass prairie as described in Section 2.7.1. Few areas of endemic tall grass prairie remain on the CPSES site for a comparison of wildlife to the present environment. Avian succession is common phenomenon related to the various seral stages caused by stress on the environment. For example, the bobwhite quail is not an inhabitant of the tall grass prairie but an inhabitant of an early seral phase. On the CPSES site, the bobwhite is adapted to grassland that has been thinned by stress. Light-to-moderate grazing pressure from domestic livestock is one such stress that has allowed the bobwhite to survive on the CPSES site. Excessive grazing pressure removes the protective grass and herbaceous cover required by quail while the absence of livestock allows grass and herb density to increase beyond the tolerance of quail.

Forest communities, once found primarily on alluvial soil, have been replaced by agricultural cultivated communities, with the exception of a remnant along Squaw Creek. The mourning dove, horned lark and meadow lark, are common to the cultivated fields and use the trees that border the Squaw Creek and dot the landscape. These species were probably uncommon to the endemic tall grass prairie before man's influence. The robin is also a common resident that has benefitted from an association with man.

An examination of the common mammals and their habits show several examples of succession on the CPSES site environs.

The small mammal trapping success obtained by Guthery and Synatzske [57] provides some leads as to the wildlife species present in the little bluestem prairie that was endemic to much of the site prior to man's influence. The effects may be summarized as follows:

Location Description	Deer Mouse	Fulvous Harvest Mouse	White-Footed Mouse	Wood Rat	Cotton Rat	Pygmy Mouse	Brush Mouse
Fencerow, sandy upland	12	4	1	-	-	-	-
Ungrazed shrubless pasture	-	-	2	2	2	1	-
Grazed Juniper, bluestem, broomweed	-	-	-	-	2	6	2
Herb-grass edge of cultivated field	-	-	1	-	5	-	-
Grazed juniper, grama,threeawn	-	-	1	-	1	-	-
Fencerow Riparian	-	-	-	1	-	-	-

The difference in the number of species and number of individuals demonstrates the numerical changes from one seral stage to another under the influence of man. Of the seven sites, the ungrazed pasture has a rodent population typical of a later successional stage (high diversity, low numbers of each species) whereas the other sites show a greater influence of man-made stress. Only three or fewer species were trapped on sites that were grazed. The trapping data on the site adjacent to a cultivated field was also low in diversity and abundance. Additional factors may cause the difference in trapping success between sites such as intensity of grazing, slope, vegetative cover and vegetative distribution.

The reduction in vegetative diversity and introduction of both livestock grazing and agriculture have reduced the carrying capacity of the area for native wildlife. The endemic vegetation for the most part has been replaced by invading species with lower nutritional values. These environs are best suited for wildlife with an omnivorous diet. Hence, the opossum, skunk, and ringtail cat are abundant residents. These species were not so abundant in the tall grass prairie and oak savanna that were endemic to the site. The white-tailed deer is now common to the multi-seral landscape where forage and browse is available along the borders of fences, roads and cultivated fields, and stream sides that represent different succession stages. The white-tailed deer feeds on browse and may have been present in the timbered areas along streams but was not present in the tall grass prairie. Grazing animals, like the antelope and American bison, were abundant; feeding selectively in the tall grass prairie. The introduction of domestic livestock that is non-selective in their feeding habits was competitive with the antelope and bison and one factor in their decline. Livestock are presently competitive with the white-tailed deer and this competition has been identified as a factor in deer mortality [84].

Grazing, however, has been beneficial to another mammalian species, the California jackrabbit. It is most numerous on grazed range.

The coyote is a recent invader of the Texas plains because grazing created open range more suitable for its requirements. The coyote is extending its range eastward where it is replacing, as well as hybridizing with, the Texas red wolf [94].

2.7.3 AQUATIC ECOSYSTEM

Contacts with State and Federal agencies and a general review of the available information relative to Squaw Creek, the Paluxy River, the Brazos River and Lake Granbury revealed that very little aquatic biological survey work had previously been done. A program has been instituted to determine baseline conditions and to monitor future population changes. Details of the monitoring program are discussed in Section 6.2.5.

Southern Methodist University has conducted an aquatic survey for the Applicant to establish the baseline conditions for the site environs. The final report [191] was completed in December 1973 and is included in Appendix D of the ER.

This limnological survey includes both chemical and biological data which provide information relative to the distribution and abundance of the principal aquatic species, their habitat requirements, and interrelationships with the biotic and abiotic surroundings. The important consumer classes are identified and information pertaining to the area usage of the different components is presented. 2

2.7.3.1 Physical Description of Site Area

2.7.3.1.1 Squaw Creek

Squaw Creek, in the area of the CPSES, is an interrupted stream. Originating near Tolar, Texas it flows in a general southeasterly direction across Hood and Somervell counties for a distance of 23 miles to its confluence with the Paluxy River. The Paluxy River, in turn, merges with the Brazos River a short distance from the mouth of Squaw Creek.

The volume of water in the creek is dependent on local climatic conditions. The flow in upper Squaw Creek is dependent on surface runoff while the lower reaches derives its flow from surface runoff, vadose waters and groundwater.

The creek is characterized by narrow riffles, shallow pools and cascades (areas with current too slow to be classed as a riffle and too shallow to be classed as a pool). The riffle areas are narrow, with an average width of five feet, a depth of two inches and a substrate of coarse gravel. The average pool has a width of 15 feet, maximum depth of three feet and a substrate of bedrock covered by silt and herbaceous material. Substrate of the areas classed as cascades is bedrock with little rubble, gravel or other fine materials. During summer months, the flow goes underground at certain points, causing an interrupted type flow.

Seasonal temperatures in Squaw Creek range from freezing in winter to 91°F in July and August. Water temperatures correspond closely with that of the atmosphere except in areas which receive groundwater [101]. Immediate areas of groundwater confluence can be as much as 10.8°F cooler than the ambient air and water temperatures.

2.7.3.1.2 Lake Granbury

Lake Granbury is a 33-mile long impoundment on the Brazos River. It is located approximately 30 miles southwest of Fort Worth in Hood County, Texas. Built primarily for flood control, the 8500-acre lake also serves as a source for municipal, industrial, and agricultural water. (See Section 2.5).

Lake Granbury has a maximum depth of approximately 75 feet at the base of the dam with an average channel depth of 43 feet[103]. (Further discussion of Lake Granbury follows in Sections 3.4, 4.1 and 5.1).

2.7.3.1.3 Paluxy River

The Paluxy River flows southeasterly across parts of Erath, Hood and Somervell counties into the Brazos River about 1.4 miles east of Glen Rose. The Paluxy River is characterized by riffles, shallow pools and many small waterfalls (one to two feet in height). The stream has an average depth of 2.5 feet and an average width of 85 feet[104]. The substrate is composed of limestone with boulders and small rocks in the riffle areas.

Temperatures in the Paluxy River range from freezing in winter to 94°F in mid-summer[105]. The water temperature corresponds closely with the atmospheric temperature.

Additional water quality data were discussed in Section 2.5.

2.7.3.1.4 Brazos River

The Brazos River originates in eastern New Mexico, flows southeasterly across Texas and empties into the Gulf of Mexico near Freeport. The substrate of the Brazos River, in the vicinity of the site, is largely composed of sand with some gravel[106]. Scouring occurs throughout the basin during periods of heavy rain and high flow. Stream temperatures as recorded at U.S.G.S. Station 8-0910, range from 35°F in winter to 96°F in summer[105]. Water temperatures are thought to correspond closely with ambient air temperatures.

Additional water quality data were discussed in Section 2.5.

2.7.3.2 <u>Aquatic Biota of Squaw Creek</u>

2.7.3.2.1 Aquatic Vegetation

There is an abundance of aquatic plants in Squaw Creek[101]. A typical pool area has a dense growth of muskgrass (<u>Chara sp.</u>) around its outer edge, with other aquatic macrophytes noted including pond weed (<u>Potamogeton sp.</u>), bushy pond weed (<u>Naias sp.</u>)

and milfoil (Myriophyllum sp.), green algae (*Spirogyra sp.*) were observed in the riffle areas and aquatic moss (*Amblystegium sp.*) was noted near the confluence of groundwaters. Littoral emergent plants along Squaw Creek consist of cattail (*Typha sp.*), sedge (*Scirpus sp.*), willow (*Salix sp.*), saw grass (*Cladium sp.*) and spike rush (*Juncus sp.*).

2.7.3.2.2 Plankton

Little is known about the phytoplankton and zooplankton inhabiting Squaw Creek. Studies have been conducted by SMU to establish baseline conditions. Data from these studies are presented in Appendix D. 3

Blum[107] reports some of the commoner algae found as plankters include *Asterionella formosa*, *Fragilaria capucina*, *F. crotenansis*, *Synedra ulna*, *S. acus*, *Tabellaria fenestrata*, *Melosira granulata*, *M. varians*, *Stephanodiscus hantzchii*, *Dinobryon sertularia* and species of *Pediastrum*, *Scenedesmus*, *Closterium* and *Euglena*. Many of the organisms listed above are known to occur in the area[103], although their presence in Squaw Creek has not yet been documented.

Benthic algae are dominated in much of the north temperate zone by *Cladophora glomerata*, which grows in riffles and in rapidly flowing water, but never in still water[107]. *Cladophora glomerata* is known to occur in large quantities in the riffle portions of Squaw Creek.

2.7.3.2.3 Benthos

Studies have been initiated by SMU to establish benthic macroinvertebrate conditions. For details, see Appendix D. 3

Substrata of Squaw Creek range in size from coarse gravel to silt particles. Based on general data from the literature[108], it is expected that a very diverse group (large variety of species) of organisms do occur in the riffle areas and a relatively small variety of species in silt-bottomed pools.

2.7.3.2.4 Fish

Twenty-six species, representing nine families, of fishes are known to inhabit Squaw Creek based on collections made near the plant site and observations by state fisheries and game personnel. These, along with species known in the Paluxy and Brazos Rivers, are shown in Table 2.7-18. The most abundant fish in Squaw Creek, especially in the shallow pools and slow riffles, is the stoneroller minnow (*Compostoma anomalum*). This forage species inhabits most small streams of northcentral Texas and is known to become very abundant in favorable habitat[109].

Principal game fish in the site area are largemouth and spotted bass. Large numbers of small bass, two to six inches in length, were taken in the collections, along with several adult fish weighing one to two pounds[101]. The size and numbers of these fish indicate that suitable spawning habitat exists and that the creek, although intermittent, is able to support aquatic life throughout the year. Other abundant game fish include green, bluegill, lonear and redear sunfishes. Less abundant species of game fish in the creek were channel catfish and white crappie.

The only species of rough fish found in the Squaw Creek during the study were black and yellow bullhead catfish, river carpsucker, gray redhorse and gizzard shad (one specimen observed). Large numbers of rough fish species are likely restricted from the creek due to the lack of suitable habitat. In addition, migration of rough fish from the Paluxy and Brazos Rivers is restricted by a small dam (approximately five feet high) seven-tenths of a mile above the mouth of the creek[101].

Squaw Creek is located in the Texas Biotic Province. No endemic or endangered species of fish have been reported in this primarily transitional Biotic Province[109]. Additional studies are presently being conducted in Squaw Creek and regions of the Paluxy River adjacent to the site area to assess the possibility of endemic, rare and endangered species.

2.7.3.2.5 Fish in Adjacent Waters

Fish species in adjacent waters (i.e., Paluxy River, Brazos River and Lake Granbury) differ somewhat from those found in Squaw Creek, (see Table 2.7-19). Six of these 10 species found are considered rough fish (fish of little or no sport value) by the Texas Game & Fish Commission, with the remaining four being classed as game or sport fish[104,110,111].

There is a high probability that the species listed in Table 2.7-19 will be introduced to SCR via the Lake Granbury-SCR make-up water pipeline. The two factors limiting the number of rough fish in Squaw Creek (lack of suitable habitat and the small dam barring migration) will be essentially ineffective when the reservoir is filled.

2.7.3.3 Aquatic Biota of Lake Granbury

2.7.3.3.1 Aquatic Vegetation

Aquatic vegetation is sparse in the area of the proposed intake and discharge facilities in Lake Granbury. Aquatic macrophytes known to be in the area include pond week (Potamogeton sp.), stonewort (Nitella sp.), muskgrass (Chara sp.), milfoil (Myriophyllum sp.) and hornwort (Ceratophyllum sp.). Littoral emergent plants have not been observed in the area. This can possibly be attributed to lake-level fluctuations.

2.7.3.3.2 Plankton

Phytoplankton populations varied considerably with each seasonal sampling. Average crops in the area of the proposed intake and discharge structure ranged from 5.17 million cells/liter in January to 9.93 million cells/liter in July, with a yearly average of 6.88 million cells/liter [103]. The predominant plankton was the green algae (Actinastrum gracillimum), which reached concentrations of almost 11 million cells/liter in the study areas during July. It was the most predominant form found throughout the lake, averaging approximately 5 million cells/liter. Diatoms dominated the remainder of the taxa. Dominant diatom genera include Cyclotella, Diploneis, Navicula, Sunedra and Fragillaria. Other phytoplankton genera found in larger numbers include Anabaenopsis, Dermocarpa, Stichosiphon and Malleochloris. From the data, there appears to be no distributional gradients either vertically or linearly. Total productivity (standing crop) appears to be slightly decreased during October and January [103].

Populations of zooplankton, limited primarily to a few species of rotifers, cladocerans and copepods, are small but characteristic of saline-alkaline waters [102]. According to Pennak [112], and Reid [113], the rotifers Brachionus, Keratella, Asplanchna, Nothalca and Filinia and the copepod Eurytemora affinis are common in such waters, although rotifers are usually poorly represented in brackish habitats. In addition to those listed above, other zooplankton collected were the cladocerans Bosmina, Daphnia and Diaphanosoma and the copepods Cyclops.

Standing crops ranged from an average of 44 zooplankers/liter in May to 12.3 zooplankers/liter in July. Dominant forms in May were Brachionus caudata, Bosimina longirostris, Daphnia pulex and the dinoflagilate Certatium. Brachionus caudata was the most prevalent organism in July [103].

2.7.3.3.3 Benthos

Mecom [103] conducted a study of the benthic organisms in Lake
Granbury. Some sampling sites occurred in the area of the proposed
intake and discharge structures. Standing crops obtained from
these data ranged from zero organisms per square meter in mid-July
to 2,109 organisms per square meter in January. The lack of orga- 1
nisms in July is thought to be a result of low dissolved oxygen
levels in the study area. Dissolved oxygen levels of 0 ppm to 0.5
ppm were recorded at water depths of 17 meters and 15 meters respectively in the intake area during July. Levels of eight parts
per million and above were recorded in the same area in January

The sampling procedures used during this study are described in that report.

1 The dominant benthic organism in Lake Granbury was the gastropod, *Physa virgata*, however, the dominant invertebrates in the samples taken near the dam included the larval forms of the dipterans Chaoborus sp., and Tendipes (Chironomus) sp. as well as adult forms of the oligochaetes Linnodrilus hoffmeisteri and Limnodrilus claparendianus, (Family Tubificidae). Macan [114] reports that certain species of the genus Chironomus (Family Chironomidae) are able to survive in shallow lakes where lack of oxygen may be acute but not prolonged, while other species may inhabit deeper lakes where oxygen may be absent for long periods.

The presence of large numbers of these kinds of organisms can possibly be attributed to bottom type and low dissolved oxygen levels. As stated in Hynes[115] "where only very little oxygen remains in the water, or the river bed is completely covered over with organic solids or sewage fungus, the main inhabitant is always the so-called 'sludge worms' of the Family Tubicifidae. Species of the genera *Tubiflex* and *Limnodrilus* have been most frequently reported from the grossly polluted water, but others may occur, and these two genera are of course by no means confined to foul water. In such places however, they are particularly favored; they have abundant food in the rich organic mud, and they are free from enemies and competitors which cannot stand the low concentrations of oxygen. In areas where the concentration or organic matter is lower, the Tubificidae then begin to be accompanied by chrironomid larvae. Most obvious among them are the large red 'blood worms' which are the larvae of the midge *Chironomus*."

The abundance of organisms collected in the January samples may again be linked to the amounts of dissolved oxygen present at that time. Levels up to eight parts per million of dissolved oxygen were recorded at a depth of 17 meters. Of the 2,109 organisms/square meter collected, the genus *Chaoborus* contributed 95 percent (2,001 organisms) of the total. *Chaoborus* sp. of the Family Culicidae is reported by Pennak[112] to inhabit lakes and ponds frequently. As the larvae feed on algae and detritus, they exhibit a daily migratory action, moving to the bottom during the day, then to the surface at night. Two forms of the benthic organisms sampled considered "not common" to the area are the oligochaete, *Branchuira sowerbyi*, and the odonate *Telebasis* sp. (These forms were found in other portions of Lake Granbury but not in the immediate area of the proposed intake and discharge). However, the majority of the forms taken are common lake fauna [103].

2.7.3.3.4 Fish

There are 30 species of fish representing 11 families in Lake Granbury. The species correspond closely with those described as occurring in the Brazos River. The presence or absence of certain fish in Lake Granbury can generally be attributed to habitat requirements or stocking by Texas Parks and Wildlife personnel. As an example, spotted gar are generally associated with heavy vegetation and quiet waters[116], and are dependent on vegetation for spawning[117]. These conditions occur simultaneously and with greater frequency in Lake Granbury and sections of the Brazos River than in the Paluxy River or Squaw Creek.

Four species of fish (black striped topminnow, plains killifish, stoneroller minnow, and the orangethroat darter) are usually found only in small streams[109,118]. Two species of fish, yellow bullhead catfish and the bullhead minnow, were collected in all the streams in the area, but were not present in Lake Granbury collections[110]. Based on their presence in streams within the study area and in Lake Whitney (located approximately 68 miles downstream on the Brazos River), these species are thought to inhabit Lake Granbury also[119].

The Texas Parks & Wildlife Department is attempting to establish a population of striped bass (Morone saxatilis) in Lake Granbury [104]. This is an anadromous species which normally lives in brackish estuaries and oceans, and spawns in fresh water. However, a sustaining, land-locked population of striped bass was discovered impounded in the Santee-Copper Reservoir in South Carolina in the 1950s. A total of 27,250 fingerlings derived from this population were stocked in Lake Granbury in June, 1972 in an attempt to establish a sustaining population in Texas. (Striped bass fingerlings derived from the Santee-Copper population had been introduced previously into such Texas waters as Lake Navarro Mills, Lake Texoma, E.V. Spence Reservoir, Lake Bardwell, Toledo Bend Reservoir, and the Red River[120]). It was thought that due to the relatively high salinity of Lake Granbury and its major water source, the Brazos River, these waters offered the best possibility of establishing a sustaining population in Texas[121]. The chief requirement for successful spawning appears to be a turbulent enough current to prevent the semi-buoyant eggs from settling on the bottom and being silted over. The eggs are reported as hatching in about 70 to 74 hours at a temperature of 58 to 60°F[122]. It is estimated that an uninterrupted length of some 50 or more miles of fast flowing river would be required, therefore, for successful hatching[120]. The 112 mile distance from the upper end of Lake Granbury to the next upstream impoundment, Possum Kingdom, is well within this basic requirement.

With the exceptions of the upstream spawning runs and the downstream drift of the eggs and developing larvae, the remainder of the life cycle of the land-locked striped bass is spent in the lacustrine environment. It is in this environment that adverse effects of plant operation (if any), relative to the striped bass, should be manifest.

2.7.3.4 Aquatic Biota of Paluxy & Brazos Rivers

2.7.3.4.1 Aquatic Vegetation

Aquatic vegetation in the Paluxy River does not differ measurably from that found in Squaw Creek. Submersed plants found in the Paluxy River include pondweed (Potamogeton sp.), muskgrass (Chara sp.), and green algae (Cladophora sp.). Littoral emergent plants along the stream include cattail (Typha sp.), bullrush (Scirpus sp.), horsetail moss (Equisetum sp.), saw grass (Caldium sp.), and willow (Salix sp.)[104].

There is very little flora in the Brazos River. Lamb[106], states that "there is little or no aquatic vegetation in this (Brazos) watershed since these streams are subject to the scouring effect of intense floods. The flooding, together with the release of water from the dams on the Brazos and Leon Rivers, tend to prevent the growth of the large aquatic plants".

2.7.3.4.2 Plankton

Little is known about the phytoplankton and zooplankton which inhabit the Brazos and Paluxy Rivers within the study area. Plankton in these areas are presently being studied, but data are not yet available.

Plankton in the Brazos River will be quite similar to that found in Lake Granbury. Lake plankters that have developed in reservoirs usually predominate in the streams into which they discharge if they join no streams with greater discharge[123]. Mecom[103], has described the phytoplankton population found in Lake Granbury as being dominated by the green algae Actinastrum gracilliinum.

Predominant zooplankters recorded were the rotifer Brachionus caudata and the cladocerna Bosmina longirostris. (For more information concerning Lake Granbury results, see Section 2.3.3.3). Many of these same forms will be swept over De Cordova Bend Dam into the Brazos River. Actual species composition will be determined during the baseline survey presently underway.

The plankton to be found in the Paluxy River will probably be similar to that found in Squaw Creek due to similarities in bottom types, chemical make-up, and drainage areas.

2.7.3.4.3 Benthos

The macroinvertebrate fauna of the Paluxy and Brazos Rivers near the site area are not known. No field data are available. Some general comments regarding potential communities are presented in the following paragraphs.

The substratum of the Paluxy River is composed of bedrock with boulders, small rocks, and gravel in the riffles. The kinds and types of organisms will probably approximate those found in Squaw Creek, with a reduction expected in population within individual species.

Benthic organism types found in the Brazos River should be fewer in number than those to be found in either Squaw Creek or the Paluxy River due to bottom type. The substrate consists mostly of sand with some gravel, and this type of bottom is not considered to be rich in numbers of species[108]. Stewart[124], described the benthic organisms in a substrate similar to that of the Brazos River near the study area to be few in species and few in numbers.

2.7.3.4.4 Fish

There are 29 species of fish representing 10 families in the Paluxy River[104]. A complete listing of these fishes is contained in Table 2.7-18. Fish which differ from those species found in Squaw Creek include longnose gar, threadfin shad, smallmouth buffalo, carp, flathead catfish, white bass, warmouth sunfish, and the freshwater drum. Of these eight species, three are considered game fish (flathead catfish, white bass, and warmouth sunfish); the remaining five are considered rough fish.

Fish species found in the Brazos River are represented by 34 species and 12 families. (See Table 2.7-18). The only fishes not collected in the Brazos River, but found in the study area, are the plains killifish and the striped bass. According to Cross [125], the plains killifish occurs mainly in smaller streams and rivers and is rarely found in water more than six inches deep.

The striped bass has recently been stocked in Lake Granbury, (See Section 2.7.3.3) and it is suspected that some of these fish will be "washed" downstream into the Brazos River below De Cordova Bend Dam.

2.7.3.5 Regional Fisheries Data

The following subsections present general background information on the types of fish in the area, their reproduction and migratory habits and their sport or commercial value.

2.7.3.5.1 Reproduction Requirements

Reproductive periods for fish inhabiting Squaw Creek and adjacent waters generally extends from early spring through late summer. Spawning activity is basically dependent on water temperature and photo period.

Based on their roles in food-web relationships, fish are divided into three basic categories: game fish, rough fish, and forage fish. The spawning periods and factors involved in reproduction for representative species of each group are given in Table 2.7-20. A general discussion of the species included follows:

Game Fish: Representative game fish include channel catfish, flathead catfish, largemouth bass, warmouth, and green and bluegill sunfishes.

