3 AFFECTED ENVIRONMENT

The purpose of this section is to describe areas potentially affected by the proposed project. The beginning of this section addresses general area-wide attributes while latter portions describe geographically specific conditions.

a. Study Area. The study area encompasses all of the Wichita River from the upstream brine collection facilities downstream to the Wichita River's confluence with the Red River and the upper Red River from its confluence with the Wichita River downstream to Lake Texoma. A map delineating the project study area and study reaches is shown in Figure 3-1. Hydrologic study reaches included Reach 11 (South Fork of the Wichita River), Reach 10 (North & Middle Fork of the Wichita River), Reach 9 (main stem Wichita River to Lake Diversion dam), Reach 8 (Wichita River from Lake Diversion dam to confluence with the Red River), Reach 7 (Red River at Cooke/Montague county line to Wichita River confluence), Reach 6 (Cooke/Montague county line to Lake Texoma), and Reach 5 (Lake Texoma). The study area also encompasses lands within 50 elevation feet of rivers and reservoirs within the study area as well as agricultural lands within each hydrologic region affected by potential changes in irrigation. The project area and scope constitutes a major change over the RRCCP in that several reaches previously evaluated have not been included in this study and would not be affected with implementation of the currently proposed project.

1. Physiographic and Climate Setting. The study area in north central Texas is approximately 250 miles north of the Gulf of Mexico. Elevation of the area's rolling hills range from 500 to 800 feet above sea level. The area lies within the Rolling Plains ecoregion. This region is characterized by a slightly undulating land surface dominated by native rangelands. The general setting of the study area is the Central Rolling Red Plains physiographic region of Texas.

The climate is humid-subtropical with hot summers. It is also continental, characterized by a wide annual temperature range. Precipitation also varies considerably, ranging from 18 inches to more than 36 inches. Throughout the year, rainfall occurs more frequently during the night. Usually, periods of rainy weather last for only a day or two and are followed by several days with fair skies. A large part of the annual precipitation results from thunderstorm activity, with occasional heavy rainfall over brief periods of time. Thunderstorms occur throughout the year, but are most frequent in the spring. Hail falls on about 2 or 3 days a year, ordinarily with only slight and scattered damage. Windstorms occurring during thunderstorm activity are sometimes destructive. Snowfall is rare.

Winters are mild but "blue northers" occur about three times each winter month. Precipitous drops in temperature typically accompany these events. Periods of extreme cold occasionally occur but are short-lived so that even in January mild weather frequently occurs.

The highest temperatures of summer are associated with fair skies, westerly winds, and low humidity. Characteristically, hot spells in summer are broken into three-to-five day periods by thunderstorm activity except during El-Niño years. There are only a few nights each summer when the low temperature exceeds 80 °F. Summer daytime temperatures frequently exceed 100 °F. Average low and high temperatures range from 37 °F in January to 98 °F in August.

The average length of the warm seasons (freeze-free period) is about 249 days, or about 6 months. The average last occurrence of 32 °F or below is mid-March, and the average first occurrence of 32 °F or below is in late November.