Mature channel catfish in Texas spawn during May or June as water temperatures approach 75°F. Preferred spawning habitat includes areas such as overhanging rock ledges, deeply undercut banks and hollow logs [120]. As noted in Trautman[116], "adults appear to be highly migratory, ascending surprisingly small streams for the purpose of spawning". The normal spawning period of the flathead catfish begins in late May and extends through August. Similar to the channel catfish, flathead males select hollow logs, underwater caves and rock crevices as nesting sites.

Members of the sunfish family begin spawning in spring as water temperatures reach 60°F. (Some species require slightly higher temperatures). The largemouth bass also spawns when water temperatures approach 60°F. This species prefers to nest in quiet water two to eight feet deep, often on the roots of aquatic plants[120].

Warmouth sunfish spawning commences when water temperatures reach 70°F[126]. They are known to spawn over a long period of time and under varied conditions. In Texas, Toole[127] reported, "one pair of these fish was observed to spawn three different times during one year from April to October". Larimore[126], noted that both bottom materials and cover influence the selection of nest location. "In Park Pond (Illinois), warmouths nested among weed masses, stumps, roots, and brush; they nested in areas where the water was less than four feet deep..." and that "no nests were found on clean sand (such as is often selected by bluegills and pumpkinseeds)".

The green sunfish nests in colonies in shallow water near shore. Spawning begins in late spring when water temperatures reach 60°F and extends through mid-August.

Bluegills spawn over an extended period of time, beginning when water temperatures reach 70°F and continuing until cool weather in the fall. Males usually choose nesting areas over clean sand or gravel bars in waters one to four feet deep. This lengthy season (May through September) is often responsible for overpopulation in smaller bodies of water.

Rough Fish: Rough fish can be described as those fish being of little or no sport value to local fishermen. Fish are often termed rough fish due to their small size (e.g., black bullhead catfish), poor-tasting flesh, or when they are thought to be a pest and a threat to game fish populations (e.g., gar and carp) [120]. Many of these species are of considerable commercial value, however (Section 2.7.3.5.3).

Of the 11 rough fish species listed in Table 2.7-18, six representative species have been selected for discussion of their requirement for reproduction (Table 2.7-20). These species include: spotted gar, longnose gar, smallmouth buffalo, river carpsucker, gizzard shad, and black bullhead catfish.

As noted by Echelle and Riggs[128], spawning times in Lake Texoma for both spotted and longnose gar commenced in April and continued until late May. Spawning was observed at water temperatures from 68 to 86° F. Spotted gar were observed to spawn over dead vegetation and algae mats in quiet, weedy waters and longnose gar spawned over algae and bare rock along windswept shorelines and rocky points. Longnose gar are also reported to spawn in shallow, weedy bays, depositing its eggs on submerged vegetation or aquatic plant roots[117].

The smallmouth buffalo spawns in spring when water temperatures approach 60°F. Spawning takes place randomly over weed beds or mud bottoms in rivers and lakes[120]. (The term "random spawning" refers to the type of spawning when eggs are not deposited in a nest, but are distributed over large areas). Random spawning occurs with all rough fish species discussed in this report with the exception of the bullhead catfishes.

Jester[129], reports that a summary of all observations of spawning activity of river carpsucker indicates that spawning is controlled largely by temperatures. The spawning season may occur between early April and early August in a range of 18.3 to 24°C. Spawning takes place in shallow water (one to three feet deep), over bottoms of sand and silt.

As with the river carpsucker, the spawning season for gizzard shad is dependent on water temperature and occurs at different times from year to year. Jester and Jensen[130], report that gizzard shad spawn from early May through late June at temperatures from 64 to 75°F. A second spawn may occur in late summer. Gizzard shad are known to spawn over a variety of bottom types ranging from sandy, gravel-covered bars to shallow silt beds. Shad generally spawn in shallow water but have also been observed spawning at the surface where water was 50 feet deep.

Although the adult gizzard shad is known as a rough fish, the juvenile shad serves as a valuable forage source for game species. Shad have the ability to utilize plankton and convert this resource to food for predaceous fishes.

As previously stated, the bullhead catfish is considered by Texas Parks & Wildlife personnel as a rough fish in waters near the site area[101]. Two species inhabit the waters of Squaw Creek, the yellow bullhead and the black bullhead. Spawning requirements are similar for both species, and only the black bullhead is discussed in this section. Dennison and Bulkley[131], report that black bullhead catfish spawn in May or early June when water temperatures average 68°F. Nests are usually constructed in water two to four feet deep in weedy or muddy areas[117]. Due to its prolific nature it "has the tendency to overpopulate its environment[120].

Forage Fish: Forage fish are those species which serve as food for other fish during some stage of their life cycle. The species described in this section inhabit Squaw Creek and are considered to be the primary sources of forage in the area. It should be noted that the young of all fish species can and often do serve as forage fish. Those considered here can generally be classed as "minnows" which seldom exceed six inches in length as adults. These include the stoneroller minnow, flathead minnow, plains killifish and the red shiner. The forage value of the young gizzard shad has been discussed in the previous section.

The stoneroller minnow is reported by Simon[118] to spawn in May or June. This species ascends smaller streams where it builds nests along the downstream edges of pools in small gravel-bottomed creeks when water temperatures exceed 60°F.

The flathead minnow is a species commonly stocked in lakes and ponds across the United States as a forage fish. Spawning occurs in May through August when water temperatures exceed 16°C (60.8°F). Eggs are laid in quiet shallow water on various kinds of substrates.

The plains killifish is known to spawn from April to August when water temperatures approach 80°F[132]. Spawning usually occurs over gravel in shallow pools where the current is very weak. The plains killifish is also important in reducing mosquito larvae in areas where both fish and larvae are abundant.

As reported by Everhart and Seaman[133], the red shiner deposits its eggs among debris, aquatic plants and other substrates in June and July. Spawning may begin when water temperatures approach 68°F. The red shiner's usual habitat is in quiet streams and ponds[118].

2.7.3.5.2 Sport Fishing

No creel census data have been developed to date for Squaw Creek, the Paluxy River, that portion of the Brazos River immediately below Lake Granbury, nor Lake Granbury itself (with the exception of spot checks involving 25 fishermen or less). It is not possible at present, therefore, to assess the area's sport fishing quantitatively. However, it can be said that with the exception of intermittent Squaw Creek, sport fishing is significant in these water bodies.

The principal sport species are largemouth bass, spotted bass, channel catfish and flathead catfish. The striped bass may become an important addition to the Lake Granbury Fishery in the future (Section 2.7.3.3.4).

2.7.3.5.3 Commercial Fishing

Rough fish can be of commercial value[134]. During the course of a rough fish control program on Possum Kingdom Lake, located on the Brazos River near Mineral Wells in Palo Pinto County, contract netters were allowed to sell the undesirable species to defray the cost of their operations. The retail market value of fish taken from Possum Kingdom Lake for the period November 1, 1955 through October 31, 1956 was reported to be $38,917.23. Of approximately 43,000 rough fish caught, 85 percent of this number was smallmouth buffalo (Ictiobus bubalus).

At present, commercial fishing occurs only on Lake Whitney, located approximately 68 miles southeast of DeCordova Bend Dam. The present day retail market value of fish netted in Lake Whitney during the period March 20, 1972 through March 19, 1973 was reported to be $47,282.05. A commercial catch of 31,000 fish were taken during this period of which 88 percent were smallmouth buffalo (Ictiobus bubalus). 1

No commercial fishing has occurred on Lake Granbury to date.

This information was provided by the Texas Parks and Wildlife Department.

2.7.3.5.4 Nursery Areas

There are no major nursery areas near the site.

2.7.3.5.5 Migration

Migration in the area is limited to the movement of mature fish into local tributaries for spawning. Anadromous and catadromous fish migration is obstructed by several large dams located on the Brazos River, both above and below the area of the proposed site. Possibly the longest migration occurring in the area will be that of the striped bass from Lake Granbury up the Brazos River. This has been discussed in more detail in Section 2.7.3.3.

2.7.3.6 Pre-existing Stress on the Aquatic Environment

2.7.3.6.1 Pesticides and Herbicides

Pesticide and herbicide use in Hood and Somervell counties is given in Tables 2.7-3 and 2.7-4. Pesticides used in the area include Aldrin, DDT, Diphenylamine, Lindane, Methoxychlor, Malathion, Ronnel, Rotenone, Sevin and Toxaphene. Herbicides used include Treflan, Atrazin, Princep, 2,4-D, 2,4,T-5, TCA and Ammate-X.

At present, water quality data are not available to determine if pesticide-herbicide residues are present in Squaw Creek or adjacent waters. Texas A & M University has initiated studies to evaluate the level of pesticide residues, if any, present in the aquatic system. A general discussion of the potential influence of pesticides and herbicides is presented in the following paragraphs.

Pesticides. The effects of pesticides on the productivity of natural phytoplankton communities are well illustrated by Butler [135]. Seven of the pesticides used in his study area were shown to decrease phytoplankton productivity from seven to 90.8 percent during a four-hour exposure to a concentration of one ppm. Butler also states that, "although a majority of the chemicals tested caused a significant decrease in productivity at one ppm, at lower concentrations, an increase in productivity rate was frequently observed. This was apparently due to the fact that the pesticide was toxic primarily to the animal part of the community".

A great deal of information is available on pesticide effects on aquatic organisms. DDT is known to drastically affect the aquatic environment. As reported by Bridges and Andrews, [136] "In 1960, studies were made on the effects of aerial application of DDT for spruce budworm control in the Gallatin River Drainage in Montana. Measurements on a tributary, Swan Creek, showed that a drastic kill of aquatic invertebrates took place, leaving the sprayed portion of the stream essentially devoid of bottom organisms." It was also noted that, "there were no apparent acute effects on fish" at that time. The DDT, 24-hour LC_{50} (1) in micrograms/liter (ug/l) (2) for bluegill and redear sunfishes are given in Reference [135] as five to six ug/l and 19 ug/l, respectively. The 24-hour LC_{50} for Aldrin was 10 ug/l for the bluegill sunfish. In the testing of heptachlors effect on redear sunfish, 24-hour LC_{50} ranged from 0.022 ppm to 0.092 ppm depending upon temperature. LC_{50} values in parts per million of Malathion to bluegill sunfish for 24-hours range from 0.07 ppm to 0.28 ppm depending on temperature.

The insecticides Rotenone and Toxaphene have been used as pesticides in the past. Rotenone is reported by Lennon [137] as the most widely used fish toxicant. The 48-hour LC_{50} for bluegill exposed to Rotenone is 0.022 ppm as reported in Reference [138]. Toxaphene became the second most used toxicant in the United States in the 1950's before its dangers were appreciated. Because of the known hazards, the Bureau of Sport Fisheries &

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(1) LC_{50} Lethal concentration 50, is the concentration of toxicant in the environment which kills 50 percent of the test organisms exposed to it. The expression is used by biologists working with aquatic organisms in water contaminated with a toxicant.

(2) ug/l Micrograms per liter, is another expression much the same as the ratio of ppb, as the weight of a liter of water is approximately 1,000,000,000 micrograms, but the weight in micrograms of toxicant per volume of material is given.

Wildlife banned further use of Toxaphene as a fishery tool in federal operations in 1963 [137].

The pesticides discussed are those commonly in use or those which have been frequently used in the past which might occur in water quality samples.

Herbicides. According to Sanders, [139] the herbicide "2,4-D showed the greatest range of toxicity to the crustaceans, ranging from no apparent effects at 100 mg/l for crayfish to a 48-hour TL_{59} (3) value of 0.10 mg/l for daphnia," (Cladocera). Additional results showed that "daphnia were found to be generally most sensitive to the herbicides tested, followed in descending order of sensitivity by seed shrimp (Ostrocoda), glass shrimp (Decopoda), sowbug (Isopoda), scud (Amphipoda) and the crayfish (Decopoda). The 48-hour TL_{50} for bluegill sunfish ranged from 0.90 milligrams per liter (mg/l) to greater than 100.0 mg/l depending upon the herbicide vehicle used.

The effects of Princep (Simazine) on the aquatic ecosystem are discussed in Reference [138]. LC_{50} levels over a 48-hour exposure period for bluegill sunfish, stoneflies, and amphipods were 118 ppm, 50 ppm, and 21 ppm, respectively. The LC_{50} levels of Treflan (Trifluralin) on bluegill sunfish over a 48-hour period range from 0.008 ppm to 5.9 ppm depending on temperature. The 48-hour LC_{50} levels for cladocera, stoneflies, and amphipods were 0.24 ppm, 4.2 ppm, and 5.6 ppm, respectively.

The herbicides discussed are those commonly in use or those heavily used in the past which might be present in water quality samples.

2.7.3.6.2 Inorganic Nutrients and Organic Materials

Inorganic nutrients are added to the aquatic system through direct runoff from agricultural agreas and indirectly by groundwater seepage into streams. The addition of nutrients affects the entire aquatic food chain from bacteria to the highest level carnivore. Nutrient pollution is often evidenced by a large abundance of aquatic plants and phytoplankton.

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(3) TL_{50} (TLm) Median tolerated limit, is the median amount or concentration which produces mortality to 50 percent of the tested population in a given period of time. Commonly used periods in fisheries experiments are 24 hours (24-hour TLm), 48 hours (48-hour TLm), or 96 hours (96-hour TLm).

Organic material serves as a base component of the aquatic food chain. Additional organic material is introduced to Squaw Creek through local agricultural practices. Waste products from livestock grazing in the reservoir area increase the organic load in the creek. Although a quantitative estimate of increased organic amounts cannot be made at this time, it is probable that this is an important stress on the aquatic environment of Squaw Creek.

Texas Parks & Wildlife Department biologists have reported that pollution in Squaw Creek is limited to land usage in the area and a small effluent below the Y.W.C.A. camp. Effluent from the Y.W.C.A. swimming pool was found to be increasing the chloride content of the water from 320 ppm to 770 ppm.

2.7.3.6.3 Heavy Metals

Compounds of many metals are known to be lethal to fish and other aquatic organisms, since they alter the mechanism used by fish to rid themselves of particulate matter deposited on the gills or body surface, coagulating and precipitating the mucus secreted by the gills of fishes [140]. In addition, some metallic salts, if present in sufficient quantities, may increase the acidity of the water to a level dangerous for aquatic life [141].

The presence of heavy metal ions in the aquatic ecosystem will be determined during the baseline survey. Specifically, tests will be conducted to determine the concentration levels of the following heavy metals:

Arsenic
Mercury
Cobalt
Iron
Nickel
Lead
Chromium
Zinc
Manganese
Cadmium
Molybdenum
Copper

2.7.3.6.4 Fish Kills

Fish kills are known to have occurred in the study area. In late summer of 1972 (August 17, 1972) a minor fish kill was observed on Squaw Creek. No visible signs as to the cause of the fish kill were evident at that time. The frequency of fish kills on the creek is not known.

A fish kill in the Paluxy River was recorded on July 10,1971. This kill was attributed to the dumping of Rotonone by local inhabitants [104].

2.7.3.6.5 Lake Granbury

A 775 megawatt electrical power generating facility is presently under construction at Walters Bend on Lake Granbury and is expected to begin operation in 1975. Cooling water will be discharged into Lake Granbury via a drainage canal approximately eight miles upstream of DeCordova Dam.

The DeCordova Steam Electric Station is a gas/oil fired unit which uses water from Lake Granbury for once-through condenser cooling water. The station condenser is a single pass surface condenser containing 312,360 square feet of surface. Four-113,000 gpm lake-water circulating pumps are installed at a conventional outdoor type intake structure near the station. After the lake water is pumped through the condenser, it is returned to the lake upstream from the station through a 7978-foot long discharge canal.

The heated effluent from the DeCordova Steam Electric Station is expected to have very little, if any, effect on water temperatures at the depth of the SCR diversion intake in Lake Granbury. This opinion is based on results presented in the study; <u>Thermal Aspects of a Proposed Power Plant on Lake Granbury</u>, prepared by W.G. Wyatt and D.C. Price for Texas Power and Light, Dallas, Texas, September 15, 1970.

2.7.3.7 Succession

Comprehensive studies on the progress of succession of fish fauna 1
in Texas reservoirs are not presently available; however, general trends are well known. Texas rivers generally contain a high ratio of rough and forage fish to game fish. Upon impoundment, fast growth rates and quick attainment of sexual maturity initially favor predacious fishes such as the bass, catfish and sunfish. After about four to six years of desirable rough to game fish ratios, however, the trend again shifts to favor the rough fish. Carp, shad, gar and buffalo eventually attain sizes that allow them to escape predation. Such an uncontrolled adult population leads to higher productivity among the rough fishes. Headed effluents may alter this succession, first by adding stresses that delay successional maturity and second by favoring the replacement of gizzard shad which is more easily controlled by predators. Also, increased temperatures could speed up developmental rates thereby favoring certain fast growing predatory fishes.

2.7.3.8 Temperature and Salt Tolerances of Fish in Heated Reservoirs

Two Texas reservoirs with temperature conditions similar to those expected in Squaw Creek Reservoir are Lake Colorado City and Lake Alcoa located in Mitchell and Milam Counties respectively. Lake Colorado City, constructed in 1949, has a capacity of 31,970 acre-feet and a surface area of 1,618 acres. Lake Alcoa has a capacity of 10,500 acre-feet, a surface area of 703 acres and was completed in 1953. According to Drew and Tilton[172], temperatures of up to

102°F have been recorded at this lake. Similar temperatures have been recorded in Lake Colorado City during warm weather conditions. It should be noted also that Lake Alcoa has maintained the highest nettable weight of fish taken for each foot of net set than the other reservoirs in Texas.

Literature on temperature tolerances of fish in Texas is somewhat limited. Most temperature tolerance work has been conducted under laboratory conditions which often times does not exhibit conditions
1 encountered in the field. For example, Clark[173], lists the upper lethal limit of the largemouth bass (*Micropterus salmoides*) to be approximately 96°F, whereas Drew and Tilton[172] report this species to be caught on hook and line at 101.6°F in Lake Alcoa, Texas. Such variance in data is not uncommon due primarily to varied conditions under which tests are run. Other literature which describes tolerances of fish for temperature and salt includes Alpaugh[174], Hubbs[175], Hubbs and Burnside[176], and Hubbs, et al. [177].

Due to the relatively high salinity of the Brazos River, it is reasonable to assume that species presently found there adapted to salt levels above those found in many Texas reservoirs. High salinity levels may favor establishment of a striped bass population in Lake Granbury (see Section 2.7.3.3.4) and result in improved sport fishing for this lake. There is some indication that the zooplankton population is dominated for forms considered to be "brackish" (Mecom, 1972). No other definite statements can be made until more collections have been examined.

2.7.4 INSECTS

2.7.4.1 General Entomology

There are so many species of insects and so many individual insects that they have attained a great ecological importance throughout the biosphere. Their primary function is to convert plant tissues to animal tissues. Insects, because of their small size, are closer to the bottom of the consumer food web than are the larger animals. Odum and Smalley [142] discussed the importance of a herbivorous grasshopper in the coastal salt marsh ecosystem. Needham, Traver, and Hsu [143] found that the aquatic nymphs of the Ephemeroptera eat mostly vegetative matter, especially diatoms, green algae (non-filamentous), and fragments of higher plants. These insects in turn feed the small forage fish which feed the larger fish. Crossley and Howden [144] and Crossley [145] discussed the consumption of vegetation by insects and the mineral nutrient recycling which is accomplished thereby. Arthropods, especially insects, are the vector of numerous diseases of man. An excellent introduction to medical entomology can be found in Herms and James [146].

2.7.4.2 Entomology of Site Region

Many studies have been done in the general site region. [148] Bromley discussed cicadas in east central Texas. Ferguson [149] published on the dragonflies of Dallas County. Glass [150] wrote a masters thesis on the aquatic beetles of the Dallas area. Hall [151] wrote on the caddisflies of Dallas County. Keeton, Kerby, Murphy, and Faulkner [152] wrote on the bottom fauna of Benbrook Lake in Tarrant County. Moore [153] wrote a masters thesis on the mayfly nymphs in the streams of Dallas County. Freeman [154] wrote on the hesperid butterflies of Dallas County. Hess [155] wrote on soil texture and the ants of Dallas County. McClusky [156] wrote on the bionomics of the mosquitoes of the Dallas area. Millspaugh [157] wrote on the bionomics of the Hemiptera of Dallas County. Strecker [158, 159] wrote on butterflies of the vicinity of Waco, Texas. These studies congregrate around the major universities of the area, primarily SMU in Dallas. No ecological study of the insects of Hood and Somerville counties has been found in the literature.

Limited entomological information pertinent to the site is found in a publication on the beetles of Central Texas which lists records from the Brazos River at Granbury [147]. The species found at Granbury are listed in Table 2.7-21.

2.7.5 SOILS

Soils at the CPSES and SCR are shown in a profile of the plant and reservoir sites (Figures 2.7-2a and b). Soil descriptions were based on investigations conducted by the U.S. Soil Conservation Services.

Only six soil series were identified (Bosque, Lewisville, Tarrant, Hassee, Pedernales, and Windthorst) along the environmental profile (Figure 2.7-2), however, a total of 13 soil series were identified on the CPSES site area. The 13 soil series are described in the following paragraphs.

2.7.5.1 Bosque Series Soils

The Bosque soil is a well-drained, moderately permeable, calcareous, bottomland soil (flood plain). It has a dark grayish brown loam surface and a brownish clay loam subsoil. The soil depth is 50 to 60 inches. It has formed in calcareous alluvial sediments. Slopes are mainly less than one percent. Most areas are being farmed to sorghums, small grains, and pecan orchards. Some areas are used for bermudagrass pastures. Native trees are elm, hackberry, pecan, and cottonwood. Grasses include big and little bluestems, Indiangrass, switchgrass, and sideoats grama. [166].

The soil supports, on the average, 6.5 animal unit months (AUM). An animal unit month is the number of months that one acre of improved pasture will support one animal unit equivalent to a 1000 lb. steer or one cow and her calf.

2.7.5.2 Lewisville Series Soils

The Lewisville soils are well-drained, moderately permeable, calcareous soils formed in old alluvium along major streams. They have dark grayish brown clay surface layers and brownish silty clay subsurface layers. Slopes range from zero to ten percent, but are predominantly two to about six percent. The soils are mostly cultivated, mainly to small grains. Originally vegetation was mid and tall grasses and a few widely separated elm, hackberry and mesquite trees. [167].

The soil supports, on the average, five to six animal unit months. The higher productivity results when the slope ranges from zero to three percent. The lower figure results when the slopes range from five to ten percent.

2.7.5.3 Tarrant Series Soils

The Tarrant stony soils are well drained, stony, shallow, upland soils overlaying Glenrose formation (limestone). They are a very dark grayish brown cobbly clay. Slopes are mainly one to eight percent, but range up to 40 percent. The soil contains 35 to 65 percent, by volume, coarse fragments of limestone. The soil depth ranges usually less than 20 inches to hard limestone. Tarrant stony soils are used entirely as rangeland. The original vegetation included little bluestem. The present range is buffalograss, Texas wintergrass, green sprangletop, threeawn, panicum, agarito, prickly-pear, a few mesquite, many live oak and yucca [168]. This soil is only suited for range. 2

2.7.5.4 Hassee Series Soils

Hassee fine sandy loams are deep, somewhat poorly drained, very slowly permeable upland soils. They have grayish brown and light gray massive loam A horizons resting abruptly on blocky, dark gray and grayish brown clay Btg horizons that contain carbonate in the lower part and grade to calcareous Cca horizons. Slopes range from zero to three percent, but are dominantly less than two percent. The soils are mainly cultivated to forage sorghums, grain sorghums, and small grains. Native vegetation is a sparse cover of mid and short grasses, and mesquite with a few scattered post oak trees [169]. 2

The potential yields for this soil type are as follows: 3,000 pounds of grain sorghum per acre, 30 bushels of oats per acre, 5.5 animal unit months for improved pasture.

2.7.5.5 Pedernales Series Soils 2

Pedernales soils are well-drained, moderately permeable upland soils. They have a reddish brown fine sandy loam surface with red sandy clay subsoil over light reddish brown calcareous, sandy clay loam. These soils occupy nearly level to sloping landscapes with slopes ranging from 0.5 to eight percent [164]. They are largely cultivated and used mainly for growing grain sorghums, small grain, peanuts, and peaches. Native vegetation is post oak, mid and tall grasses [170]. 2

The potential yields can be variable and range as follows: oats can range 35 to 65 bushels per acre, wheat ranges from 20 to 30 bushels per acre, the animal unit months on improved pasture range from three to four. 2

2.7.5.6 Windthorst Series Soils

Windthorst soil is a moderately well-drained, moderately permeable soil on uplands. It has grayish brown to light yellowish brown 3

fine sand loam surface layers, and red to yellowish red blocky sandy clay subsoils that become prominently mottled with red, yellowish brown and pale brown below 38 inches. Slopes are
2 gentle to steep, and range from one to eight percent [171]. Depth to rock is more than 40 inches.

Many of the gently sloping areas are cultivated; peanuts, sorghums and small grains are the main crops. Many steep areas have eroded and are now in pasture. Native vegetation is post oak and blackjack oak trees with a ground cover of little bluestem, greenbriars, and annual grasses [171].

The potential yields are highly variable depending on slope. The
2 potential yield for peanuts ranges from 800 to 1,200 pounds per acre, oats range 25 to 40 bushels per acre. The potential yield for improved pasture ranges from three to six animal unit months.

2.7.5.7 Thurber Series Soils

Thurber clay loams occur in valley or streamhead positions, are moderately well drained and very slowly permeable upland soils. The A horizon is 4 to 12 inches of dark grayish brown clay loam resting on brown clay B21t, B22t and Cca horizons. The C horizon is yellowish brown clay from 48 to 62 inches in depth. The soils are mildly alkaline. Surface gradients range from zero to three percent but are predominantly less than two percent.

Thurber soils are used primarily for rangeland but small grain and sorghum are cultivated on small acreages. Buffalograss, curly mesquite, vine-mesquite grass, and Texas wintergrass are common members of the native flora occurring on these soils [183].

2 High level management of coastal Bermudagrass on Thurber Series Soils will yield 4 animal unit months. The Thurber soils will yield 1500 lbs/acre of grain sorghum or 35 bu/acre of oats.

2.7.5.8 Bolar Series Soils

The Bolar series soils are well drained, moderately permeable with surface gradients ranging from one to five percent but as much as eight percent has been noted for these upland soils. The Bolar soils are calcareous soils with dark brown clay loam A horizon, a pale brown B horizon followed by an R horizon of indurated limestone bedrock. Fragments of limestone and $CaCO_3$ concretions of gravel to stone sized particles are present from 15 to 35 percent by volume in the lower horizons. The depth to rock ranges from 20 to 40 inches. The Bolar soils support pasture and native range of midgrasses, including little bluestem and sideoats grama [184].

The Bolar soils support from 4.5 to 5.0 animal unit months. The highest production occurs on slopes from one to five percent and the lowest on slopes greater than five percent. These soils are capable of yielding from 25 to 40 bu/acre of oats and from 2000 to 2250 lbs/acre of grain sorghum. The lower yields are on the steeper surface gradients.

2.7.5.9 Krum Series Soils

The Krum silty clay soils are well drained with a moderately slow permeability. They are located along stream terraces and along stream valleys with slopes that range from zero to eight percent. The A horizon is moist, dark grayish brown silty clay that extends through cracks into a similar textured B horizon. Fine concretions of $CaCO_3$ occur in the Band C horizons ranging from five percent by volume in the former to two percent by volume in the latter horizon.

Agriculture occupies two-thirds of these soils while the remainder is used for rangeland. Sorghums and small grains are common cultivated crops whereas both tall and mid grasses and clumps of live oak and other hardwood trees occupy the rangeland [185].

The Krum series soils are capable of yielding between 4.5 and 8.0 animal unit months. The highest number of animal unit months occur on slopes from zero to three percent and the lowest on those of five to eight percent. The yield of crops on cultivated soils ranges from 40 to 70 bu/acre of oats and 3500 to 4000 lbs/acre of grain sorghum.

2

2.7.5.10 Frio Series Soils

The Frio silty clay soils occupy flood plains, are well drained and have a moderately slow permeability. These soils are formed along streams that drain soils formed from limestone. The dark grayish brown A horizon is fine granular to moderately fine subangular, blocky structure and moderately alkaline. Clay content is between 35 and 50 percent. The B horizon is replaced by the Cca of dark grayish brown silty clay with a minor occurrence of $CaCO_3$ masses in a soft powdery form. The surface gradient ranges from zero to two percent. The depth to gravel, sand or limestone ranges from 6 to 30 feet. The Frio soils are primarily cultivated to crops of cotton, corn, and grain sorghums. Native vegetation is an open canopied forest of pecan, elm, and oak. A variety of productive grasses are present resulting in favorable rangeland [186].

The Frio series soils are capable of yielding 6.5 animal unit months. Crop yields include 35 bu per acre of corn and 4,000 lbs per acre of grain sorghum.

2.7.5.11 Menard Series Soils

The undulating uplands occupied by the Menard fine sandy loam range in gradient from one-half to eight percent. Permeability is moderate and the soils are well drained. The A horizon, which ranges through various shades of brown sandy loam, is neutral to mildly alkaline. The B2t horizons are reddish brown to yellowish red in color and sandy clay loam in texture. The B3ca horizon is an intense brown, weakly blocky structure, and contains some $CaCO_3$. Limestone fragments, nodules of $CaCO_3$ or a few concretions are present in 5 to 20 percent of volume of the Cca horizon. Depth to rock is over 60 inches. The cultivation of grain sorghum, small grain, peanuts, and peaches are common on the Menard soils. Native grasses include mostly little bluestem, sand lovegrass, purpletop, sand dropseed, tumble windmill grass, and hairy tridens. Woody vegetation consists of post oak, mesquite, white brush, tasajillo, prickly pear, and Texas persimmon [187].

The Menard fine sandy loam will support, under high level management, between 4.5 and 5.5 animal unit months depending on the surface gradient. These soils are capable of such crop yields as 1200 lbs per acre of peanuts, 1250 to 17,500 lbs per acre of grain sorghum, or 35 to 40 bu per acre of oats.

2.7.5.12 Selden Series Soils

2 The Selden Series Soils are on uplands, are moderately well drained, and have moderately slow permeability. The surface gradient ranges from one to eight percent. The A horizon is fine sand or loamy fine sand that may be one of several shades of brown. It is neutral to medium in acidity. The B2t horizons are sandy clay loam or clay loam in texture with clay content ranging from 20 to 35 percent. These horizons are often coarsely mottled with yellow, light gray and red. The acid content is slightly higher than found in the A horizon. The C horizon is absent with rock more than 60 inches deep. Pasture is the predominant land use of the Selden Series Soils. Peanuts, sorghums, and vegetable crops are farmed in a few areas. Native vegetation includes an overstory of post oak and blackjack oak with an understory of greenbrier, little bluestem, and purpletop tridens [188].

The Selden soils will support 5.5 animal unit months on slopes of one to five percent and fewer AUM's on steeper slopes.

2.7.5.13 Purves Series Soils

Purves Series Soils are found on uplands with a slope gradient range up to 5 percent. These soils are well drained and have a moderately slow permeability. These soils are shallow ranging in depth from 8 to 20 inches overlaying limestone. The A horizons may be various shades of dark grey to brown clay loam or silty clay loam. The clay content ranges from 35 to 55 percent and limestone fragments occur from zero to 35 percent by volume. The A horizon is generally followed by indurated limestone rock. The Purves soils are used primarily as rangeland with mid grasses and some live oak and mesquite trees [189]. Purves soils will support as high as 4.0 animal unit months.

2.7.6 ECOLOGICAL SUMMARY

The relationships of a biotic community and its abiotic elements existing in a dynamic state of equilibrium comprise an ecosystem. The ecosystem involves the interactions of organism with organism as well as organism with element. Ecosystems may exist having diverse characteristics resulting from the different components which comprise each ecosystem. The importance of a regional ecosystem is high in the framework of the other ecosystems with which it has associations. In particular, the ecosystem of the Squaw Creek area is important from many standpoints. In describing the interrelated components of the ecosystem, the complexity of the biological communities requires an integrating approach in order to give an understanding of the major functional and energy-flow relationships.

To facilitate a greater comprehension of the entire ecosystem, a diagrammatic representation of the functional relationships that presently exist on the 8876 acre site and in the connecting waterways is presented in Figure 2.7-2. An attempt is made to integrate the information that has been developed separately by the different scientific disciplines. Analysis of the ecosystem is important to an understanding of the energy-flow pathways, the various trophic levels, in addition to nutrient and chemical cycling. By analyzing the input energy to each trophic level as well as the output products, the importance of each component of the system can be drawn into focus. The input energy and output products have an influence on other components of the ecosystem through the energy-nutrient cycles.

To provide an analysis of inter-relationships of the ecosystem, the following paragraphs describe the structural components and functional relationships depicted by the various blocks and directional arrows in Figure 2.7-3. This descriptive material is intended to serve as a background for a subsequent analysis of the projected ecological changes that are anticipated as a result of the construction and operation of CPSES. The analysis of ecological effects during operation is presented in Subsection 11.2.3 which in turn refers to a modified verion of Figure 2.7-3 (i.e. Figure11.2-1) showing altered relationships and the relative degree of impact on each structural component.

2.7.6.1 Savanna & Uplands Vegetation

The vegetation of the savanna and uplands is comprised of several distinct types or zones. Categorized for convenience these vegetative zones are: Cross Timbers, Cross Timbers Savanna, Juniper-Threeawn Uplands, Broomweed Benches and Juniper-Hairy Grama slopes. The diversity existing within each of these vegetative zones is large. However, some of the same species are found to occur in each zone, though the relative frequency of the species may vary considerably. The savanna and upland vegetation is separated from the other vegetation zones primarily as the result of the distinct life forms (i.e. growth forms) found in the area.

Savanna and uplands vegetation holds an important and unique position in the ecology of the Squaw Creek area. The following correlation of environmental factors may help to evaluate the relative importance of the ecological components and to identify the input and output energy sources on which the flora and fauna of the area are dependent.

The savanna and uplands vegetation receives its primary energy inputs from the sun, water, minerals and the atmosphere. Sunlight provides the energy needed for the photosynthetic processes to take place in the vegetation. Water is an important requirement of plants for hydraulic support as well as transport of gases and chemicals. Minerals are a requirement of plants to provide the various electrolytes and physiological cell materials required to conduct normal growth, flowering and reproductive processes. The atmospheric gases, in particular, carbon dioxide and oxygen, are required by the plant to permit photosynthetic processes and respiration to occur. These primary inputs supply vegetation with the materials basic to survival and growth.

Plants supply several important commodities to the biotic community. As a result of being the primary producers in the community, plants function as a foundation of the food web. In this unique position of primary producer, plants provide basic energy in the form of nutrients to the biota. This energy from plants is in the form of forage materials which supply vitamins, starches, sugars and other compounds necessary for the life of terrestrial animals (herbivores). In the savanna and uplands, in particular, the forage value of the vegetation is high owing to the prevalence of grass and shrub species which are used by the animals in this habitat.

In addition to forage provided by the savanna and uplands vegetation, the plants also provide cover and concealment for terrestrial animals which utilize this vegetative zone as habitat. Cover is an important factor governing the rates of predation occurring in terrestrial animal populations. Specifically, the cover for large animals provided by the savanna and uplands is somewhat sparce. This results from lack of a predominant tree or forest canopy. However, small animals and birds which utilize the savanna and upland are provided with adequate cover and concealment.

In addition to providing protection for animals, the vegetation of the savanna and uplands collectively provides protection in addition to enrichment for the soil. The roots of the vegetation in the savanna and uplands provide a "living foundation" preventing the erosion of the soil by wind or rain. Decay or organic material such as leaves, twigs and brush adds a protective cover to the soil preventing erosion and preserving soil moisture. In addition to providing protection to the soil the decaying vegetative matter returns the nutrients to soil. This cycle progresses throughout the successional history of the area. Over a long period the cycle adds to the soil profile.

2.7.6.2 The Riparian

The riparian vegetation zone in the Squaw Creek area has a distinct flora which separates it from other vegetative zones. The riparian can be subdivided into two principal categories: the upper riparian and the lower riparian. The upper riparian has greater diversity of species than is found in the savanna or the uplands vegetation previously mentioned. However, the upper riparian is not as diverse as its companion zone, the lower riparian. The nature of these zones and amount of diversity which occurs within them can largely be explained by greater abundance of water which is a characteristic of estuarian-riparian zones. Availability of water in turn provides for more diversified and abundant vegetative cover in both riparian zones.

Diversity of vegetation is very great in the riparian zones. The diversity within the riparian is much greater than that found in any of the other vegetative zones discussed. Due to the fact that water availability largely dictates the dimensions of the riparian zone it is not very common in the Squaw Creek area with the exception of Squaw Creek itself and several other drainage zones. Therefore, while water provides the requirements that allow the riparian to exhibit greater diversity the lack of water in other areas also restricts riparian development.

Vegetation of riparian areas supply several commodities to the biotic community of which it is a part. First, the riparian provides forage in the form of succulent herbs, forbs and shrubs for terrestrial animals and birds. Secondly, the riparian provides a greater diversity of cover to animals in the form of trees and shrubs.

The riparian provides an enhanced protection of the soil as well as animals and birds that occur within the community. The organic litter from the riparian vegetation covers the soil preventing wind ablation and also preventing erosive action by water. The roots of vegetation occurring within the riparian area also provide some foundation or ground-holding capabilities which are not found in other highly eroded sites. In addition to providing organic material to the soil the riparian vegetation also provides organic material to the streams; in the form of leaves, twigs, brush and other organic litter. Thus, the riparian vegetative zone supplies nutrient cycling in the form of enriched organic material to the animals, to the birds, to the soil and finally to watercourses.

Within the riparian community itself, some distinct differentiation is found. Upper riparian vegetation is less dense and has fewer species than are found in the lower riparian. The greater variety of species occurring in the lower riparian is in large measure dictated by the greater water availability. The upper riparian is dependent on groundwater, interflow water and precipitation water for a fulfillment of its moisture requirements. The uniqueness of the riparian vegetation zone is largely a function of the availability of water and nutrients. Plants of the riparian zones supply several commodities necessary to the terrestrial animals and birds that comprise the associated biotic community. Prevalence of herbs, shrubs and forbs serve to enrich the riparian community and make it one of high forage value. The abundance of organic solids and nutrients in streams and on the soil enhances the functional diversity of the riparian zones.

2.7.6.3 Litter

Litter consists principally of the leaves and other vegetative parts which have been shed at the end of the growing season or period. This input to the litter energy cycle provides food to the decomposers and micro-organisms as well as insects which thrive in the litter mat occurring within the savanna and uplands or in the riparian vegetative zones.

Litter occurring within the Squaw Creek area is principally composed of two main forms: first, organic litter consisting of twigs, leaf litter, mulches, and brush - the undecomposed component of the biotic community. The second major component of litter is humus - litter that has undergone organic aerobic and anerobic decomposition into organic and inorganic components.

Litter also conditions the soil profile by adding humus content to upper horizons of the soil. The litter mat builds the soil profile and also helps to increase the availability of water to plants. Plant roots, bacteria, fungi and small animals found within the surface soil or litter mat enhance the characteristics of the soil.

At the elemental level litter is a storage point in the nitrogen, phosphorus and the sulphur cycles. Carbohydrates in the form of polysaccharoides, monosaccharoides and starches comprise a large proportion of the organic material found in the litter mat.

These compounds, as well as lignins, proteins and amino acids, are food for micro-organisms which mediate in the cycling of nutrients into the inorganic forms required for plant growth.

Organic matter within the Squaw Creek area is not the same in all soils. Leafy organic matter content of the soil horizon is dictated by its vegetation. Soil-building grasses and shrubs serve to build up a rich soil profile in a short time. However, certain decreaser and invader species that merely utilize the soil without returning their nutrient value, readily deplete and leach the soil profile. Thus, the organic matter in that horizon becomes very limited.

2.7.6.4 Natural Soils

Natural soil is both cause and result of many environmental influences to the ecosystem. Soil serves as the starting point in developing carrying capacity of land for both plant and animal communities. In large measure, soil serves as a foundation on which the "pyramid of biomass" is based. Soil is an ultimate storehouse for materials which the plants (the primary producers) require to develop and grow.

Soil in the Squaw Creek area, in particular, is composed of three distinct types. First, somewhat sandy soil exists in the Cross Timbers and Cross Timbers Savanna. Secondly, the limestone soils of the slopes and benches are characteristic of the Squaw Creek area. Finally, alluvial soils can be found in the riparian sites of the Squaw Creek area. The physical and chemical characteristics of soils in the Squaw Creek area largely dictate the types of vegetative and wildlife associations which can succeed under the prevailing climatic conditions. Soils also supply dissolved minerals and other nutrient materials to the aquatic ecosystem.

Natural soils occurring in the Squaw Creek area, or in any area, are important interfaces between the producer, decomposer and abiotic elements involved in the flow and degradation of energy.

2.7.6.5 Roots

The roots occurring in the terrestrial environment are essentially a transfer point in the nutrient cycling profile. Roots absorb nutrient material and transport it in a useful form to the plants of which they are the foundation. Chemical energy is expended in the process of absorbing water and inorganic nutrients and incorporating them into plant components.

Roots provide all of the mineral elements as well as water requirements to the plant. An efficient root network can supply a large vascular plant and cycle the water as well as the nutrients at a phenominally rapid rate. In addition, they provide structural stability to the plant and to the surrounding soil. Highly developed and diversified root systems encourage plant development and good soil profile development, hence fostering natural successional patterns occurring within an area.

2.7.6.6 Stems

Stems function as the pipelines of the plant community. As their input energy, stems utilize sunlight, carbon dioxide, minerals and other inorganic elements. Absorption of sunlight for photosynthetic activity takes place in green stems as well as the other vegetative organs of plants. Carbon dioxide absorption takes place both directly in the stems and through the root network into the stems. Minerals and inorganic elements are absorbed through the root network and transported in vascular bundles contained within the stem. There are many caregories by which stems may be divided. Three useful categories for grouping stems are:

1. Woody stems
2. Shrub and forb stems
3. Grass stems

In the terrestrial ecosystem the stem has four primary functions: support, transport, carbohydrate synthesis, and reproduction. Whether a stem is rigid, upright woody stem, or a climbing vine which utilizes another plant as a foundation, the structure of the stem is uniquely specialized for support of itself as well as its associated plant parts. The stem also serves as a conductor of liquids and dissolved materials. Cellular conduction of materials occurs within the vascular bundles, which are cells specialized for fluid transport. In some stems, primarily green stems, food is manufactured in the form of starches and sugars. In addition to food production, stems are modified for food storage. Stems of some species are modified to the extent that they are potential reproductive structures. These functional positions of stems give them the unique trophic position which they hold in the ecosystem.

Stems of the woody, shrub-herb and grass species which vegetate the Squaw Creek area are an important source of food. Stems provide sugars as well as starches to the terrestrial animals and birds. These are highly valuable forage materials for animals and birds in the late fall and through the winter period when the vegetation productivity is drastically limited. Another important output from stems is the addition to organic litter, in particular, wood, cork, gums, resins, balsams, and fibers which add their various chemical contributions to the humus profile. This organic material eventually reaches the aquatic ecosystem where it provides food, minerals and other materials which affect the aquatic environment.

2.7.6.7 Fruits

Fruits play an important role in the energy-nutrient cycling in an ecosystem. As a source of input energy fruits receive water, gases and mineral elements from the soil. This energy material is absorbed by the roots and carried through the stems and plant organs and finally to the fruits. Fruits are storehouses for proteins, enzymes, fats,carbohydrates, vitamins and minerals. All of these various materials are needed by animal and bird populations found to occupy a regional ecosystem.

Taxonomically, a true fruit is that portion of a plant derived solely from the floral ovary. Any other production from a plant in the form of a body developed as a result of a long period of time is considered to be a vegetative or vegetable part. There are many forms of fruit produced by plants. Indehiscent fruits include achenes, grain, samaras, and nuts. Dehiscent fruits include legumes, follicles, capsules and siliques. Fleshy fruits include the true berries and drupes. Fruits developed not solely from the plant ovary include the false berry and the pome.

In the Squaw Creek area there is a great diversity in the fruits represented. Principal fruits include acorn, sugar hackberry, rustic blackhaw, greenbriar, mesquite beans, juniper berries, prickly pear fruits, Agarito, American beautyberry, pecan, roughleaf dogwood, wild grape and the Virginia creeper. Widespread fruit production serves to meet many different dietary requirements of animals, birds and insects. Because fruits are concentrators of energy they hold an important position in the primary production trophic level.

Fruits supply energy-nutrient materials to the ecosystem in several ways. Fruits contain large amounts of starch and sugar materials as well as enzymes and vitamins necessary for normal growth and reproduction in animal populations. Fruits are enriched embryos and plant species development depends on the animal and bird populations which disseminate them over the expanse of an ecosystem. Finally, perhaps as important as providing food to terrestrial animals, is the process by which fruits replenish the soil profiles. By adding organic replenishment to the litter mat, fruits assist in developing the humus profile and add enzymes needed for decomposition by bacteria, fungi and other soil micro-organisms which exist as components in the ecosystem.

2.7.6.8 Wildlife - Fructivores

Most wildlife receive benefits from vegetation either in the form of food or shelter. Vegetation either supplies food products directly or acts as the substrate for animal life, such as insects, that are eaten by secondary and tertiary consumers among the wildlife community.

The diet of a variety of wildlife include fruits and seeds. For example, pygmy mice feed primarily on seeds of grasses and forbs and white-footed mice feed primarily on shrub seeds and nuts from the oak and pecan [80]. The fox squirrel feeds on seeds, fruits, and other vegetative parts. The opossum, raccoon, skunk, and ringtail cat are omnivorous in their feeding habits of which fruit, seeds, or nuts are a part of the diet.

Birds utilize one or more strata in vegetation between the ground and the top of the crown of trees where food and cover are found. A preference of a specific strata is often dependent upon the specialization of the species to fulfill its dietary needs and the location of those needs in the strata. The granivorous birds occur more often as ground feeders among the grasses and forbs. Fruits may be procurred in any strata from the ground upward by the fructivorous birds.

The fruits and seeds provide nutrients, such as vitamins, proteins and carbohydrates, necessary for metabolic and biologic processes of the animal. The term "biological processes" is used here to mean the maintenance of an animal's health and vitality to assure its place in the social organization within the population and between other species. An environment containing food and adequate cover is ncessary to assure that the species perpetuates itself.