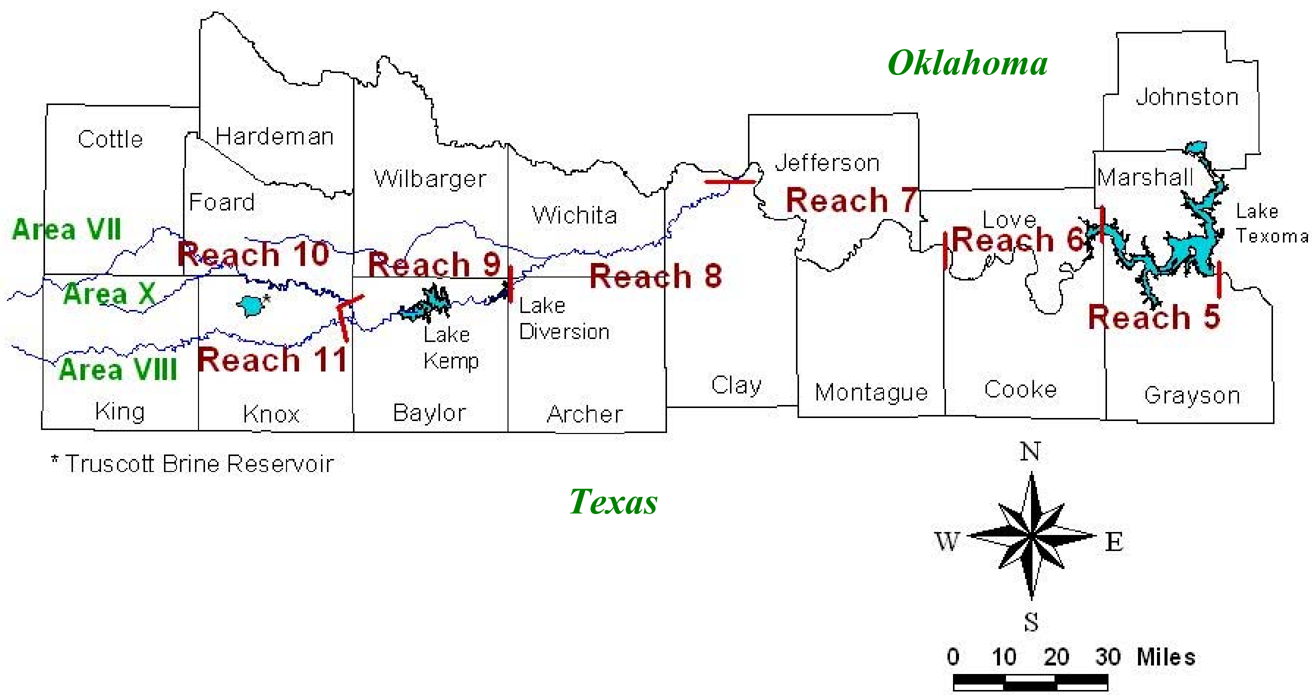
2. Vegetation. Vegetative communities occurring within the study area are predominantly a function of human influence. Existing vegetative communities throughout the entire basin include a number of different types composed of various sub-climax stages. True climax communities are largely absent throughout this area having been modified by cultivation, fire control, and grazing. Agriculture is the principal land use throughout the study area. Native floodplain vegetation largely has been cleared or fragmented into small, isolated patches and replaced with tame pasture, hay, vegetables, and small grains. Although highly impacted by human activity, remnant habitats still provide essential life requisites for aquatic and terrestrial life. The Wichita River Basin is dominated by rangeland used primarily for grazing cattle. Most of the study area watershed is a mixture of juniper and mesquite shrubs and grassland, with some areas of cropland. The riparian community is relatively narrow in most of the watershed and consists largely of saltcedar (*Tamarix chinensis*), willow (*Salix spp.)* and some cottonwood (*Populus deltoides)*.

3. Soils. The proposed plan features would be located in north central Texas in a region dominated by Permian Age sedimentary rocks. The project lies near the southwestern edge of the Osage Plains section of the Central Lowlands Physiographic Province and adjacent to the High Plains Physiographic Province to the west. The project sites are underlain by the relatively flat lying Permian age Flowerpot Shale and Blaine Formations. Flowerpot Shale is a thick unit of impervious red-bed shales, interbedded with thin green-gray shales and, in the upper part of the formation, with bed of gypsum and dolomite. The overlying Blaine formation consists of interbedded gypsum, dolomite, and shale. With the exception of low-lying drainage areas, bedrock consisting of the above-described units is exposed or is anticipated to be present at shallow depths across most of the upland surfaces.

Soils in the proposed project area consist primarily of colluvial deposits on the upland areas and sidehill slopes. These deposits consist primarily of silt and clay with varying amounts of bedrock float fragments and are interpreted to be the product of weathering of the underlying bedrock. These deposits range in depth from zero feet, where bedrock is exposed on the surface, to a depth of several feet, generally near the base of slopes. Alluvial deposits are present in the drainage areas. The deposits are generally in the form of flat surfaced terraces. In some of the larger drainage areas, two levels of terraces are present – low narrow terrace adjacent to the active stream channel and a higher level terrace beyond. The thickness of the deposits are thinnest near the margins of the drainage and adjacent to the steeper slopes and range from 10 to 20 feet in thickness near the drainage. These deposits generally consist of an upper portion of sandy, silty clay underlain by coarse grain sediments consisting of silt, sand and gravel with occasional cobbles. Features of the proposed plan are located in these shallow soil areas.

4. Air Quality. A non-attainment area is an area which does not meet one or more of the National Ambient Air Quality Standards (NAAQS) for criteria pollutants listed in the Clean Air Act (CAA). Information from the TNRCC indicates that the project is not located in a non-attainment area.

FIGURE 3-1
HYDROLOGIC REACHES FOR THE PROPOSED PROJECT



5. Wild and Scenic Rivers. In the 1960's, there was a growing awareness that our nation's rivers were being dammed, dredged, diverted, and polluted at an alarming rate. In 1968, Congress passed the Wild and Scenic Rivers Act, requiring it to be the policy of the United States that *"certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations."*

The act established three classes of river areas: 1) Wild river areas**,** characterized as being unpolluted, free from impoundments, generally inaccessible except by trail, with primitive watersheds or shorelines; 2) Scenic river areas, characterized as being free from impoundments, generally accessible in places by road, and having shorelines or watersheds still largely undeveloped; and 3) Recreational river areas**,** which may include some development along their shoreline, readily accessible by road or railroad, and may have undergone some impoundment or diversion in the past. Rivers that may be impacted by the proposed plan include the Wichita River and the Red River.