Metabolic processes demand an input of oxygen and food and an output of metabolic wastes as urine, feces, and gases. Urine returns water and nitrogen from uric acid to the soil for the nutrient cycles. Feces are decomposed by invertebrate and microorganism activity into raw nutrients. The nutrients may be lost to the system or returned to the system by uptake in plants.

Mortality within a population returns animal tissue to be decomposed into simpler organic matter. Animals in the second and third trophic levels feed on primary consumers and secondary consumers, respectively, for energy to maintain their metabolic and biologic processes. Wastes incurred from partially eaten carcasses and metabolic wastes of urine and feces are decomposed and returned to the soil as organic matter.

Another output from granivores is the dissemination of seeds. Seeds with hard coats pass through the digestive tract or seeds and fruits are carried elsewhere to be consumed. Seed deposited on the ground may find the organic matter, soil, moisture and micro-climate suitable for germination. This is one factor that assists the natural succession of vegetative communities.

2.7.6.9 Wildlife - Herbivores, Omnivores, Carnivores

Animals that feed on other vegetative parts, including leaves, stems, and roots are classified as herbivores. Herbivores include both grazing and browsing wildlife species. As defined here, grazers feed primarily on grasses and forbs and browsers feed primarily on twigs and leaves of woody plants. Grazers and browsers include only a few birds but many mammals such as the wood rat, cotton rat, brush mouse, rabbits and hare, white-tailed deer and fox squirrel. These species feed on the leaves and twigs of a variety of plants in the Cross Timbers Post-Oak region and timbers along Squaw Creek. Vegetative parts supply the energy and nutrients necessary for the metabolic and biological processes of each animal.

The oppossum, skunk, raccoon and ringtail cat are omnivorous species consuming vegetative parts and fruits as well as animal matter as secondary consumers. Other secondary and/or tertiary consumers on the Squaw Creek reservoir area include the coyote, bobcat, and red fox. These species depend primarily on animal tissue to provide energy.

Herbivores often leave vegetative matter unassimilated. This vegetation is added to the available organic matter in the litter.

A fraction of the nutrients that enter an animal are returned to the ecosystem in the urine, feces, or in the tissue of a dead animal. Feces and dead animals are decomposed and some nutrients are returned to the soil for uptake by plants. Animals may be eaten by carnivores and the total energy transferred to successively higher trophic levels decreases drastically from primary producer to top carnivore. The predatory hawks and owls, bobcat, coyote, raccoon, ringtail cat and skunk consume the tissue of other animals as part of their diet to supply nutrients for metabolic and biologic processes. They return matter to the environment in the form of urine, feces, and finally, body tissue when they die.

2.7.6.10 Leaves

The development of leaves in the agricultural community is primarily geared toward production. The production of leaves on a large scale, although consisting of relatively few species, is needed for various purposes within the agricultural community. Agricultural leaves have the same input requirements as their counterparts in the natural ecosystem. Organic and inorganic fertilizers are applied to increase the amount of production in desirable species while chemical sprays are used to reduce those species which are undesirable. Leaves which are particularly important from the agricultural standpoint include the grasses, such as oats, rye, sorghums and milos as well as some of the leafy vegetable species. Simple leaves carry on photosynthetic and transpiration activities, some leaves are modified for food storage, such as the onion, and other leaves have scales which provide various requirements geared toward particular plant needs. Management of the agricultural community causes a local breach in the cycling of nutrients. After the plants have produced their foliar growth, they are harvested and removed from the field where they were planted. This prevents the return of leaf material to soil for organic profile enhancement. The absence of natural soil replenishment necessitates the use of agricultural fertilizers to replenish the soil artificially.

Characteristically, leaf production in the agricultural community provides little or no canopy cover, or protection, for wildlife, thus lowering the carrying capacity and animal species diversity of the area. Leaves produced in pastures and improved rangeland have a beneficial output in the form of forage for domesticated cattle. There is a partial recycling of nutrients back to the soil through the feces, however, the animal biomass produced is removed from the land creating a significant discontinuity in nutrient cycling.

2.7.6.11 Agricultural Fruits

Agricultural fruits unlike naturally occurring fruits in the ecosystem, are geared towards production. Therefore the great diversity that exists in the biotic community is not found in the agricultural community. In the Squaw Creek area, the agricultural fruit production is limited to a few selected types that include pecan, peaches, apples and cherries. This system has the same kind of output as its companion system in the undisturbed ecosystem but it is geared to large scale production. Added inputs to the agricultural fruit ecosystem include extensive use of fertilizers and pesticides. In addition to using fertilizers and pesticides some growth-regulating substances may be applied to set blossoms, to set fruit, or to maintain fruit on the tree and prevent spoilage from occurring should the fruit drop prematurely. Selected pruning of agricultural fruits is geared towards large scale production of a fruit crop. Outputs from the agricultural fruit community include essentially those products mentioned for the naturally-occurring ecosystem. The quantity of organic litter output from the agricultural fruit community is diminished and fertilization is required. In the Squaw Creek area, in particular, there is little agricultural land devoted exclusively to fruit production. As the result, this particular trophic level in the ecosystem is not extensive in its effect on the overall regional biotic community.

2.7.6.12 Agricultural Stems

In the agricultural ecosystem stems play essentially the same functional rule as do their counterparts in the natural environment. Additionally, in large measure production of agricultural stems is geared toward development of usable forage material for domestic livestock and organic material replenishment.

Agricultural stems, too, can be divided into three main classes: the woody species stems, the grass species stems and the shrub-forb species stems.

Input energy to the agricultural stems takes several forms. Direct energy input involves sunlight, carbon dioxide and oxygen. The stems receive indirect inputs from the roots and occasionally from the leaves. Fertilizers and growth stimulating chemicals are supplied in the form of sprays or powders delivered to the plant and soil alike using broadcast techniques. Peripheral additions to the plant by way of the stems involve pesticides and herbicides used to increase desired species production while diminishing undesirable species production albeit plant, animal or insect.

The relative importance of using agriculturally produced stems for organic material supplementation is very high. Due to the production-oriented nature of agricultural soils, there is less re-cycling organic material owing to the harvesting techniques and machinery currently employed. Therefore, addition of organic material to the litter profile is not as highly developed in the agricultural ecosystem as is found in the natural ecosystem.

2.7.6.13 Agricultural Roots

Roots existing in the agricultural ecosystem hold the position of a transfer point similar to roots in the natural ecosystem. In the agricultural system however, there are fewer types of roots present. The major categories of roots include simple, runner, rhizome and tuber root structures. Roots specifically, and plants generally, are end products of the dynamic relationships of many parameters in the ecosystem. In the agricultural ecosystem the farmer has little interest in production beyond plant growth, maturation and harvesting. Production of economic plants is governed by the capacity for growth permitted by the environment.

2.7.6.14 Agricultural Soils

In the diagrammatic representation on-site agricultural soil is separated from natural soil. This distinction is based on use, form and composition of agricultural soil which separates it from the natural soil. Agricultural soils start out as natural soils characteristic to an area. Land is then cleared and soil plowed and cultivated for the production of a standing crop. To assist in optimum production from the soil the farmer utilizes fertilizers, pesticides, herbicides and other chemicals to enhance production and limit or eliminate waste. Productive agricultural land is "short circuited" successionally in that the normal organic cycle must be supplemented to maintain high soil fertility, a requisite for good agricultural development.

Man has introduced several factors in addition to natural inputs which tend to alter soil characteristics. Cultivation has the effect of increasing aeration of soil and provides some organic additions at a more rapid rate. Physically, cultivation causes greater moisture evaporation by exposing a greater proportion of the agricultural soil surface. The cultivation may also increase the compaction of the substrate layers by physical compression of the soil resulting from movement of cultivating machinery over the soil surface.

Surface water runoff from agricultural soils may contain a considerable amount of soluble and suspended material including organic matter, fertilizers, silt and the residues of herbicides and pesticides. These materials enter adjacent waterways and can have a pronounced effect on the aquatic ecosystems.

2.7.6.15 Forage

Forage material in the agricultural ecosystem is a commodity which supplies energy to the primary consumer trophic level. The function of forage is to enhance the "carrying capacity" of land for domestic animals without increasing the amount of land required for grazing or feed. Supplemental feedings of forage material are used by the farmer for nutritional enhancement. Forage is produced as the result of cultivation in the agricultural ecosystem. Forage output therefore is geared primarily toward particular dietary requirements of specific domestic animals. Fertilizers are necessary in the agricultural ecosystem to replenish the soil as well as increase the vitality of plants. Chemical growth regulators are used to cause greater plant production by increasing various cellular activities.

Forage nutrient energy is important throughout the year but has its primary importance throughout the winter periods when available nutrients are otherwise low in production. In the Squaw Creek area the production of Bermuda grass by farmers is an important forage additive. The forage trophic level is important to the natural and the agricultural ecosystem by supplying the nutrient-energies required by animal consumers at the next higher trophic level.

2.7.6.16 Grazers

Man is using the land to maximize the production of domestic products, agriculture and livestock. To achieve this goal, the natural environment characterized by a high diversity of plants and animals and a high ecological stability has been replaced by a stressed environment with a lower diversity of plants and animals and a lower ecological stability. This is recognized by the fact that nutrient cycling is not continuous in the ecosystem, some nutrients must be introduced (fertilizer) and a large proportion is removed (crops and livestock).

A variety of land management practices are used to enhance the agricultural productivity of the area such as brush clearing, fire, herbicides, pesticides, fertilizer and plowing. These methods encourage low diversity and a low ecological stability. Grazing has reduced the endemic forage plants containing high nutrient values and encouraged the invasion of pioneer plants species that are tolerant to grazing and often have lower nutritional values.

Grazing has reduced plant density and composition which reduced the available supply of organic material for the development of litter. The probability of surface erosion removing litter and nutrients has increased as a result of soil compaction and an increase in exposed soil surfaces. These are factors that reduce the penetration of nutrients into the soil where they could reach the plants through the roots.

The lower nutrient values, lower vegetational cover, and erosion are three factors that reduced the carrying capacity of the range for domestic and native animals. Changes in carrying capacity occur by either lowering the number of animals of each species the range can support or lowering and sometimes increasing the abundance of one species over another. The latter is probably the case in the Squaw Creek area whereby rodents have been reduced in species composition but the cotton rat has increased in abundance and the opossum, raccoon, and skunk have also increased because of their omnivorous feeding habits.

Agricultural cultivation maximizes nutrient values in a few grain crops which are used as forage for livestock. High nutrient values in the grain crop are obtained with applications of fertilizer which replaces the natural organic matter. Seed from grain crops were in the diet of bobwhite quail, and mourning doves (two game species), as well as, no doubt, in the diet of some granivorous song birds and mammals. The cotton rat has probably taken advantage of the concentration of grain in cultivated fields judging from the number of individual rats trapped along the edge of an oat field.

Native wildlife that feed on grass and forb vegetative parts are included here under the classification of grazers. Native animals are distributed in vegetative types that supply the shelter and food required for survival. Livestock is competitive with native grazing species for food resources. Livestock grazing removes both the shelter and food for native species. As shelter and food resources decline, the native grazers are forced to compete intra- and inter-specifically for the remaining areas of optimum and marginal habitat. Those species that cannot tolerate the change are eliminated through predation, disease or emigration. Changes in the grazing pressure from a low density of cows per acre to a high density of cows per acre will cause a decline in the carrying capacity for native grazers.

Livestock are far more inefficient in the cycling of energy and nutrients through the ecosystem of the Squaw Creek area than native animals. An input occurs from plants having both low and high nutrient values. Nutrients required for biological processes are utilized or stored and metabolic wastes are eliminated in the form of urine and feces. These waste products are decomposed and some nutrients may once more become available to the ecosystem. Dairy products which contain stored nutrients as proteins, fats, carbohydrates, etc., are not returned to the nutrient cycles of the site area.

Livestock provide dairy products and meat for human consumption, calf production, and milk for calf and human consumption. Energy transferred to these outlets is removed from the ecosystem of Squaw Creek.

2.7.6.17 Browsers

Animals that feed on leaves and twigs of woody plants are classified as browsers. This includes domestic livestock and native animals such as rabbits, and white-tailed deer. The domestic livestock is competitive with the native browsing species in a similar manner as described for grazers. Domestic livestock lower the carrying capacity for native species by reducing the available forage and browse, by reducing the available nutrients and by reducing the available shelter. Nutrients are again shunted into animals that permanently remove nutrients from cycles in the Squaw Creek area.

Again, output products include wastes from metabolism, occasional mortality, the food products for man, and finally, a lower carrying capacity of the range for all animals.

2.7.6.18 Food Products

Cultivation and harvest of vegetative food products in the agricultural ecosystem is an important output from the primary producer trophic level. Vegetative food products are used for livestock and human consumption. Production of fruits, grains, leaves, stems, silage, fodder and other forage products is important to the entire ecosystem. Environmental inputs to production of vegetative food products involve sunlight, moisture, minerals, inorganic elements and the influence of animals and man.

Vegetative food products extend carrying capacity for consumers of all classes by providing additional nourishment without necessitating range extensions. Food products for animals and man reduce grazing pressures by providing supplemental feed to animals.

Vegetative food products from the Squaw Creek area include pecans, berries, peanuts, soybeans, sorghums and small grains. These products can be used directly for human consumption or may be processed and then used.

Food production in the Squaw Creek also takes the form of animals of primary consumer trophic levels. Livestock products are mainly for human consumption.

The ecosystem has been altered to achieve high productivity in grain crops and livestock. Much of the grain crops are eventually fed to livestock such as cows, hogs, and a few poultry. Food products from agricultural development include meat, dairy products, and eggs. Nutrients move from the vegetation to the animal and finally to man and domestic animals. Some nutrients, however, return to the soil when plants die and decompose, some nutrients are returned as metabolic waste from animals, and yet some nutrients are transferred to a fetus.

Some men obtain native wildlife as a natural food product during the fall and winter season. However, native wildlife occurs in only a small fraction of the diet of a very few families. Use of this resource is generally seasonal.

2.7.6.19 Groundwater

Groundwater and runoff are the major transport systems to and from the terrestrial and aquatic ecosystems. In the plains and specifically in the Squaw Creek area, groundwater and runoff are important to the biotic community. The primary input is in the form of precipitation and the runoff adds volume to the groundwater. Sources of groundwater and runoff which are more subtle in their additions include surface drainages, artesian sources, and aquifers. Surface drainages supply a volume of water to the groundwater reserve during times of abundant water supply. Artesian sources supply the groundwater with additives by way of underground springs and pools. Finally, aquifers are large containments of collected groundwater forming a type of reserve pool. The aquifer can supply water to the groundwater and runoff flow in periods when the water table fluctuates during a change from arid to moist conditions.

Other inputs to the groundwater and runoff system are organic and inorganic chemicals and atmospheric gases. Organic products in the groundwater result from decomposition of organic litter and humus by fungi, bacteria and other decomposer organisms. Organic products are moistened and physically percolate to the groundwater flow. Inorganic chemicals also percolate through the soil and are collected in the groundwater. Breakdown of organic substrate materials also adds to the inorganic elements found in the groundwater. Generally, the agricultural ecosystem has in recent years made many additions to the groundwater in the form of salts, fertilizers (organic and inorganic) pesticides and herbicides.

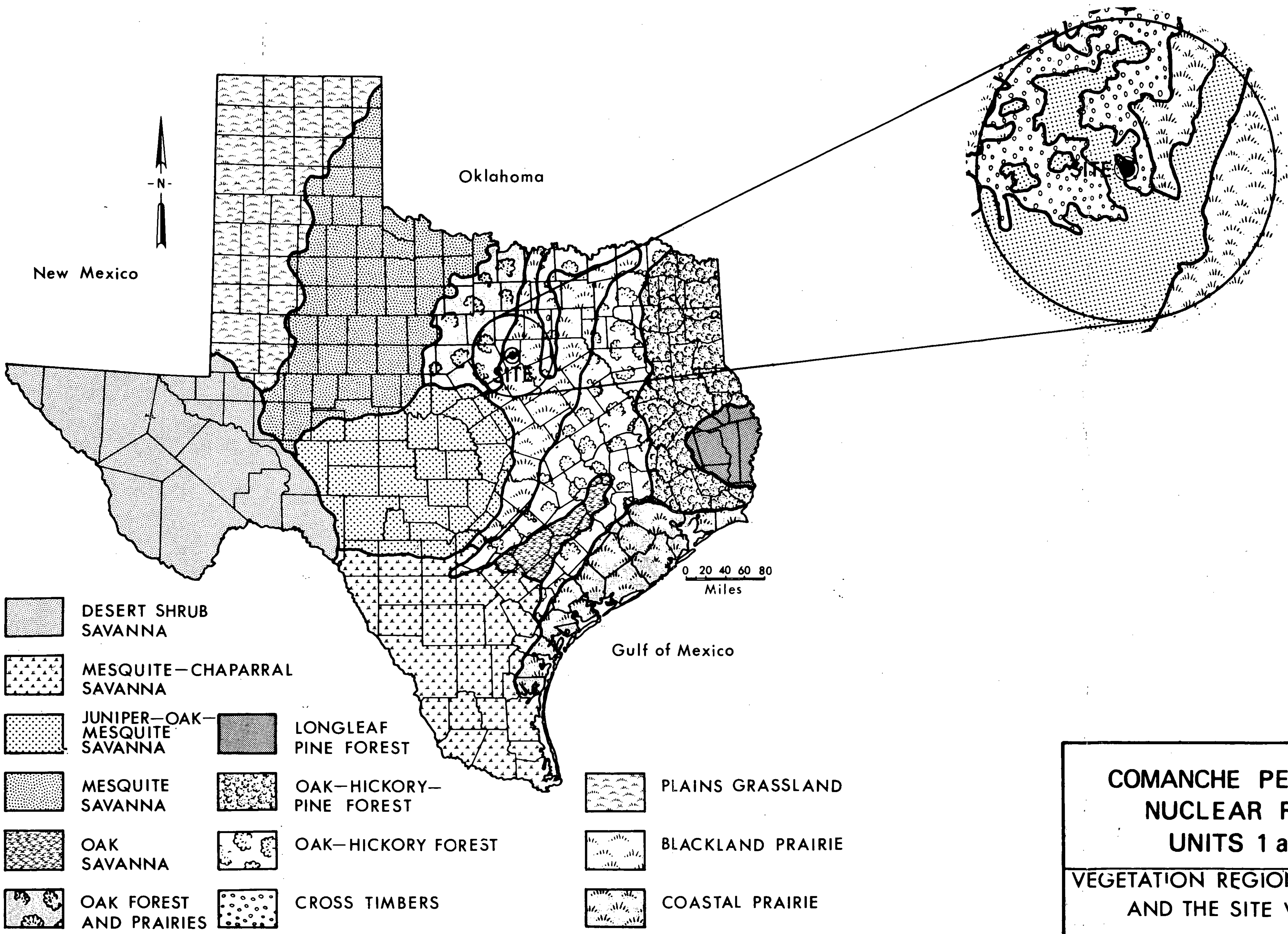
The functional importance of the groundwater is widespread in the aquatic and terrestrial ecology of the Squaw Creek area. The groundwater provides a moisture storage facility for vegetation of the area. This water flow generates a nutrient cycling pathway from the terrestrial to the aquatic and back. In addition, the groundwater flow provides a means of drainage from the terrestrial system stabilizing soil moisture content and water table levels.

Water quality in the aquatic ecosystem is determined by the groundwater and runoff available to the area. Groundwater provides many functions to the terrestrial ecosystem thereby supporting the carrying capacity of the land. In the Squaw Creek area, the moisture from the groundwater supply is important in supplying the vegetation with needed water. Water addition also indirectly adds to the animal community by supporting the growth of cover for the wildlife species of the area. The groundwater is the "unseen stream" which supplies vitally important components to the aquatic and terrestrial ecosystems of the Squaw Creek are.

2.7.6.20 Man

Man is an extremely important and influential component of the biological community and modern technology has enabled him to assume a dominant role in the ecosystem as opposed to the dependent, if not harmonious, role of primitive man in his natural surroundings. The residents of Hood and Somervell Counties are almost completely independent of their immediate surroundings for direct support. Excluding the requirements for clean air and fresh water, most of the essential commodities of life (food, fuel and construction materials, etc.) are obtained from distant sources. Few, if any, live off the land entirely.

However slight may be his direct dependence on a specific area, such as the SCR site, man is depicted as a consumer in the diagrammatic representation in Figure 2.7-3 because he does utilize local resources including water, fish, wildlife and agricultural products which may be adversely affected by the CPSES project.



COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

VEGETATION REGIONS OF TEXAS
AND THE SITE VICINITY

FIGURE 2.7-1

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE
RECORD TITLED:
"AN ENVIRONMENTAL
PROFILE OF THE SITE AREA,
FIGURE 2.7-2"

WITHIN THIS PACKAGE...OR
BY SEARCHING USING THE
DOCUMENT/REPORT NO.

D-02

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED: "SCR Area Soils and Vegetation, FIGURE 2.7-2a"

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D-03

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"AN ENVIRONMENTAL PROFILE OF THE SITE AREA, FIGURE 2.7-2b"

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Vegetational Distribution,
FIGURE 2.7-2c"

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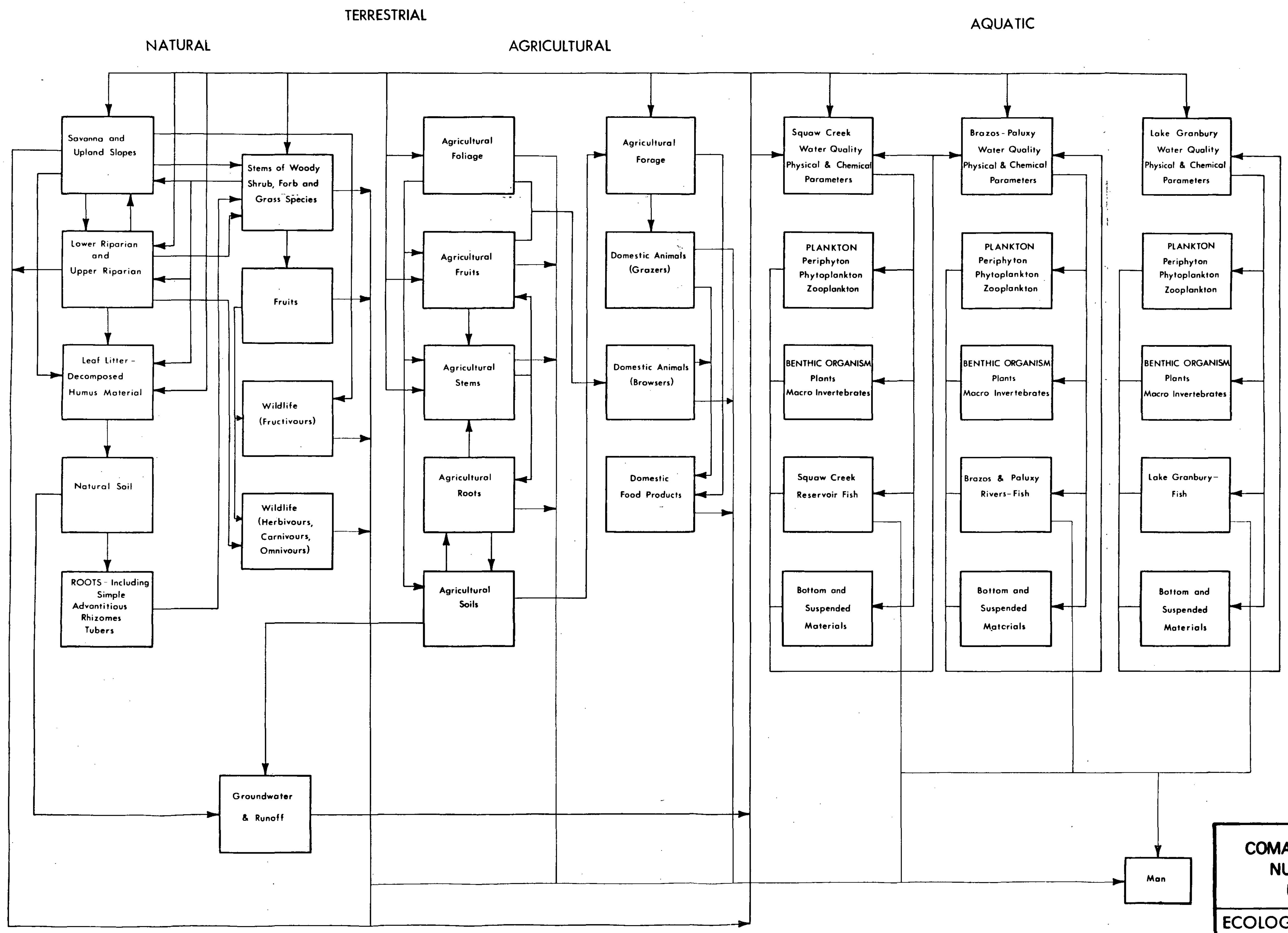

COMANCHE PEAK S.E.S.
NUCLEAR PLANT
UNITS 1 and 2

ECOLOGICAL RELATIONSHIPS ON THE SITE AREA AND CONNECTING WATERWAYS

FIGURE 2.7-3

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TABLE 2.7-1

VEGETATIVE FORAGE VALUE

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
VEGETATION ZONE - CROSS TIMBERS					
Quercus stellata (Post oak)	Acorns; high in carbohydrates/low in protein	10-14" dia. oak = 0.7-2.8 lb ac/tree	Browse on acorns dropped except squirrel which actively seek acorns on limbs	Deer/squirrel/ turkey	Highly palatable/ a desirable forage species.
Quercus marilandica (Black Jack oak)	Acorns; low in protein, high in available carbohydrates	10-14" dia. oaks produce 0.7-2.8 lb acorns/tree	Browse on acorns dropped except squirrel which actively seek acorns on limbs	Deer/squirrel/ turkey	Highly palatable/ a desirable forage species.
Bumelia lanuginosa (Gum elastic)	Leaves/twigs/bark contains oleoresin; has carbonhydrates; no available protein	Unknown	Browse on leaves and twigs; some bark digestion in winter	Rabbit/ squirrel/deer	Palatable through not a source of high nutritional value.
Viburnum rufidulum (Rusty blackhaw)	Fruits/twigs contains carbohydrates	Unknown	Browse of fruits by terrestrial mammals & birds	Fox/rabbit/ deer/bobwhite grouse/pheasant	Good palatability/ good source of carbohydrate energy.
Celtis laevigata (Sugar hackberry)	Drupes/leaves/ twigs contain carbohydrates and Vitamin C	2000-2400 fruits/ lb of tree production	Browse on fruits/ leaves & twigs from midfall through spring	Rabbit/deer/ squirrel/ raccoon	Good palatability & source of vitamins & organic acids.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
VEGETATIVE ZONE - CROSS TIMBERS					
Schizachyrium scoparius (Little bluestem)	Grain/stalks; provides carbohydrates & protein including B_{12} vitamins	3/4-2 tons/acre produced by pure stands	Browse & graze of grain and shoots through summer on into winter	Domestic cattle/ deer/squirrel/ turkey & birds/ microtines	Excellent palatability, rich nutritional source.
Eragrostis trichodes (Sand lovegrass)	Grain/stalks; provides high carbohydrates & proteins	100 lb/acre produced in dry-land row plantings	Browse & graze of grains & shoots throughout year	Domestic cattle/deer/ turkey/microtines	Excellent palatability, good carbohydrate source.
Eragrostis spectabilis (Purple lovegrass)	Grain/stalks; provides carbohydrates, proteins & carotin	Unknown	Browse early spring & fall	Domestic cattle/deer/ rabbit	Good palatability.
Tridens flavus (Purpletop)	Grain/stalks; carbohydrates	Unknown	Browse spring & summer	Domestic cattle/deer/ birds	Good palatability; moderate nutritive value.
Aristida longespica (Slimspike threeawn)	No nutritive value	Unknown	Present only when land severely overgrazed	Domestic cattle	Unpalatable; little nutritive value.
Ascyrum hypericoides (St. Andrews Cross)	Leaves; little carbohydrates available	Unknown	Browse in late fall & early winter	Squirrel/ raccoon/ rabbit/birds	Palatable; moderate nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
VEGETATIVE ZONE - CROSS TIMBERS					
Smilax rotundifolia (Greenbriar)	Berries/leaves carbohydrates & vitamin C	Unknown	Browse year-round; found as a Liana on other species	Deer/squirrel fox/birds	Good palatability; good carbohydrate source.
CROSS TIMBERS SAVANNA					
Ulmus crassifolia (Cedar elm)	No nutritive value	Unknown	Occasional browse	Domestic	Unpalatable; little nutritive value.
Quercus marilandica (Black Jack oak)	Acorns; high in carbonhydrate/low in protein	Oaks of 10-14" dia.; produce 0.7-2.8 lb acorns/tree	Browse on acorns dropped; squirrels actively seek acorns on limbs	Deer/squirrel/ turkey	Highly palatable; a desirable forage species.
Quercus stellata (Post oak)	Acorns; high in carbohydrate/low in protein	Oaks of 10-14" dia.; produce 0.7-2.8 lb acorns/tree	Browse on acorns dropped; squirrels actively seek acorns on limbs	Deer/squirrel/ turkey	Highly palatable; a desirable forage species.
Prosopis glanducosa (Mesquite)	Bean pods/twigs/ leaves; moderate carbohydrates, some protein	25-30 shrubs/ acre for domestic livestock	Browse on leaves & twigs; selective removal & digestion of bean pods	Domestic cattle/deer fox/rabbit/ squirrel/birds	Palatable fall & winter forage species.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
CROSS TIMBERS SAVANNA					
Zanthoxylum clauaherculis (Hercules club)	Leaves; moderate carbohydrates	Unknown	Browse on leaves	Deer/squirrel raccoon	Palatable; moderate to poor nutritive value.
Juniperus ashei (Ashe-juniper)	Berries/twigs; source of citric acid/carbohydrates	Unknown	Browse on leaves; selective browse on berries	Deer/rabbit/ birds	Palatable; moderate nutritive value.
Opuntia compressa (Prickly pear)	Fruits/blossoms/ herbaceous stock, rich in carbohydrates	Unknown	Selective browse on blossoms & fruits; general browse on herbaceous stock	Domestic cattle/rabbit	Palatable; moderate to good nutritive value.
Bothriochloa ischaemum (King ranch bluestem)	Grain/stalks; carbohydrate & protein source	100 lb/acre produced in dry-land row plantings	Browse on grain & stalks throughout the year	Domestic cattle/fox/ rabbit/deer/ raccoons	Good palatability excellent carbohydrate & protein source.
Schizachyrium scoparius (Little bluestem)	Grain/stalks; provides carbohydrates & proteins.	100 lb/acre; produced in dry-land row plantings	Browse & graze of grain & shoots through summer & winter	Domestic cattle/deer squirrel/ turkey/birds	Excellent palat- rich nutritional source.
Aristida oligantha (Oldfield threeawn)	No nutritive value	Unknown	Present only on severely overgrazed land	Domestic cattle	Unpalatable; little nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
CROSS TIMBERS SAVANNA					
Eragrostis oxylepis (Red lovegrass)	Grain/stalks; provides carbohydrates & some proteins	100 lb/acre produced in dry-land row plantings	Browse of grain & stalks summer & fall	Domestic cattle/deer/ fox/rabbit/ birds	Good palatability; excellent carbohydrate & protein source.
Heterotheca latifolia (Champhor weed)	No nutritive value	Unknown	Occasional blossom; browse/ overgrazed land	Domestic cattle	Unpalatable; no nutritive value.
Conyza canadensis (Horseweed)	No nutritive value	Unknown	Characteristic of overgrazed land	Domestic cattle	Unpalatable; no nutritive value.
Hypericum drummondii (Drummond St. Johnswart)	Poisonous range plant	N.A.	Grazed only under starvation conditions; causes photosensitization	Domestic cattle	Poisonous; no nutritive value.
JUNIPER-THREEAWN UPLANDS (Cleared)					
Juniperus ashei (Juniper-ash)	Berries/twigs; source of citric acid/carbohydrates	Unknown	Browse on leaves; selective browse on berries	Deer/rabbit/ birds	Palatable; moderate nutritive value.
Juniperus pinchoti (Juniper-redberry)	Berries/twigs; source of citric acid/carbohydrates	Unknown	Browse on leaves; selective browse on berries	Deer/rabbit/ birds	Palatable; moderate nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
JUNIPER-THREEAWN UPLANDS (Cleared)					
Prosopis glandulosa (Mesquite)	Bean pods/twigs/ leaves; moderate carbohydrates; some proteins	25-30 shrubs/acre for domestic livestock	Browse on leaves & twigs; selective removal & digestion of bean pods	Domestic cattle/deer fox/rabbit/ squirrel/birds	Palatable; fall & winter forage species.
Celtis laevigata (Sugar hackberry)	Drupes/leaves/ twigs; contains carbohydrates & vitamin C	2000-2400 fruits/ pound of tree production	Browse on fruit/ leaves & twigs from midfall through spring	Rabbit/deer squirrel/ raccoon	Good palatability; source of carbohydrates & vitamins.
Berberis trifoliolata (Agarito)	Berries/leaves carbohydrates; some protein	Unknown	Browse on berries & leaves year-round	Deer/rabbit	Moderate palatability; moderate nutritive value.
Bumelia lanuginosa (Gum elastic)	Leaves/twigs/bark; carbohydrates; no available proteins; contains oleoresin	Unknown	Browse on leaves & twigs; some bark digestion in winter	Rabbit/deer/ squirrel	Palatable though not a source of high nutritive value.
Aristida oligantha (Oldfield threeawn)	No nutritive value	Unknown	Present only on severely overgrazed land	Domestic cattle	Unpalatable; little nutritive value.
Erioneuron pilosum (Hairy tridens)	Grain/stalks; carbohydrate source	Unknown	Browse on grain & stalk; principally in spring & early summer	Domestic cattle/deer/ rabbit/raccoon	Moderate palatability; good nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
JUNIPER-THREEAWN UPLANDS (Cleared)					
Bouteloua curtipendula (Sideoats grama)	Grain/stalks; good carbohydrate source	Unknown	Browse on grain & stalk summer & fall	Domestic cattle/deer	Good palatability; excellent nutritive value.
Sporobolus asper (Tall dropseed)	Grain/stalks; carbohydrate source	Unknown	Browse on grain & stalk	Domestic cattle/deer	Moderate palatability; fair nutritive value.
Leptoloma cognatum (Fall witchgrass)	No nutritive value	Unknown	Characteristic of overgrazed land	Domestic cattle	Unpalatable, no nutritive value.
Bothriochloa ischaemum (Silver bluestem)	Grain/stalks; only when young; low carbohydrates	Unknown	Characteristic of overgrazed land	Domestic cattle	Palatable; low nutritive value.
Bouteloua rigidiseta (Texas grama)	Grain/stalks; carbohydrates & some proteins	Unknown	Browse on grain & stalks in summer, fall & winter	Domestic cattle/deer/ raccoon	Moderate palatability; moderate nutritive value.
Stipa leucotricha (Texas wintergrass)	Grain/stalks; carbohydrates; low in protein	Unknown	Browse on grain & stalks; midsummer thru fall	Domestic cattle/deer	Good palatability; good nutritive value.
Sida filicaulis (Spreading sida)	Foliage; low carbohydrate availability	Unknown	Browse on foliage	Deer/raccoon/ squirrel	Moderate palatability; low nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
JUNIPER-THREEAWN UPLANDS (Cleared)					
Xanthocephalum dracunculoides (Broomweed)	No nutritive value	Unknown	Browse causes inflammation of the conjunctiva	Domestic cattle	Unpalatable; no nutritive value.
JUNIPER-THREEAWN UPLANDS (Uncleared)					
Juniperus ashei (Juniper-ash)	Berries/twigs; source of citric acid/carbohydrates	Unknown	Browse on leaves, selective browse on berries	Deer/rabbit/ birds	Palatable; moderate forage value.
Juniperus pinchoti (Juniper-redberry)	Berries/twigs; source of citric acid/carbohydrates	Unknown	Browse on leaves, selective browse on berries	Deer/rabbit/ birds	Palatable; moderate forage value.
Forestiera pubescens (Elbow bush)	Foliage; low carbohydrate availability	Unknown	Browse on foliage	Domestic cattle	Low palatability; low nutritive value.
Aristida glauca (Blue threeawn)	No nutritive value	Unknown	Characteristic of overgrazed land	Domestic cattle	Unpalatable; no nutritive value.
Aristida longespica (Slimspike threeawn)	Low carbohydrates	Unknown	Browsed only in spring	Domestic cattle	Low palatability; low nutritive value.
Carex filifolia (Sedge)	Shoots; carbohydrates	Unknown	Browse in spring & fall	Domestic cattle/deer	Moderate palatability; low nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
JUNIPER-THREEAWN UPLANDS (Uncleared)					
Bouteloua rigidiseta (Texas grama)	Grain/stalks; carbohydrates & some proteins	Unknown	Browse on grain & stalks in summer, fall & winter	Domestic cattle/deer/ raccoon	Moderate palatability; moderate nutritive value.
Sporobolus asper (Tall dropseed)	Grain/stalks; carbohydrate source	Unknown	Browse on grain & stalk	Domestic cattle/deer	Moderate palatability; fair nutritive value.
Bouteloua hirsuta (Hairy grama)	Grain/stalks; carbohydrates & proteins	Unknown	Browse throughout summer period	Domestic cattle/deer/ birds	Good palatability; excellent nutritive value.
BROOMWEED BENCHES					
Prosopis glandolosa (Mesquite)	Bean pods/twigs/ leaves; moderate carbohydrates; some proteins	25-30 shrubs/acre for domestic livestock	Browse on leaves & twigs; selective removal & digestion of bean pods	Domestic cattle/fox/ rabbit/birds/ squirrel	Palatable; fall & winter forage species.
Xanthocephalum dracunculoides (Broomweed)	No nutritive value	Unknown	Browse causes inflammation of the conjunctivae	Domestic cattle	Unpalatable; no nutritive value.
Iva angostifolia (Narrowleaf sumpweed)	No nutritive value	Unknown	Indicates abused range or overgrazed land	Domestic cattle	Unpalatable; no nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
BROOMWEED BENCHES					
Bothriochloa ischaemum (King ranch bluestem)	Grain/stalks; carbohydrate & protein source	100 lb/acre produced in dry-land row plantings	Browse of grain & stalks throughout the year	Domestic cattle/fox/rabbit/deer/rodents	Good palatability; excellent carbohydrate & protein source.
Sporobolus asper (Tall dropseed)	Grain/stalks; carbohydrate source	Unknown	Browse on grain & stalk	Domestic cattle/deer	Moderate palatability; fair nutritive value.
Muhlenbergia reverchonii (Seep muhly)	Little nutritive value	Unknown	Browse only in early spring	Domestic cattle	Unpalatable; no nutritive value.
JUNIPER-HAIRY GRAMA SLOPES					
Juniperus ashei (Ash juniper)	Berries/twigs; source of citric acid/carbohydrates	Unknown	Browse on leaves; selective browse on berries	Deer/rabbit/birds	Palatable; moderate forage value.
Juniperus pinchoti (Redberry juniper)	Berries/twigs; source of citric acid/carbohydrates	Unknown	Browse on leaves; selective browse on berries	Deer/rabbit/birds	Palatable, moderate forage value.
Prosopis glandulosa (Mesquite)	Bean pods/twigs/leaves; moderate carbohydrates; some proteins	25-30 shrubs/acre for domestic livestock	Browse on leaves & twigs; select browse on bean pods	Domestic cattle/deer/fox/birds/squirrel/rabbit	Palatable; fall & winter forage species.
Bouteloua hirsuta (Hairy grama)	Grain/stalks; carbohydrates & some proteins	Unknown	Browse on grain & stalks through summer & fall	Domestic cattle/deer/raccoon	Moderate palatability; moderate nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
JUNIPER-HAIRY GRAMA SLOPES					
Aristida wrightii (Perennial threeawn)	No nutritive value	Unknown	Characteristic of overgrazed land	Domestic cattle	Unpalatable; no nutritive value.
Bouteloua pectinata (Tall grama)	Grain/stalks; carbohydrates & protein	Unknown	Browse on grain & stalks through entire growing season	Domestic cattle/deer/ raccoon	Moderate palatability; moderate nutritive value.
RIPARIAN					
Ulmus crassifolia (Cedar elm)	No nutritive Value	Unknown	Occasional browse	Domestic cattle	Unpalatable; little nutritive value.
Quercus macrocarpa (Bur oak)	Acorns; high in carbohydrates; low in protein	10-14" dia. oak = 0.7-2.9 lb ac/tree	Browse on acorns dropped; squirrels actively seek acorns on limbs	Deer/squirrel/ turkey	Highly palatable; good nutritive value
Juniperus ashei (Ash juniper)	Berries/twigs; source of citric acid/carbohydrates	Unknown	Browse on leaves, selective browse on berries	Deer/rabbit/ birds	Palatable; moderate forage value
Juniperus pinchoti (redberry juniper)	Berries/twigs; source of citric acid/carbohydrates	Unknown	Browse on leaves, selective browse on berries	Deer/rabbit/ birds	Palatable; moderate forage value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
RIPARIAN					
Callicarpa Americana (American beautyberry)	Berries/twigs/ leaves; carbohydrate source	Unknown	Browse through spring, summer, fall	Deer/squirrel/ rabbit/birds	Palatable; moderate nutritive value.
Carya illinoensis (Pecan)	Nuts; high carbohydrates; moderate proteins	10-14" dia. pecan = 2.4-4.5 lb/pecans/tree	Browse in midsummer through fall & winter	Deer/cattle/ squirrel/birds	Palatable; good nutritive value.
Celtis laevigata (Sugar hackberry)	Drupes/leaves/ twigs; contains carbohydrates & vitamin C	2000-2400 fruits/ lb of tree production	Browse on fruits/ leaves/twigs from fall thru spring	Rabbit/deer/ squirrel/ raccoon	Good palatability; good nutritive value.
Sapindus drummondii (Soapberry)	No nutritive value	Unknown	Clustered fruits reported; poisonous	Domestic cattle	Poisonous; no nutritive value.
Cornus drummondii (Roughleaf dogwood)	Fruits/leaves; high carbohydrate, vitamin C & good protein source	Unknown	Browse principally on fruits in early fall	Grouse/turkey/ bobwhite/ pheasant	Good palatability; good nutritive value.
Vitis mustangensis (Grapes)	Fruit/leaves; high carbohydrates & vitamins	Unknown	Browse on fruits & leaves midsummer thru fall; principally Liana	Grouse/turkey/ partridge/ pheasant/skunk/ squirrel	Excellent palatability; good nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
RIPARIAN					
Parthenocissis Quinquefolia (Virginia creeper)	Fruits/leaves/ twigs; high carbohydrates	Unknown	Browse on fruit/ foliage fall thru spring	Birds/mice/ squirrel/skunk/ chipmonk/deer	Good palatability; good nutritive value.
Rhus toxicodendron (Poison oak)	Poisonous range plant	N.A.	Browse is indicator of extensive overgrazing	Avoided by most wildlife	Poisonous; no nutritive value.
Smilax rotundifolia (Greenbriar)	Berries/leaves; carbohydrates & vitamin C	Unknown	Browse year-round; found as a Liana on other species	Deer/fox/skunk/ raccoon	Good palatability; good carbohydrate source.
Elymus virginicus (Virginia wildrye)	Grain/stalks; high in carbohydrate; some protein	Unknown	Browse on grain & stalks	Domestic cattle/deer/ mice/birds	Good palatability; good nutritive value.
Geum canadense (White avens)	Stalks; carbohydrates	Unknown	Occasional browse	Deer/raccoon	Palatable; low nutritive value.
Tridens flavus (Purple top)	Grain/stalks; high in carbohydrates; some protein	Unknown	Browse spring & summer	Domestic cattle/deer/ birds	Good palatability; moderate nutritive value.
Verbesina virginica (White crownbeard)	Foliage; low carbohydrates	Unknown	Browse on leaves	Birds & squirrel	Palatable; low nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
RIPARIAN					
Eupatorium serotinum (Late eupatorium)	Poisonous range plant	N.A.	Browse in May-June; causes general respiratory collapse in cattle & horses	Domestic cattle	Poisonous; no nutritive value.
Eupatorium coelestinum (Mist flower)	Poisonous range plant	N.A.	Browse in spring causes respiratory collapse	Domestic cattle	Poisonous; no nutritive value.
Elephantopus carolinianus (Elephantfoot)	Foliage; low carbohydrates	Unknown	Occasional browse	Domestic cattle	Palatable; low nutritive value.
Avena sativa (Wildoats)	Grains/stalks; carbohydrates & some protein	100 lb/acre reduced in dry land row plantings	Browse on grain & stalks throughout year	Cattle/deer/ raccoon/birds/ squirrel	Good palatability; good nutritive value.
Croton texensis (Texas croton)	Poisonous range plant	N.A.	Browse most dangerous in fall; powerful cathartic & blistering agent	Domestic cattle	Poisonous; no nutritive value.
Sesbania vesicaria (Bagpod)	Beans/foliage; some carbohydrates & vitamins	Unknown	Browse of beans & foliage in fall	Domestic cattle/deer	Palatable; moderate nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
RIPARIAN					
Setaria geniculata (Knotroot bristlegrass)	Grain/stalks; rich in carbohydrates; some protein	Unknown	Occasional browse	Domestic cattle	Palatable; good nutritive value.
RIPARIAN (Upper)					
Ulmus crassifolia (Cedar-elm)	No nutritive value	Unknown	Occasional browse	Domestic cattle	Unpalatable; little nutritive value.
Juniperus ashei (Ash juniper)	Berries/twigs; source of citric acid/carbohydrates	Unknown	Browse on leaves; selective browse on berries	Deer/rabbit/birds	Palatable; moderate nutritive value.
Juniperus pinchoti (Redberry juniper)	Berries/twigs; source of citric acid/carbohydrates	Unknown	Browse on leaves; selective browse on berries	Deer/rabbit/birds	Palatable; moderate nutritive value.
Quercus macrocarpa (Bur oak)	Acorns; high in carbohydrates; low in protein	10-14" dia. oak = 0.7-2.8 lb ac/tree	Browse on acorns dropped; squirrel actively seek acorns on limbs	Deer/squirrel/turkey	Highly palatable; good nutritive value.
Carya illinoensis (Pecan)	Nuts; high in carbohydrates, low in protein	10-14" dia. pecan = 2.4-4.5 lb/pecans/tree	Browse in mid-summer, fall & winter	Deer/cattle/squirrel/birds	Palatable; good nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
RIPARIAN (Upper)					
Sapindus drummondii (Soapberry)	No nutritive value	Unknown	Clustered fruits; reported poisonous	Domestic cattle	Poisonous; no nutritive value.
Prosopis glandulosa (Mesquite)	Bean pods/twigs/ leaves; moderate carbohydrates; some proteins	25-30 shrubs/acre for domestic cattle	Browse on leaves/ twigs; selective removal of bean pods	Cattle/deer/ fox/rabbit/ squirrel/birds	Palatable; fall & winter forage species.
Cissus incisa (Ivy treebine)	Leaves; moderate carbohydrates	Unknown	Browse on leaves	Cattle/deer	Palatable; low nutritive value.
Parthenocissus quinquefolia (Virginia creeper)	Fruits/twigs/ leaves; high carbohydrates	Unknown	Browse on fruit/ foliage, fall thru spring	Rabbit/deer squirrel/ raccoon	Good palatability; good nutritive value.
Rhus toxicodendron (Poison oak)	Poisonous range plant	N.A.	Browse is indicator of extensive overgrazing	Avoided by most wildlife	Poisonous; no nutritive value.
Vitis mustangensis (Grapes)	Fruit/leaves; high carbohydrates & vitamins	Unknown	Principally a Liana; browse on fruit midsummer thru fall	Goose/partridge/skunk/ pheasant/ turkey/squirrel	Excellent palatability; good nutritive value.
DISTURBED SITES					
Cnidoscolus texanus (Texas bullnettle)	No nutritive value	Unknown	Overgrazing indicator	Domestic cattle	Unpalatable; no nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
DISTURBED SITES					
Martynia louisianica (Devils claw)	No nutritive value	Unknown	Overgrazing indicator	Domestic cattle	Unpalatable; no nutritive value.
Euphorbia marginata (Snow-on-the-mountain)	Poisonous range plant	N.A.	Indicator of extensive overgrazing	Domestic cattle	Poisonous; no nutritive value.
Croton monanthogynus (One-seed croton)	Poisonous range plant	N.A.	Browse most dangerous in fall; powerful cathartic & blister agent	Domestic cattle	Poisonous; no nutritive value.
Solanum rostratum (Buffalobur)	Poisonous range plant	N.A.	Indicator of extensive overgrazing	Domestic cattle	Poisonous; no nutritive value.
Croton texensis (Texas croton)	Poisonous range plant	N.A.	Browse most dangerous in fall; powerful cathartic & blister agent	Domestic cattle	Poisonous; no nutritive value.
Eryngium leavenworthii (Leavenworth eryngo)	No nutritive value	Unknown	Seldom browse; principally an invader	Domestic cattle	Unpalatable; no nutritive value.
Euphorbia prostrata (Euphorbias)	Foliage; carbohydrates	Unknown	Only on overgrazed sites	Domestic cattle	Palatable; low nutritive value.

TABLE 2.7-1 (continued)

Species (Common Name)	Nutritive Value and/or Source	Grazing Potential including Carrying Capacity	Characteristic Grazing Practice	Consumer Class	Palatability
DISTURBED SITES					
Ambrosia psilostachya (Western ragweed)	No nutritive value	Unknown	Invader on overgrazed sites	Domestic cattle	Unpalatable; no nutritive value.
Setaria geniculata (Knotroot bristlegrass)	Grain/stalks; rich in carbohydrates; some proteins	Unknown	Occasional browse browse	Domestic cattle	Palatable; good forage value.
Helianthus annuus (Common sunflower)	Flower/seed/ foliage; carbohydrates & proteins	Unknown	Browse on some overgrazed sites	Cattle/deer/ raccoon/skunk/ rabbit/squirrel	Palatable; good forage value.
Solanum dimidiatum (Western horsenettle)	Poisonous range plant	Unknown	Overgrazing indicator	Cattle	Poisonous; no nutritive value.

SOURCE: REFERENCES [3, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16]

TABLE 2.7-2

INFESTATIONS OF DOMINANT TREE SPECIES OF HOOD AND SOMERVELL COUNTIES

Infestation	Juniperus (Ashe juniper and redberry)	Populus (Eastern cottonwood)	(Salix) Black willow	(Quercus) (Black jack, post oak, live oak)	Celtis (Sugar hackberry)	Mesquite (Proscopis)
INSECTS						
Bark feeders	(Hylobius, Pales) Pales Weevil	(Saperda calcarata) Poplar borer	Gimbex americana Elm sawfly Sapedra calcarata Poplar borer	N.A. Prionus laticollis Broad-necked borer	N.A.	Neoclytus caprea Banded ash borer Oncideres cingulata Girdler
Borers - bark and phloem	N.A.	N.A.	Plectrodera scalator	Goes tigrinus White oak borer Prionus laticollis Broad-necked borer	Agrilis celti Oak borer Scolytus muticus Hackberry engraver	Aneflus protensus
Borers	(Phloeosinus dentatus) Eastern juniper bark beetle (Leperisinus aculeatus)	(Agrilus liragus) Bronze poplar borer	Conopia proxima	N.A.	N.A.	N.A.
Borers - Cone	N.A.	N.A.	Aegeria tibialis	N.A.	N.A.	N.A.
Borers - shoot and twig	N.A.	(Gypsonoma Haimbachiana)	N.A.	N.A.	N.A.	Elaphidionoides villosus Twig pruner
Borers - root	N.A.	(Prionus laticollis) Broad-necked root borer	Rhynchaenus rufipes Willow flea weevil Polydrusus impressifrons	Goes tesselatus Oak sapling borer Goes dibilis Oak branch borer	Hylotrupes bajulus Old-house borer	Gnathamitermus perplexus Termite Gnathamitermus tubiformanus Termite

TABLE 2.7-2 (Continued)

Infestation	Juniperus (Ashe juniper and redberry)	Populus (Eastern cottonwood)	(Salix) Black willow	(Quercus) (Black jack, post oak, live oak)	Celtis (Sugar hackberry)	Mesquite (Proscopis)
INSECTS						
Borers - wood	(Callidium texanum) Black-horned juniper borer (Callidium antennatum hesperum) Black-horned pine borer	(Chalcophorella campestris) Flat-headed sycamore heartwood borer	Chrysobothris azurea Chalcophorella campestris Flat-headed sycamore heartwood borer	Megacyllene caryae Painted hickory borer	Chrysobothris femorata Flat-headed appletree borer Hylocurus rudis Hylocurus langstoni	Melipotis fasciolaris Cutworms
Gall insects	(Contarinia juniperina) Juniper midge	(Mordwilkoja vagabunda) Poplar vagabond aphid (Mayetiola rigidae) Willow-beaked-call midge	Oberea ferroginea Stem borer Saferoa fayi Thorn-limb borer	Callirhytis punctata Gouty oak gall	Pachypsylla celtidisastericus Hackberry stargall Pachypsylla celtidismamma Hackberry-nipple gall maker	N.A.
Leaf feeders	(Phyllobius intrusus) Arboruitae weevil (Argyrotaenia velutinana) Red-banded leaf-roller (Coleotechnites juniperella) Moth (Neodiprion lecontei) Red-headed pine saw fly	(Chrysomela scripta) Cottonwood leaf beetle Phyllobius oblongus European snout beetle	Altica subplicata Flea beetle Maladera castanea Asiatic garden beetle	Crytepistomus castaneus Asiatic oak weevil Archips griseus Leaf roller	Nymphalis antiupa Morning cloak butterfly Megalopyge opercularis Puss caterpillar	Mozena obtusa Leaf-footed bug

TABLE 2.7-2 (Continued)

Infestation	Juniperus (Ashe juniper and redberry)	Populus (Eastern cottonwood)	(Salix) Black willow	(Quercus) (Black jack, post oak, live oak)	Celtis (Sugar hackberry)	Mesquite (Proscopis)
PATHOGENS						
Blights	Phomopsis blight	Leaf blight Plagiostoma populi Cercospora populina	N.A.	Physalospora glandicola	Pelucularia koleroga Corticium stevensii	N.A.
Foliage disease	Phomopsis blight Stigmina jupierina Cercospora sequoiae Coryneum juniperinum Gymnosporangium clavariiformae	Ciborinia bifrons Myrioconium comitatum Didymosphaeria populina Venturia populina Venturia tremulae Marssonina populi Linospora tetraspora	Fusicladium saliciperdum Physalospora miyabeana Cercospora salicina Phyllactinia guttata	Gnomonia veneta Gloeosporium quercinum Taphrina caerulescens Cronartium fusiforme	Cercospora spegazzini Cylindrosporium defoliatum Cercosporella celtidis Mycosphaerella maculiformis Phleospora celtidis Septogloeum celtidis	Phomopsis occulta Ventura populina Melampsora aecidioides
Rusts	N.A.	Melampsora albertensis Melampsora occidentalis Melampsora medusae Melampsora aecidioides	Melampsora albertensis Melampsora occidentalis Melampsora medusae Melampsora aecidioides Melampsora epitea	Cronartium fusiforme Cronartium strobilinum Cronartium conigeum Morenoella quercina	Helicobasidium purporeum Rhizoctonia crocorum	Melampsora aecidioides Melampsora occidentalis

TABLE 2.7-2 (Continued)

Infestation	Juniperus (Ashe juniper and redberry)	Populus (Eastern cottonwood)	(Salix) Black willow	(Quercus) (Black jack, post oak, live oak)	Celtis (Sugar hackberry)	Mesquite (Proscopis)
<u>INSECTS</u>						
Root feeders	Brachyrhinus ovatus Strawberry root weevil	N.A.	Phyllobius oblongus European snout beetle	Phyllophaga trista	N.A.	Cerambycidae ssp. Long-horned borer
Sap feeders	N.A.	N.A.	N.A.	Ceratocystis fagacearum Sap beetle	N.A.	N.A.
Sucking insects	N.A.	N.A.	Lepidosaphes ulmi Oystershell scale Lecanium corni Brown elm scale	Asterolecanium luteolum Yellow oak scale	Corythucha celtidis Hackberry lace bug Diaspidiotus ancylus Putnam scale	N.A.
Others	(Semanotus ligneus) Cedar tree borer (Carulaspis carveli) Juniper scale	N.A.	N.A.	Conotrachelus carinifer Acorn borers Archips fervidanus Oak webworm	N.A.	N.A.
<u>PATHOGENS</u>						[17, 18, 19]
Diseases		Graphium rubrum Taphrina johansonii	Helicobasidium purporeum Phymatotrichum omnivorum	Hypoxylon atropunctatum Ceratocystis fagacearum	Phymatotrichum omnivorum	Phymatotrichum omnivorum

TABLE 2.7-2 (Continued)

Infestation	Juniperus (Ashe juniper and redberry)	Populus (Eastern cottonwood)	(Salix) Black willow	(Quercus) (Black jack, post oak, live oak)	Celtis (Sugar hackberry)	Mesquite (Proscopis)
PATHOGENS						
Stem diseases	Phomopsis juniperovora Phomopsis occulta Coccomyces juniperi Diplodia pinea	Hypoxylon mammatum Hypoxylon cruinatum Cytospora chrysosperma Dothichiza populea Neofabraea populi	Botryosphaeria ribis Cryptodiaporthe saligina Cytospora chrysosperma Agrobacterium tumefaciens	Endothia parasitica Endothia gyrosa Stromella coryneoidea Nectria galligena Irpex mollis	Phoradendron serotinum Septobasidium burtii	Phoradendron serotinum
Trunk rots	Fomes juniperinus Fomes earlii Daedalea juniperina Daedalea westii	Fomes ignarius Fomes applanatus Armillaria mellea	Trametes suaveolens Daedalea ambigua Fomes applanatus Fomes connatus Polyporus munzii	Physalospora glandicola Phomopsis ssp. Phoradendron villosum	Armillaria mellea Phymatotrichum ssp. Pleurotus ostreatus Polyphorus tulipiferus	Physalospora glandicola Phomopsis occulta Phoradendron villosum
Other	Seedling Diseases: Phytophthora cinnamomi Root nematode Pratylenchus penetrans	Seedling Diseases: Septoria musiva Dothichiza populea Septotina populiperda Melampsora medusa	Eastern mistletoe Phoradendron serotinum	Epiphyte: Tillandsia usneoides	N.A. N.A.	Eastern mistletoe Phoradendron serotinum

SOURCE: REFERENCES [19, 20, 21, 22, 23, 24, 25]

TABLE 2.7-3

PESTICIDE USE IN HOOD AND SOMERVELL COUNTIES

Pesticide Name	Formulation	Principal Use	Normal Application Rate and Time	Amount of Use
Aldrin	Liquid spray	Rootworm control in field corn crops	Preplanting, broadcast application. 1-3 qt. spray concentrate/acre	Moderate though not as commonly as 5 years ago
DDT	Liquid spray	Insect control in field crops	Preplanting and throughout season. 2-6 lb/acre	Low amount of use, not recommended for past 15 years
Diphenylamine (35%) ("Smear 62")	Liquid spray or paste application	Screwworm control in beef cattle only	Whenever livestock affected, amount used must be minimum necessary to treat wound	Moderate to good use in last 18 months
Lindane (3%)	Oil emulsion	Screwworm control in beef cattle only	Whenever livestock affected, amount used should be limited to spot treatment only	Moderate to good use in last 18 months
Methoxychlor (0.5% sp. or dip or 50% WP dust)	Spray, dip or WP Dust spray	Hornfly control in beef & non-lactating dairy cattle only	When effected. For WP, 1 Tbsp. per animal	Moderate to good use for past 5 years
Malathion (0.5% sp. or 4-5% dust)	Spray, dip or dust spray	Hornfly control in beef & non-lactating dairy cattly only	Whenever effected. 2 oz. of 4% or 1-1/2 oz of 5% dust per animal	Moderate to good use in past 5 years
Ronnel (0.25% sp. or dip)	Aerosol spray or dip	Lice & sucking insects of livestock	Minimum of 56 days after last application. Do not apply to lactating dairy cattle	Frequently in use

TABLE 2.7-3 (Continued)

Pesticide Name	Formulation	Principal Use	Normal Application Rate and Time	Amount of Use
Rotenone (5% powder or 1% dust)	Aerosol spray powder or dust	Lactating dairy cattle	Do not use near feed, water, milk or milking utensils	Frequently in use
Sevin (Carbaryl)	Spray	Beef and non-lactating cattle	Minimum 7 days from last application	Frequently in use
Toxaphene (0.5 and 5%)	Spray, dip or dust	Beef and non-lactating cattle	Minimum of 28 days between applications	Infrequent use

SOURCE: REFERENCES [37, 38, 39, 40, 41, 42, 43, 44]

TABLE 2.7-4 A
HERBICIDE USE IN HOOD AND SOMERVELL COUNTIES

Herbicide Name	Formulation	Principal Use	Normal Application Rate and Time	Amount of Use
Treflan	Liquid spray	Weed control in peanuts	Once yearly in spring prior to planting time. 1 pt/acre	Moderate to common usage
Atrazin	Wettable powder	Weed control in pecans	Once yearly in mid-summer. 1-1/4 lb/acre	Little used currently. Used in past in moderate amounts
Princep	Wettable powder	Weed control for Buffalobur & annuals in Bermuda grass	Once yearly in spring. 1 lb/acre	Common usage
2,4-D	Liquid spray in oil base	Brush control	Once yearly. 3 lb/100 gal. oil	Not used in last 15 years as brush control
2,4,5-T	Liquid spray in oil base	Brush & weed control/ used for some trees	Once in spring. 2 lb/85 gal. oil	Not used for brush control for past 15 years; however used for some tree control in past 5 years
TCA (Trichloroacetic acid)	Spray solution	Contact herbicide & soil sterilant	Once yearly. 100 lb/acre usual; 200 lb/acre occasional	Intermittent use in area by only Texas State Highway Dept. for brush control in roadways

TABLE 2.7-4 A (Continued)

Herbicide Name	Formulation	Principal Use	Normal Application Rate and Time	Amount of Use
Ammate-X	Spray solution	Contact herbicide & soil sterilant	Once yearly. 60 lb/acre	Intermittent use in area by only Texas State Highway Dept. for brush control in roadways
Note: TCA and Ammate-X are sometimes used together as:	Spray solution	Contact herbicide & soil sterilant	Once yearly. TCA = 100 lb/acre Ammate-X = 60 lb/acre	Intermittent use in area by only Texas State Highway Dept. for brush control in roadways

SOURCE: REFERENCES [37, 45, 46, 47]

TABLE 2.7-4 B

PESTICIDE & HERBICIDE DOSAGES FOUND TOXIC TO LABORATORY & WILD ANIMALS COMMON IN HOOD & SOMERVELL COUNTIES[1] 1

Pesticide or Herbicide	Target Animal	LD_{50} (mg/kg)	LC_{50} (ppm)	Application Rate	Comment
ALDRIN	Rat	54-56			
	Rabbit	<150			
	Mallard (young)	520	164		
	Bobwhite quail(young)	6.6	39		
DDT	Rat	420-800			
	Mouse	200		2 lb/A up to 2 lb/A	° Maryland, white-footed mouse - no noticeable effect. ° Forest, spray, one year delay in soil accumulation, no mortality observed in white-footed mouse population.
	Rabbit	250-400			
	Mallard (young)	>2240	850-1200		
	Lesser Sandhill crane	>1200			
	Bobwhite quail		600-1000		
	Birds				° House sparrows fed earthworms with 298 ppm (wet weight) died within 1-10 days. (DDT levels exceptionally high)
					° House sparrows fed earthworms with 86-90 ppm (wet weight) survived 2-6 days. (DDT levels exceptionally high)
				1.9 lb/A	° New Hampshire, Dutch Elm Disease Control - 3 year study. 151 birds died on treated area vs. 10 on untreated area.
				8.2 lb/A	° Larch Forest - no noticeable effect on birds.
				10.0 lb/A	° Caused Spring mortalities of over 85% of robin populations.
	Bullfrog	>2000		1.0 lb/A	° Minnesota, tent caterpillar control, 32% mortality occurred among bullfrogs by the following day

TABLE 2.7-4 B (Continued)

Pesticide or Herbicide	Target Animal	LD_{50} (mg/kg)	LC_{50} (ppm)	Application Rate	Comment	
DDT (continued)	*Rana sylvatica*			1 lb/A		
LINDANE	Rat	125-200				
	Mouse	86				
	Rabbit	60-200				
	Mallard (young)	>2000				
	Mallard (adult)		75000			
	Bobwhite quail		900-1100			
	Fowler's toad[2] tadpoles	14 (24 hrs)				1
METHOXYCHLOR	Rat	$5\text{-}6 \times 10^3$				
	Mouse	800				
	Mallard (young)	>2000	5000			
	Bobwhite		>5000			
	Robin				Less toxic to robins than DDT.	
	Fowler's toad[2] tadpole		0.76			
MALATHION	Rat	480-1500		2 lb/A	° Ohio watershed aerially sprayed, mice and chipmunks reduced but shrews and larger mammals unnoticeably affected.	
	Mouse	885-1120				
	Mallard (young)	1485	>5000			
	Bobwhites		3300-3700			
	Reptiles & Amphibians			2 lb/A	° Ohio watershed aerially sprayed, no noticeable effect to Reptiles & Amphibians.	

TABLE 2.7-4 B (continued)

Pesticide or Herbicide	Target Animal	LD_{50} (mg/kg)	LC_{50} (ppm)	Application Rate	Comment
MALATHION (continued)	Fowler's toad [2] tadpoles		1.9		
RONNEL	Rats	1740			
ROTENONE	Rat	132			
	Mallard (young)	>2000			
SEVIN	Rat	540		2 lb/A	° Inhibited reproduction and reduced populations of cotton rats in a grassland.
	Mouse			2 lb/A	° No apparent effect to house mouse or old-field mouse population in a grassland.
	Mallard (young)	>2179	>5000		
	Bobwhite		>5000		
TOXAPHENE	Rat	69		2 lb/A	° North Dakota marsh, no young produced by sora rail, coot, and black tern; but redwing blackbird produced young.
	Mouse	112			
	Goat	>160			
	Mallard (young)	71	563		
	Bobwhite (young)	85	834		° Diet containing 50 ppm limited bobwhite quail reproduction by at least 25%.
	Sandhill cranes	100-316			
	Fowler's toad [2] tadpoles		0.6		° Plants and animals absorb toxaphene applied to a lake.

1

TABLE 2.7-4 B (continued)

Pesticide or Herbicide	Target Animal	LD_{50} (mg/kg)	LC_{50} (ppm)	Application Rate	Comment
TREFLAN	Rat	>10000			
	Mouse	5000			
	Rabbit	>2000			
	Mallard (young)	>2000			
	Fowler's toad[2] tadpoles		0.18		
ATRAZINE	Rat	3080			
	Mouse	1750			
	Mallard	>2000	>5000		
	Bobwhite quail (yg)		700-800		
PRINCEP	Rat	>5000			
	Mallard		>5000		
2,4,5-T	Rat	300			
	Mallard		>5000		
TCA	Rat	5000			
	Mouse	3640			
	Rabbit	4000			
AMMATE-X	Rat	3900			

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[1] Source: Reference [138]

[2] Not known on CPSES site but represents toxic dosage to an amphibian.

Diphenylamine and 2,4-D are not included.

TABLE 2.7-5

BIRDS OF SQUAW CREEK RESERVOIR AREA

(Checklist and relative abundance of birds deriving ecological requirements from the Squaw Creek Reservoir Area during spring (Sp), summer (Su), fall (F), and winter (W). An asterisk (*) indicates that the species has been observed in the area.)

FAMILY Scientific Name[1]	Common Name	Period of Occurrence	Relative Abundance
ARDEIDAE			
Ardea herodias*	Great Blue Heron	SpSuFW	Uncommon
Butorides virescens*	Green Heron	Su	Uncommon
ANATIDAE			
A. platyrhynchos	Mallard	W	Uncommon
A. strepera	Gadwall	W	Uncommon
Mareca americana	American Widgeon	W	Uncommon
CATHARTIDAE			
Cathartes aura*	Turkey Vulture	SpSuFW	Common
Coragyps atratus*	Black Vulture	SpSuFW	Uncommon
ACCIPITRIDAE			
Accipiter cooperii	Cooper's Hawk	FW	
A. striatus	Sharp-shinned Hawk	FW	
Buteo jamaicensis*	Red-tailed Hawk	SpSuFW	Uncommon
B. swainsonii	Swainson's Hawk	SpSu	
Circus cyaneus*	Marsh Hawk	Sp FW	Uncommon
Ictinia misisippiensis	Mississippi Kite	Su	
FALCONIDAE			
Falco columbarius	Pigeon Hawk	Sp F	
F. mexicanus	Prairie Falcon	Sp W	
F. peregrinus	Peregrine Falcon	Sp FW	
F. sparverius*	Sparrow Hawk	SpSuFW	Uncommon

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[1] Scientific names after Peterson [58]

Table 2.7-5 (Continued)

FAMILY Scientific Name	Common Name	Period of Occurrence	Relative Abundance
PHASIANIDAE			
_Colinus virginianus_*	Bobwhite Quail	SpSuFW	Common
CHARADRIIDAE			
_Charadrius vociferus_*	Killdeer	SpSuFW	Common
SCOLOPACIDAE			
Totanus sp.*	Yellowlegs	Su	Uncommon
COLUMBIDAE			
_Scardafella inca_*	Inca Dove	SuF	Uncommon
_Zenaida asiatica_*	White-winged Dove	Su	Rare
_Zenaidura macroura_*	Mourning Dove	SpSuFW	Abundant
CUCULIDAE			
_Coccyzus americanus_*	Yellow-billed Cuckoo	Su	Uncommon
_Geococcyx californianus_*	Roadrunner	SpSuFW	Uncommon
TYTONIDAE			
Tyto alba	Barn Owl	SpSuFW	
STRIGIDAE			
_Bubo virginianus_*	Great Horned Owl	SpSuFW	Uncommon
Otus asio	Screech Owl	SpSuFW	
Strix varia	Barred Owl	SpSuFW	
CAPRIMULGIDAE			
_Chordeiles minor_*	Common Nighthawk	SuF	Common

Table 2.7-5 (Continued)

FAMILY Scientific Name	Common Name	Period of Occurrence	Relative Abundance
APODIDAE			
Chaetura pelagica*	Chimney Swift	SpSu	Uncommon
TROCHILIDAE			
Archilochus alexandri	Black-chinned Hummingbird	SpSu	
A. colubris*	Ruby-throated Hummingbird	SpSu	Uncommon
ALCEDINIDAE			
Megaceryle alcyon*	Belted Kingfisher	SpSuFW	Common
PICIDAE			
Centurus carolinus*	Red-bellied Woodpecker	SpSuFW	Uncommon
Colaptes auratus*	Yellow-shafted Flicker	FW	Common
C. cafer*	Red-shafted Flicker	FW	Common
Dendrocopos pubescens	Downy Woodpecker	SpSuFW	
D. scalaris*	Ladder-backed Woodpecker	SpSuFW	Uncommon
D. villosus	Hairy Woodpecker	SpSuFW	
Melanerpes erythrocephalus	Red-headed Woodpecker	SpSuFW	
Sphyrapicus varius	Yellow-bellied Sapsucker	FW	
TYRANNIDAE			
Contopus virens	Eastern Wood Peewee	SpSuF	
Muscivora forficata*	Scissor-tailed Flycatcher	SpSuF	Common
Myiarchus crinitus*	Great Crested Flycatcher	SpSu	Uncommon

Table 2.7-5 (Continued)

FAMILY Scientific Name	Common Name	Period of Occurrence	Relative Abundance
TYRANNIDAE (Cont'd.)			
_Sayornis phoebe_*	Eastern Phoebe	SpSuFW	Uncommon
_Tyrannus tyrannus_*	Eastern Kingbird	SpSu	Uncommon
T. verticalis	Western Kingbird	SpSu	
ALAUDIDAE			
_Eremophila alpestris_*	Horned Lark	SpSuFW	Common
HIRUNDINIDAE			
_Stelgidopteryx ruficollis_*	Rough-winged Swallow	SpSuF	Common
CORVIDAE			
_Corvus brachyrynchos_*	Common Crow	SpSuFW	Common
_Cyanocitta cristata_*	Blue Jay	SpSuFW	Common
PARIDAE			
_Parus bicolor_*	Tufted Titmouse	SpSuFW	Uncommon
_P. carolinensis_*	Carolina Chickadee	SpSuFW	Common
CERTHIIDAE			
Certhia familiaris	Brown Creeper	Sp FW	
TROGLODYTIDAE			
_Thryomanes bewickii_*	Bewick's Wren	SpSuFW	Uncommon
_Thryothorus ludovicianus_*	Carolina Wren	SpSuFW	Common
Troglodytes aedon	House Wren	Sp FW	
T. troglodytes	Winter Wren	FW	
MIMIDAE			
_Mimus polyglottos_*	Mockingbird	SpSuFW	Common

Table 2.7-5 (Continued)

FAMILY Scientific Name	Common Name	Period of Occurrence	Relative Abundance
MIMIDAE (Cont'd.)			
Toxostoma rufum*	Brown Thrasher	SpSuFW	Uncommon
TURDIDAE			
Myadestes townsendi	Townsend's Solitaire	W	
Sialia sialis*	Eastern Bluebird	SpSuFW	Common
Turdus migratorius*	Robin	Sp FW	Abundant
MOTACILLIDAE			
Anthus spinoletta*	Water Pipit	Sp FW	Uncommon
A. spragueii	Sprague's Pipit	Sp FW	
SYLVIIDAE			
Polioptila caerulea*	Blue-gray Gnatcatcher	SpSuF	Common
Regulus calendula*	Ruby-crowned Kinglet	Sp FW	Common
R. satrapa	Golden-crowned Kinglet	FW	
BOMBYCILLIDAE			
Bombycilla cedrorum*	Cedar Waxwing	Sp FW	Uncommon
LANIIDAE			
Lanius ludovicianus*	Loggerhead Shrike	SpSuFW	Common
STURNIDAE			
Sturnus vulgaris*	Starling	Sp FW	Common
VIREONIDAE			
Vireo bellii*	Bell's Vireo	SpSuF	Uncommon
V. griseus	White-eyed Vireo	SpSuF	
V. olivaceus	Red-eyed Vireo	SpSuF	

Table 2.7-5 (Continued)

FAMILY Scientific Name	Common Name	Period of Occurrence	Relative Abundance
PARULIDAE			
Dendroica coronata*	Myrtle Warbler	Sp FW	Common
D. petechia	Yellow Warbler	SpSuF	
D. virens	Black-throated Green Warbler	Sp F	
Geothlypis trichas	Yellowthroat	SpSuFW	
Icteria virens	Yellow-breasted Chat	SpSuF	
Mniotilta varia*	Black-and-white Warbler	SpSuF	Uncommon
Setophaga ruticilla	American Redstart	Sp F	
Vermivora celata	Orange-crowned Warbler	Sp FW	
Wilsonia pusilla*	Wilson's Warbler	Sp F	Uncommon
PLOCEIDAE			
Passer domesticus*	House Sparrow	SpSuFW	Common
ICTERIDAE			
Agelaius phoeniceus*	Redwinged Blackbird	SpSuFW	Common
Cassidix mexicanus*	Boat-tailed Grackle	SpSuFW	Uncommon
Euphagus cyanocephalus*	Brewer's Blackbird	Sp FW	Common
Icterus spurius*	Orchard Oriole	SpSuF	Common
Molothrus ater*	Brown-headed Cowbird	SpSuFW	Common
Sturnella magna*	Eastern Meadowlark	SpSuFW	Abundant

Table 2.7-5 (Continued)

FAMILY Scientific Name	Common Name	Period of Occurrence	Relative Abundance
ICTERIDAE (Cont'd.)			
*S. neglecta**	Western Meadowlark	Sp FW	Common
THRAUPIDAE			
Piranga rubra	Summer Tanager	SpSuF	
FRINGILLIDAE			
Aimophila cassinii	Cassin's Sparrow	Su	
*A. ruficeps**	Rufous-crowned Sparrow	SpSuFW	Common
Ammodramus bairdii	Baird's Sparrow	W	
A. savannarum	Grasshopper Sparrow	SpSuF	
Calcarius ornatus	Chestnut-collared Longspur	FW	
Carpodacus purpureus	Purple Finch	FW	
*C. mexicanus**	House Finch	SpSuFW	Uncommon
*Chondestes grammacus**	Lark Sparrow	SpSuFW	Abundant
Guiraca caerula	Blue Grosbeak	SpSuF	
*Junco hyemalis**	Slate-colored Junco	FW	Common
*Melospiza melodia**	Song Sparrow	Sp FW	Uncommon
Passerculus sandwichensis	Savannah Sparrow	Sp FW	
Passerherbulus caudacutus	Le Conte's Sparrow	Sp FW	
*Passerina ciris**	Painted Bunting	SpSuF	Uncommon
P. cyanea	Indigo Bunting	SpSuF	
*Pipilo erythrophthalmus**	Rufous-sided Towhee	Sp FW	Common
*Pooecetes gramineus**	Vesper Sparrow	Sp FW	Common

Table 2.7-5 (Continued)

FAMILY Scientific Name	Common Name	Period of Occurrence	Relative Abundance
FRINGILLIDAE (Cont'd.)			
Rhynchophanes mccownii	McCown's Longspur	FW	
*Richmondena cardinalis**	Cardinal	SpSuFW	Common
*Spinus psaltria**	Lesser Goldfinch	SpSuFW	Uncommon
*S. tristus**	American Goldfinch	Sp FW	Uncommon
Spiza americana	Dickcissel	SpSuF	
Spizella arborea	Tree Sparrow	W	
*S. pusilla**	Field Sparrow	SpSuFW	Common
*Zonotrichia leucophrys**	White-crowned Sparrow	Sp FW	Common
*Z. querula**	Harris' Sparrow	Sp FW	Common

TABLE 2.7-6

BIRD DENSITIES OF SQUAW CREEK RESERVOIR AREA

(Estimated densities of birds in two habitat type on the Squaw Creek Reservoir Area based on fifteen strip censuses [57] in November, 1972)

Species or Group	Estimated Density (Number/ 100 acres)	
	Bottomlands	Uplands
Robins	605	27
Fringillids	170	225
Meadowlarks	156	43
Mourning Doves	19	12
Other Birds	205	120
Total	1,155	427

TABLE 2.7-7

BOBWHITE QUAIL OBSERVED IN FIVE TEXAS COUNTIES

(Number of bobwhite quail observed per mile during August censuses by the Texas Parks and Wildlife [65])

County	Year 1967	1968	1969	1970	1971
Bosque	0.60	1.56	0.99	0.72	0.51
Hood & Somervell	0.36	1.24	0.53	1.24	1.20
Johnson	0.68	1.91	0.80	1.16	0.14
Erath	0.27	1.25	2.20	2.59	--

TABLE 2.7-8

FOODS OF COLLECTED BOBWHITE QUAIL

(Quantitative and qualitative comparison of food items in the crops of nineteen bobwhite quail collected on the Squaw Creek Reservoir Area during fall, 1972.)

	Percent	
Food Item	Volume	Frequency
PLANT		
Western Ragweed (*Ambrosia psilostachya*)	26.0	42
Cedar Elm (*Ulmus crassifolia*)	22.4	10
Common Broomweed (*Xanthocephalum dracunculoides*)	15.4	16
Acorns (*Quercus* spp.)	12.6	16
Annual Dropseed (*Sporobolus* spp.)	12.2	58
Narrowleaf Sumpweed (*Iva angustifolia*)	1.9	47
Flame-leaf Sumac (*Rhus copallina*)	1.7	32
Oneseed Croton (*Croton monanthogynus*)	1.4	53
Green Vegetation	T[1]	84
Panic Grasses (*Panicum* spp.)	T	58
White Pricklypoppy (*Argemone albiflora*)	T	21
Silver Bluestem (*Bothriochloa saccharoides*)	T	16
Camphorweed (*Heterotheca latifolia*)	T	5
Wood Sorrel (*Oxalis dillenii*)	T	5
Hackberry (*Celtis laevigata*)	T	5
Gum Elastic (*Bumelia lanuginosa*)	T	5
Texas Stillingia (*Stillingia texana*)	T	5
Lespedeza (*Lespedeza* sp.)	T	5
Grapes (*Vitis* sp.)	T	5
ANIMAL		
Spiders (Arachnida)	1.4	16
Grasshoppers (Orthoptera)	T	26
Dipterons (Diptera)	T	21
Unknown Insect Fragments	T	16
Beetles (Coleoptera)	T	16
Snails (Gastropoda)	T	10
Homopterons (Homoptera)	T	5
Hymenopterons (Hymenoptera)	T	5
UNKNOWN	T	42
GRIT	T	16

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[1] T (Trace) is less than 0.1 percent.

TABLE 2.7-9

COMMON FOODS OF BOBWHITE QUAIL

(Identified contents having a frequency of over five percent in bobwhite quail crops collected during the hunting season from (A) Wise and Hill Counties, 1957-1958 and (B) the Possum Kingdom Management Area, 1958-1959. The number of crops is in parenthesis.)[1]

Plant Name	(A) (227)		(B) (346)	
	Percent			
	Frequency	Volume	Frequency	Volume
Croton (*Croton glandulosus*)	40.1	8.2	24.3	4.8
Spanishclover deervetch (*Lotus americanus*)	18.5	2.7	22.5	6.3
Snakeweed (*Gutierrezia* sp.)	15.8	9.3	24.3	13.4
Woolly croton (*Croton capitatus*)	22.0	16.8		
Spiny spiderflower (*Cleome spinosa*)	7.9	0.1		
Woollybucket bumelia (*Bumelia lanuginosa*)	26.9	8.5		
Insects	21.6	0.8	26.0	0.8
Small wildbean (*Strophostyles pauciflora*)	17.2	6.5	26.3	4.2
Bundleflower (*Desmanthus* sp.)	6.2	0.2		
Greens	36.1	1.4	61.6	2.0
Johnsongrass (*Sorghum halapense*)	9.7	0.9	13.0	0.6
Trailing wildbean (*Strophostyles helvola*)	8.8	3.4	10.1	3.5
Western ragweed (*Ambrosia psilostachya*)	24.7	7.1	52.0	22.0
Lewis flax (*Linum lewisii*)	9.7	4.5		
Common sunflower (*Helianthus annuas*)	9.2	2.1		

Table 2.7-9 (Continued)

Plant Name	(A) (227) Percent Frequency	 Volume	(B) (346) Frequency	 Volume
Fringeleaf paspalum (Paspalum ciliatifolium)	7.9	0.1	25.7	2.5
Grasshopper eggs	11.0	5.9		
Acorns	15.0	7.2		
Tickclover (Desmodium sp.)	11.9	4.6		
Gromwell (Lithospermum sp.)			11.3	0.1
Black locust (Robinia speudoacacia)			5.8	2.9
Western indigo (Indigofera leptosepala)			9.2	2.9
Giant ragweed (Ambrosia trifida)			5.2	2.6
Snow-on-the-mountain euphorbia (Euphorbia marginata)			6.1	0.2
Sorghum (Sorghum vulgare)			9.0	2.8
Wildbean (Strophostyles leiosperma)			7.2	0.1
Partridge pea (Chamaecrista sp.)			47.8	3.2
Bromegrass (Bromus sp.)			13.0	0.4
Common oats (Avena sativa)			5.8	1.3

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1 Source: References [70, 71]

TABLE 2.7-10

NUTRITIONAL ANALYSIS OF BOBWHITE QUAIL DIET

(Nutritional analysis of foods in the diet of bobwhite quail in Wise and Hill Counties, Texas [70].)

			Percent			
	Protein	Fat	Calcium	Phosphorus	Ash Fiber	NFE
Trailing wildbean (*Strophostyles helvola*)		0.25			4.95	8.00
Western ragweed (*Ambrosia psilostachya*)		19.06			4.25	36.05
Spanishclover deervetch (*Lotus americanus*)		7.55			4.35	10.00
Grasshopper eggs		23.82	0.10	0.50	6.30	6.70
Mimosa (*Mimosa* sp.)	35.00	1.67			3.83	13.60
Prairie acacia (*Acacia angustissima*)	29.49	2.16			3.33	11.00
Snakeweed (*Gutierrezia* sp.)	22.90	25.35	0.20	0.65	13.04	16.65
Bundleflower (*Desmanthus leptolobus*)	35.90	1.32			4.83	10.90
Small wildbean (*Strophostyles pauciflora*)	26.70	0.70			4.43	9.75
Tickclover (*Desmodium* sp.)	21.96				7.43	12.40

TABLE 2.7-11

MOURNING DOVE OBSERVED IN FIVE TEXAS COUNTIES

(Number of mourning doves observed per mile and percent change between years during August censuses by the Texas Parks and Wildlife [66].)

County	1967	Percent Change	1968	Percent Change	1969	Percent Change	1970
Bosque	9.81	- 58	4.16	- 79	0.87	+ 26	1.10
Hood & Somervell	3.22	- 52	1.55	+ 53	2.37	- 56	1.05
Johnson	1.75	- 57	0.76	- 79	0.16	+888	1.58
Erath	3.00	- 7	2.80	- 26	2.07	+ 27	2.63

TABLE 2.7-12

FOODS OF COLLECTED MOURNING DOVES

(Quantitative and qualitative comparison of food items in the crops of ten mourning doves collected on the Squaw Creek Reservoir Area during fall, 1972.)

Food Item	Percent Volume	Percent Frequency
PLANT		
Western Ragweed (*Ambrosia psilostachya*)	36.2	90
Sorghum (*Sorghum vulgare*)	33.1	50
White Pricklypoppy (*Argemone albiflora*)	13.2	30
Oneseed Croton (*Croton monanthogynus*)	10.0	50
Annual Dropseed (*Sporobolus* spp.)	3.4	30
Peanuts (*Arachis hypogaea*)	2.7	10
Panic Grasses (*Panicum* spp.)	T[1]	60
Amaranth (*Amaranthus* sp.)	T	30
Johnsongrass (*Sorghum halepense*)	T	20
Texas Stillingia (*Stillingia texana*)	T	20
Snow-on-the-Mountain (*Euphorbia marginata*)	T	10
Croton (*Croton* sp.)	T	10
Tumble Windmillgrass (*Chloris verticellata*)	T	10
Wheat (*Triticum aestivum*)	T	10
ANIMAL		
Insects	T	20
UNKNOWN	T	40
GRIT	T	10

[1] T (Trace) is less than 0.1 percent.

TABLE 2.7-12A IMPORTANT AVIAN SPECIES IN SQUAW CREEK RESERVOIR AREA 2

Scientific Name	Common Name	Seasonal Status[1]	Trophic Position[2]	Habitats[3]	Population Status[4]
Ardea herodias	Great blue heron	SP,SU,F,W	TC	R, U*	-
Butorides virescens	Green-heron	SU	TC	R*, U*	-
Cathartes aura	Turkey vulture	SP,SU,F,W	TC	R*, U*	-
Coragyps atratus	Black vulture	SP,SU,F,W	TC	R*, U*	-
Accipiter cooperii	Cooper's hawk	F,W	TC	R, U	-
Accipiter striatus	Sharp-shinned hawk	F,W	TC	R, U	-
Buteo jamaicensis	Red-tailed hawk	SP,SU,F,W	TC	U*, R*	-
Buteo swainsoni	Swainson's hawk	SP,SU	TC	U	-
Buteo lagopus	Rough-legged hawk	F,W	TC	U*	-
Aquila chrysaetos	Golden eagle	SP,SU,F,W	TC	U	-
Haliaeetus leucocephalus	Bald eagle	F,W	TC	R, U	Endangered
Circus cyaneus	Marsh hawk	SP,F,W	TC	U*, R	-
Pandion haliaetus	Osprey	SP,SU,F,W	TC	R*	Undetermined
Ictinia misisippiensis	Mississippi kite	SU	TC	R	-
Falco columbarius	Pigeon hawk	SP,F	TC	U	Undetermined
Falco mexicanus	Prairie falcon	SP,W	TC	U	Threatened
Falco peregrinus	Peregrine falcon	SP,F,W	TC	R, U	Endangered
Falco sparverius	Sparrow hawk	SP,SU,F,W	TC	U*	-
Geococcyx californianus	Roadrunner	SP,SU,F,W	TC	U	-
Tyto alba	Barn owl	SP,SU,F,W	TC	U, R	-
Bubo virginianus	Great horned owl	SP,SU,F,W	TC	R*, U	-
Otus asio	Screech owl	SP,SU,F,W	TC	R*, U	-
Strix varia	Barred owl	SP,SU,F,W	TC	R, U	-
Megaceryle alcyon	Belted kingfisher	SP,SU,F,W	TC	R*, U*	-
Lanius ludovicianus	Loggerhead shrike	SP,SU,F,W	TC	U	-
Dendroica chrysoparia	Golden-cheeked warbler	SP,SU	-	U, R	Threatened

1

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[1] Because of the rarity of many of these species, seasonal status is largely drawn from the literature. Based on Guthery and Synatzske 1973, and later observations. SP=Spring, SU=Summer, F=Fall, W=Winter.

[2] TC = Top Carnivore; threatened species and those of undetermined status are included regardless of trophic position.

[3] R = Riparian; U = Upland. Asterisk designates habitats where observed.

[4] From Office of Endangered Species and International Activities 1973.

TABLE 2.7-13

MAMMALS OF SQUAW CREEK RESERVOIR AREA

(Checklist of mammals occurring in the Squaw Creek Reservoir Area. An asterisk (*) indicates that the species has been observed on the area.)

FAMILY Scientific Name[1]	Common Name
DIDELPHIIDAE	
Didelphis marsupialis*	Opossum
SORICIDAE	
Cryptotis parva*	Least Shrew
TALPIDAE	
Scalopus aquaticus	Eastern Mole
VESPERTILIONIDAE	
Eptesicus fuscus	Big Brown Bat
Lasiurus borealis	Red Bat
L. cinereus	Hoary Bat
Pipistrellus subflavus	Eastern Pipistrel
MOLOSSIDAE	
Tadarida brasiliensis	Mexican Freetail Bat
PROCYONIDAE	
Procyon lotor*	Raccoon
BASSARISCIDAE	
Bassariscus astutus*	Ringtail
MUSTELIDAE	
Mephitis mephitis*	Striped Skunk
Spilogale putorius*	Spotted Skunk

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[1] Scientific names after Burt and Grossenheider [79]

Table 2.7-13 (Continued)

FAMILY Scientific Name	Common Name
CANIDAE	
Canis latrans*	Coyote
Urocyon cinereoargenteus*	Gray Fox
Vulpes fulva*	Red Fox
FELIDAE	
Lynx rufus*	Bobcat
SCIURIDAE	
Glaucomys volans	Southern Flying Squirrel
Sciurus niger*	Eastern Fox Squirrel
GEOMYIDAE	
Geomys bursarius*	Plains Pocket Gopher
HETEROMYIDAE	
Perognathus hispidus*	Hispid Pocket Mouse
P. merriami	Merriam Pocket Mouse
CRICETIDAE	
Baiomys taylori*	Pygmy Mouse
Neotoma micropus*	Southern Plains Woodrat
Peromyscus boylei*	Brush Mouse
P. leucopus*	White-footed Mouse
P. maniculatus*	Deer Mouse
Reithrodontomys fulvescens*	Fulvous Harvest Mouse
R. montanus	Plains Harvest Mouse
Sigmodon hispidus*	Hispid Cotton Rat
MURIDAE	
Mus musculus*	House Mouse

Table 2.7-13 (Continued)

FAMILY Scientific Name	Common Name
MURIDAE (Cont'd.)	
Rattus norvegicus	Norway Rat
R. rattus	Black Rat
LEPORIDAE	
Lepus californicus*	Blacktail Jackrabbit
Sylvilagus aquaticus*	Swamp Rabbit
S. floridanus*	Eastern Cottontail
CERVIDAE	
Odocoileus virginianus*	White-tailed Deer
DASYPODIDAE	
Dasypus novemcinctus*	Nine-banded Armadillo

TABLE 2.7-14

WHITE-TAILED DEER OBSERVED IN FIVE TEXAS COUNTIES

(White-tailed deer census (acres per deer) in five Texas counties conducted during August from 1965 thru 1970 by walking cruise lines. 1)

		YEAR					
	County	1965	1966	1967	1968	1969	1970
Acres Per Deer	Bosque	16.10	19.15	9.79	9.79	9.22	9.17
	Erath	16.52	21.09	31.70	29.32	25.58	16.98
	Hood	9.91	15.70	23.96	28.65	26.69	33.16
	Johnson	9.86	7.89	40.11	11.09	9.49	6.56
	Somervell	72.89	14.86	27.25	54.50	29.73	23.47
Does Per Buck	Bosque	4.41	3.54	3.62	3.27	3.22	2.29
	Erath	3.33	15.00	3.40	1.76	2.86	3.48
	Hood	1.67	3.00	4.92	2.37	2.10	4.29
	Johnson	1.50	11.00	2.60	3.57	2.56	2.87
	Somervell	2.50	3.00	8.00	1.33	2.67	2.33
Fawns Per Doe	Bosque	0.74	0.65	0.53	0.53	0.65	0.72
	Erath	1.04	0.76	0.68	1.11	0.98	0.57
	Hood	0.80	0.86	0.41	0.92	0.79	0.73
	Johnson	0.58	0.82	0.81	1.20	1.26	0.60
	Somervell	0.40	1.33	1.37	0.75	1.38	1.21
No. of Deer Observed	Bosque	2.89	2.80	8.45	8.45	8.64	8.25
	Erath	1.32	1.41	1.19	1.38	1.47	2.20
	Hood	.45	.37	1.11	.92	1.02	.73
	Johnson	.29	.28	.70	.66	.74	1.07
	Somervell	.09	.22	.24	.12	.22	.38

1 Source: References [81, 82, 83, 100]

TABLE 2.7-15

FREQUENCY SPECIES OCCURRENCE FOUND IN DEER STOMACHS

(Percent frequency of occurrence of food items in the stomachs of eleven white-tailed deer in Bosque County. 1)

	Percent Frequency
Churchmouse threeawn (*Aristida dichotoma*)	9.1
Oats	54.5
Greenbrier (*Smilax* spp.)	36.4
Live oak (*Quercus virginiana*) (Browse)	54.5
Live oak (*Quercus virginiana*) (Acorns)	90.9
Post oak (*Quercus stellata*) (Browse)	45.4
Post oak (*Quercus stellata*) (Acorns)	63.6
Texas oak (*Quercus shumardi*)	45.4
Flameleaf sumac (*Rhus copallina*)	36.4
Unidentified grasses	45.4
Sugarhackberry (*Celtis laevigata*)	27.3
Corn	9.1
Pricklypear (*Opuntia* spp.)	27.3
Clover (*Trifolium* spp.)	18.2
Unidentified	36.4
American-Mistletoe (*Phoradendron* spp.)	27.3
Bermudagrass (*Cynodon dactylon*)	9.1
Redbud (*Cercis canadensis*)	18.2
Osageorange (*Maclura pomifera*)	18.2
Fungi	18.2
Common hackberry (*Celtis occidentalis*)	9.1
American elm (*Ulmus americana*)	18.2
Woollybucket bumelia (*Bumelia lanuginosa*)	9.1
Johnsongrass (*Sorghum halapense*)	9.1
Unidentified	36.4
Cedar elm (*Ulmus crassifolia*)	9.1

1. Source: Reference [70]

TABLE 2.7-16

AMPHIBIANS OF SQUAW CREEK RESERVOIR AREA

(Checklist of amphibians occurring on the Squaw Creek Reservoir Area. An asterisk (*) indicates that the species has been observed on the area.)

FAMILY Scientific Name 1	Common Name
AMBYSTOMATIDAE	
Ambystoma texanum	Small-mouthed Salamander
PELOBATIDAE	
Scaphiopus couchi	Couch's Spadefoot
HYLIDAE	
Acris crepitans	Cricket Frog
Hyla chrysoscelis	Southern Gray Treefrog
H. versicolor	Northern Gray Treefrog
Pseudacris clarki	Spotted Chorus Frog
P. streckeri	Strecker's Chorus Frog
BUFONIDAE	
Bufo debilis	Green Toad
B. punctatus	Red-spotted Toad
B. speciosus	Texas Toad
*B. valliceps**	Gulf Coast Toad
B. woodhousei	Woodhouse's Toad
RANIDAE	
*Rana catesbeiana**	Bullfrog
*R. pipiens**	Leopard Frog
MICROHYLIDAE	
Gastrophryne olivacia	Great Plains Narrow-mouthed Toad

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1 Scientific names after Raun and Gehlbach [97]

TABLE 2.7-17

REPTILES OF SQUAW CREEK RESERVOIR AREA

(Checklist of reptiles occurring on the Squaw Creek Reservoir Area. An asterisk (*) indicates that the species has been observed on the area.)

FAMILY Scientific Name[1]	Common Name
CHELYDRIDAE	
*Chelydra serpentina**	Common Snapping Turtle
KINOSTERNIDAE	
Kinosternon flavescens	Yellow Mud Turtle
Sternothaeus odoratus	Stinkpot.
EMYDIDAE	
*Chrysemys scripta**	Pond Slider
*Terrapene ornata**	Western Box Turtle
TRIONYCHIDAE	
Trionyx muticus	Smooth Softshell
*T. spiniferus**	Spiny Softshell
IGUANIDAE	
*Cophosaurus texanus**	Greater Earless Lizard
*Crotaphytus collaris**	Collared Lizard
Holbrookia maculata	Lesser Earless Lizard
*Phrynosoma cornutum**	Texas Horned Lizard
*Sceloporus olivaceus**	Texas Spiny Lizard
*S. undulatus**	Eastern Fence Lizard
SCINCIDAE	
Eumeces fasciatus	Five-lined Skink
E. obsoletus	Great Plains Skink
E. septentrionalis	Prairie Skink

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[1] Scientific names after Raun and Gehlbach [97]

Table 2.7-17 (Continued)

FAMILY Scientific Name	Common Name
SCINCIDAE (Cont'd.)	
Lygosoma laterale*	Ground Skink
TEIIDAE	
Cnemidophorus gularis	Texas Spotted Whiptail
C. sexlineatus*	Six-lined Racerunner
ANGUIDAE	
Ophisaurus attenuatus	Slender Glass Lizard
LEPTOTYPHLOPIDAE	
Leptotyphlops dulcis	Texas Blind Snake
COLUBRIDAE	
Coluber constrictor	Racer
Diadophis punctatus	Ringneck Snake
Elaphe guttata	Corn Snake
E. obsoleta	Common Rat Snake
Heterodon platyrhinos	Eastern Hognose Snake
Hypsiglena torquata	Night Snake
Lampropeltis calligaster	Prairie Kingsnake
L. getulus	Common Kingsnake
Masticophis flagellum*	Coachwhip
Natrix erythrogaster*	Plain-bellied Water Snake
N. grahami	Graham's Water Snake
N. harteri	Brazos Water Snake
N. rhombifera	Diamond-backed Water Snake
Opheodrys aestivus*	Rough Green Snake
Pituophis melanoleucus	Bullsnake
Rhinocheilus lecontei	Long-nosed Snake

Table 2.7-17 (Continued)

FAMILY Scientific Name	Common Name
COLUBRIDAE (Cont'd.)	
Salvadora grahamiae	Mountain Patch-nosed Snake
Sonora episcopa	Great Plains Ground Snake
Storeria dekayi	Brown Snake
Tantilla gracilis	Flat-headed Snake
T. nigriceps	Plains Black-headed Snake
Thamnophis marcianus	Checkered Garter Snake
*T. proximus**	Western Ribbon Snake
T. sirtalis	Common Garter Snake
Tropidoclonion lineatum	Lined Snake
Virginia striatula	Rough Earth Snake
ELAPIDAE	
Micrurus fulvius	Coral Snake
VIPERIDAE	
*Agkistrodon contortrix**	Copperhead
A. piscivorus	Cottonmouth
Sistrurus catenatus	Massasauga
*Crotalus atrox**	Western Diamondback Rattlesnake

TABLE 2.7-18

FISHES FOUND IN SQUAW CREEK AND ADJACENT WATERS

Family Species	Common Name	Squaw Creek	Paluxy River	Brazos River	Lake Granbury
Lepisosteidae					
Lepisosteus oculatus	spotted gar ✓			X	X
Lepisosteus osseus	longnose gar ✓		X	X	X
Clupeidae					
Dorasoma petenense	threadfin shad ✓		X	X	X
Dorosoma cepedianum	gizzard shad ✓	X	X	X	X
Catostomidae					
Carpiodes carpio	river carpsucker ✓	X	X	X	X
Moxostoma congestum	gray redhorse ✓	X		X	X
Ictiobus bubalus	smallmouth buffalo ✓		X	X	X
Cyprinidae					
Cyprinus carpio	carp ✓		X	X	X
Notemigonus crysoleucas	golden shiner	X	X	X	X
Notropis lutrensis	red shiner	X	X	X	X
Notropis venustus	blacktail shiner	X	X	X	X
Pimephales vigilax	bullhead minnow	X	X	X	
Pimephales promelas	fathead minnow	X		X	X
Campostoma anomalum	stoneroller	X	X	X	
Ictaluridae					
Ictalurus melas	black bullhead ✓	X	X	X	X
Ictalurus natalis	yellow bullhead ✓	X	X	X	
Ictalurus punctatus	channel catfish †	X	X	X	X
Pylodictis olivaris	flathead catfish †		X	X	X
Atherinidae					
Labidesthes sicculus	brook silverside	X	X	X	X

† Game fish ✓ Rough fish * Recently stocked in Lake Granbury X Indicates presence

Table 2.7-18 (Continued)

Family Species	Common Name	Squaw Creek	Paluxy River	Brazos River	Lake Granbury
Cyprinodontidae					
Fundulus notatus	blackstriped topminnow	X		X	
Fundulus kansae	plains killifish	X	X		
Poeciliidae					
Gambusia affinis	mosquitofish	X	X	X	X
Serranidae					
Morone chrysops	white bass †		X	X	X
Morone saxatilis	striped bass † *				X
Centrarchidae					
Lepomis cyanellus	green sunfish †	X	X	X	X
Lepomis humilis	orangespotted sunfish †	X		X	X
Lepomis macrochirus	bluegill sunfish †	X	X	X	X
Lepomis megalotis	longear sunfish †	X	X	X	X
Lepomis microlophus	redear sunfish †	X	X	X	X
Micropterus punctulatus	spotted bass †	X	X	X	X
Micropterus salmoides	largemouth bass †	X	X	X	X
Pomoxis annularis	white crappie †	X	X	X	X
Lepomis gulosus	warmouth sunfish †		X	X	X
Percidae					
Etheostoma spectabile	orangethroat darter	X	X	X	X
Percina caprodes	logperch	X	X	X	X
Sciaenidae					
Aplodinotus grunniens	freshwater drum √		X	X	X

† Game fish √ Rough fish * Recently stocked in Lake Granbury X Indicates presence

TABLE 2.7-19

FISHES OCCURRING IN WATERS ADJACENT TO BUT NOT IN SQUAW CREEK

	Scientific Name	Common Name
Family Lepisosteidae		
	Lepisosteus oculatus	spotted gar ✓
	Lepisosteus osseus	longnose gar ✓
Family Clupeidae		
	Dorasoma petenense	threadfin shad ✓
Family Catostomidae		
	Ictiobus bubalus	smallmouth buffalo ✓
Family Cyprinidae		
	Cyprinus carpio	carp ✓
Family Ictaluridae		
	Pylodictis olivaris	flathead catfish †
Family Serranidae		
	Morone chrysops	white bass †
	Morone saxatilis	striped bass †*
Family Centrarchidae		
	Lepomis gulosus	warmouth sunfish †
Family Sciaenidae		
	Aplodinotus grunniens	freshwater drum ✓

† Game fish.

✓ Rough fish.

* Recently stocked in Lake Granbury.

TABLE 2.7-20

REPRODUCTIVE PERIODS FOR FISHES IN SITE AREA

Common Name	Time of Year	Approximate Water Temperature	Spawning Habitat
Game fish			
Channel catfish	Late spring (May-June)	24°C	Rock ledges, undercut banks, hollow logs
Flathead catfish	Late spring-summer (May-Aug)	24°C	Rock crevices, underwater caves and hollow logs
Largemouth bass	Spring (Feb-May)	16°C	Quiet water, 2 to 8 ft. deep, sand, gravel or aquatic vegetation
Warmouth sunfish	Spring-fall (Apr-Oct)	21°C	Quiet water less than 4 ft. deep, weeds, stumps, roots and brush
Green sunfish	Late spring-summer (May-Aug)	16°C	Shallow water, gravel bottom
Bluegill sunfish	Late spring-fall (May-Sep)	21°C	Quiet water 1 to 4 ft. deep, sand, gravel bars, sticks and mud
Rough fish			
Spotted gar	Spring (Apr-May)	20°- 30°C	Shallow weedy bays, over submerged vegetation, algae and plant roots
Longnose gar	Spring (Apr-May)	20°- 30°C	Shallow weedy bays, over vegetation; also over algae and bare rock along rocky points and shorelines
Smallmouth buffalo	Spring (April)	16°-18.4°C	Weedbeds and mud bottom; shallow water 1-3 ft. deep

TABLE 2.7-20 (Continued)

Common Name	Time of Year	Approximate Water Temperature	Spawning Habitat
Rough fish			
River carpsucker	Spring-summer (Apr-Aug)	18.3°- 24°C	Shallow water 1-3 ft. deep in weed beds, also over sand and silt bottoms.
Gizzard shad	Spring-summer (May-Aug)	17.8°- 23.9°C	Prefer shallow water over gravel bars
Black bullhead catfish	Late spring (May-Jun)	20°C	Water 2 to 4 ft. in depth, mud or sand
Forage fish			
Stoneroller minnow	Late spring (May-Jun)	16°C	Small streams with gravel bottoms
Fathead minnow	Late spring-summer (May-Aug)	16°C	Quiet shallow water
Plains Killifish	Spring-summer (Apr-Aug)	26.7°C	Shallow streams, gravel bottoms
Red shiner	Summer (Jun-Jul)	20°C	Stream pools, aquatic plants, debris

TABLE 2.7-21

BRAZOS RIVER BEETLES

(Beetles found at the Brazos River in Granbury, Texas, May 24, 1904.)[1]

FAMILY	GENUS & SPECIES
Tiger Beetles	*Cicindela rectilatera* Chd
Ground Beetles	*Pasimachus punctulatus* Hald. *Clivina pallida* Say *Bembidion (?)*[2] *laevigatum* Say *Chlaenius prasinus* Dej
Pleasing Fungus Beetles	*Ischyrus 4-punctatus* oliv.
Hister Beetles	*Saprinus Fimbriatus* Lec.
Scarab Beetles	*Phanaeus difformis* Lec.
Darkling Beetles	*Platydema excavatum* Say
False Darkling Beetles	*Eustrophus bicolor* Say

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[1] This table abstracted from an article by W. Knaus (1905) in the Canadian Entomologist, 37 (10) 348-352.

[2] Listed in the original paper as *Bembidium*.

2.8 BACKGROUND RADIATION CHARACTERISTICS

2.8.1 NATURAL RADIATION BACKGROUND

Man receives radiation from many natural sources, including the ground, the atmosphere, and through food consumption. The magnitude of this radiation level is strongly influenced by geographical location and daily pursuits. Radiological data available for the Hood and Somervell Counties indicate that natural background radiation levels will be near the average level for most locations in the United States, about 125 mrem/yr. The various components of the natural radiation background are discussed below.

2.8.1.1 Cosmic Radiation

Cosmic rays provide one of the most significant natural sources. Cosmic radiation is to some extent dependent on latitude and to a large extent dependent on altitude.

In the mid-latitudes, the cosmic radiation varies from about 50 mrem/yr at sea level to about 3800 mrem/yr at altitudes that jet aircraft fly (35,000 feet). One transcontinental round-trip by air would give the passenger an exposure of about 4 mrem.

Denver and Salt Lake City, cities of high elevation, experience about 150 mrem/yr from cosmic radiation while the average for the country appears to be about 50 mrem/yr [1]. The estimated cosmic-ray dose at the CPSES site is estimated to be 41.5 mrem/year [2]. 2

2.8.1.2 Ground Radiation

Radioactive minerals in the ground are another source of natural background radiation. These include the uranium and thorium series, together with the important uranium decay product, radium. Another significant radioisotope in the ground is potassium-40, the naturally radioactive isotope of the element potassium. This incidence of radioactive material in the ground causes the earth to act, with respect to an individual, as a large plane radiation source. This produces an average radiation exposure in the continental United States of about 60 mrem/yr. The mean terrestrial radiation dose rate at the CPSES site has been measured to be 46.5 mrem/yr, which is comparable to the national mean of 45.6 mrem/yr. 2

2.8.1.3 Radiation From Air

The fact that radioisotopes exist in the ground gives rise to a secondary source of radiation, since the natural decay of the uranium and thorium series each contains a naturally radioactive gas. These radiogases evolve from the ground at a fairly constant rate and thus concentrate in the air.

The principal constituent of this natural source of radiation is the radon radiogas, which has a 3.8-day half-life. This element, together with its daughter decay products, causes a world average total body external exposure of about 5 mrem/yr. 2 In June of 1973, an airborne radiometric survey of the site vicinity was performed for the Applicant by Utility Data Corporation [2].

2.8.1.4 Radiation From Structures

Since materials from the ground are used to construct such facilities as homes and offices, natural radioisotopes from the ground are transferred to these structures. A significant variation will result from the use of different building materials. In some cases, the reduction in dose due to shielding may exceed the increase in dose due to radioactivity in the building materials. In other cases, the increase due to radioactivity in building materials is greater than the decrease due to shielding. The indoor dose rate from radioactivity in building materials and the ground may be as great as 50 mrem/yr for a wooden structure, 70 mrem/yr for concrete and 100 mrem/yr for brick. Even the dose rates for a particular material may vary, based on where the material originated. For example, there are some types of stone (such as some granite and marble) that will produce an exposure of 350 to 500 mrem/yr. For the purpose of calculating dose from background radiation, an average dose rate indoors from building materials and terrestrial radiation is estimated to be 70 mrem/yr.

2.8.1.5 Radiation From Food and Water

Surface waters and groundwaters are now and have always been radioactive due to the presence of many naturally radioactive materials such as uranium, thorium, radium, and carbon-14, all of which have very slow decay rates ranging from thousands to billions of years.

The oceans are a good example of such natural radioactivity. The measure of radioactivity contents in liquids is usually stated in units of picocuries per liter (pCi/l); a picocurie being equal to 1×10^{-12} curies. In case of ocean water, the natural radioactivity content is about 350 pCi/l. Most of this is due to the naturally radioactive potassium-40 which has a decay rate (half-life) of 1.3 billion years. River water radioactivity usually averages between 10 and 100 pCi/l. Segments of the Paluxy and Brazos Rivers near the CPSES site were included in a study of streams and river basins in Texas, which was conducted during the period June 1958 to June 1960 [3]. During this period, gross beta radioactivity in the Brazos River near the site ranged from 0.1 to 70.8 oCi/l in the suspended fraction and 0.3 to 73.2 pCi/l in the dissolved fraction.

Gross beta radioactivity in the Paluxy River ranged from near zero to 66.6 pCi/l in the suspended fraction and from near zero to 163.9 pCi/l in the dissolved fraction. 2

A section of the Brazos River near College Station, Texas, has been monitored since April 1969 [4]. During the period April 4, 1969 to July 6, 1972, gross beta radioactivity in this section of the Brazos River has ranged from 2 to 75 pCi/l. Most of the radioactivity at the higher concentrations was associated with the suspended material. Dissolved gross beta radioactivity ranged from 2 to 13 pCi/l. The average radioactivity in some liquids is listed below.

Liquid	pCi/l
Domestic tap water	20
4% Beer	130
Ocean Water	350
Whiskey	1200
Milk	1400
Salad Oil	4900

Due to these activities in liquids used for human consumption, the average concentration in the liquids of the human body is about 300 pCi/l. The general average radiation exposure from food and water is about 25 mrem/yr, due to the deposition and retention of these radioactive materials within the body. In a typical case, about 20 mrem/yr of this exposure comes from the natural radioisotope potassium-40 which is found particularly in protein-type foods.

2.8.1.6 Total Radiation from Nature

The following tabulation summarizes the various contributions in arriving at an average natural background radiation of 125 mrem/yr for people living near the Comanche Peak Site.

Cosmic Rays	41.5	
Ground only (outside 1/4 time)	11.5	
Ground & buildings (inside 3/4 time)	53.0	2
Air	5.0	
Food & water	25.0	
	136.0	

2.8.2 MAN-MADE RADIATION BACKGROUND

Man-made radiation sources increase the total radiation exposure of man in several ways. The largest contributing factor has been from medical exposure. It has been estimated [5] that 94 percent of man-made exposure is from medical radiation and of this, 90 percent is attributed to diagonistic x-rays. Typically, an average of 55 mrem/yr [6] is received by the average United States citizen. More recent reports indicate that 35.5 mrem/yr is a more appropriate average. Specific examples of average exposures per x-ray to an individual are 25-50 mrem from an average chest x-ray, 200 mrem from an average gastro-intestinal tract examination, and a range of 5-200 mrem for a fluoroscopic examination [7]. Additionally, small levels of radiation can be received from luminous watch dials (about 2 mrem/yr) and television viewing (1 to 10 mrem/yr).

Since the middle 1940's, atmospheric testing of nuclear and thermo-nuclear weapons has contributed man-made radioactivity to the radiation background. The level of man-made radioactivity from nuclear weapons testing, e.g., tritium, strontium-90 and cesium-137, is indicated by the following data from Radiation Data and Reports [8]. Tritium concentrations in surface waters in Texas were generally below 200 pCi/l during 1968 and 1969. Strontium-90 concentrations in the Rio Grande were approximately 1 pCi/l during the first quarter of 1971. The twelve-month average concentrations of strontium-90 in milk for the period April 1971 through March 1972 were 2 pCi/l for Austin and 6 pCi/l, the practical reporting level. Diets of children in Austin were estimated to represent an average intake of 6 pCi of strontium-90 per day in 1971. Austin, Texas, is included in the Air Surveillance Network of the Western Environmental Research Laboratory, Environmental Protection Agency.

Concentration of gross beta radioactivity in airborne particulates ranged from less than 0.1 to 23 pCi/m^3 during the period of July 1971 through March 1972.

The highest concentrations occurred in January 1972 following a nuclear explosion in the atmosphere set off by the Peoples Republic of China on January 7, 1972. In September 1972, Fort Worth had an average of 0.1 pCi/m^3 gross beta radioactivity in the air. Thyroid inhalation dose to children in the Fort Worth-Dallas area as a result of the November 1971 Chinese nuclear test was 0.01 mrem.

In summary, medical exposure results in the largest man-rem per year contribution from man-made sources. However, the effect of nuclear testing, television viewing, and wearing luminous dial watches do contribute to population exposure and should be included when comparing the impact on man from these and other man-made sources.

2.8.3 TOTAL AVERAGE RADIATION BACKGROUND

The total background radiation exposure received by the average citizen is the sum of the contributions received from natural background and man-made sources. The total exposure is the 136 mrem/yr from natural sources and 50 to 100 mrem/yr from man-made sources, giving about 186 to 236 mrem/yr to the average resident of Hood and Somervell counties. 2

2.8.4 VARIATIONS IN RADIATION BACKGROUND

Variations in radiation background at the site will be measured before plant operation (See Section 6.1.5).

2.8.5 REFERENCES

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7. Hearing before the joint committee on atomic energy, Environmental Effects of Producing Electric Power, January 27-30 and February 24-26, 1970.

8. U.S. Environmental Protection Agency. 1972. Radiation Data and Reports. Vol. 13, Nos. 2-7.

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2.9 OTHER ENVIRONMENTAL FEATURES

No other relevant environmental features have been identified.