6. Environmental Justice. Environmental justice has been defined as the pursuit of equal justice and equal protection under the law for all environmental statutes and regulations without discrimination based on race, ethnicity, or socioeconomic status. There are three categories of environmental equity issues: Procedural inequity, geographical inequity, and social inequity (Bullard 1993). Procedural inequity addresses questions of fair treatment: the extent that governing rules, regulations, and evaluation criteria are applied uniformly. Geographical inequity refers to areas receiving direct benefits, such as jobs and tax revenues, from industrial production while the costs, such as the burdens of waste disposal, are sent elsewhere. Social inequity refers to the concept that environmental decisions often mirror the power arrangements of larger society and reflect existing racial biases. Finally, providing environmental justice goes beyond the stated definition and includes a guarantee of equal access to relief and meaningful community participation with government and industry decision-makers. With respect to the proposed plan, one localized brine disposal reservoir would be used while benefits would be distributed throughout the Wichita River basin.

7. Threatened and/or Endangered Species. By letter dated March 5, 1999, the USFWS identified the Federally listed species likely to be affected by the proposed project. They include the whooping crane (*Grus americana*), the bald eagle (*Haliaeetus leucocephalus*), and the interior least tern (*Sterna antillarum*), which are the same species addressed in the previous formal consultation and the 1994 USFWS Biological Opinion (BO). These species and their status can be found in Table 3-1.

A Biological Assessment (BA) for the Wichita River Basin was performed by the USACE in May 2001. This BA included revised data for the project area. Specifically, the USACE conducted avian monitoring at Truscott Brine Disposal Reservoir to address potential Se impacts. The USACE also recalculated flow and chloride concentration data for the Wichita River hydrologic reaches. Information from the 2001 BA is included in this document.

The whooping crane is a migrant through central Oklahoma and Texas during the fall and spring. Recorded sightings confirm this species' presence during migration in the general area. Sightings have been confirmed from the extreme eastern portion of Texas. Six sightings were from Clay County near Byers, Texas, and the other was from Wichita County near the city of Electra, Texas. Most of the recorded sightings for this species are in relation to the Great Salt Plains Reservoir in north central Oklahoma and the Washita National Wildlife Refuge in southwestern Oklahoma. The Great Salt Plains is recognized as an important whooping crane migration stopover area and supports from 1 to 12 birds during migration periods. Additional bird surveys conducted during the fall and/or spring of 1997-1999 at Truscott Brine Disposal Reservoir and the Area VIII collection facility resulted in no sightings of whooping cranes (USACE 2001d).

The interior least tern occurs along major rivers in Oklahoma and Texas as a summer, breeding resident (S2B – 6 to 20 occurrences within the State, very vulnerable to extinction throughout its range) and migrant. They occur in association with riverine habitats primarily on unvegetated sandbars and shorelines. A review of available literature suggests that this species occurs as a migrant within the general project area. On May 22-24, 1991, personnel from the USACE conducted a survey for the interior least tern at the Area X collection facility and Truscott Brine Disposal Reservoir. No least terns were sighted in the noted areas, and most of the areas appeared to be void of habitat typically suited for this species (USACE 2001d). The interior least tern has been observed at the Truscott Brine Disposal Reservoir more recently. Texas Tech University personnel found the least tern at Truscott Brine Disposal Reservoir during the spring and fall migrations. However, no least tern nests or nesting was observed at the lake during their bird counts conducted in the spring and winter of 1997, 1998, and January 1999 (USACE 2001d).

The bald eagle is a winter migrant throughout the State of Oklahoma and a winter resident along major rivers and impoundments. The total winter population in the study area is unknown, but eagles are likely present along the 140-mile stretch of the Red River from Lake Texoma to the Red River's confluence with the Wichita River Data provided by the USFWS in the previous BO place the wintering population of eagles in Oklahoma between 516 and 1,167. Estimates of eagle use on the Red River are difficult to obtain because few surveys are made of this remote area. Annual midwinter surveys at Lake Texoma and Waurika Lake indicate that eagles use the upper Red River. From 1984-1992, bird numbers averaged 54.5 at Lake Texoma and 4.9 at Waurika Lake. No bald eagles were sighted during the intensive bird count surveys completed from 1977-1999 at Truscott Brine Disposal Reservoir and the Area VIII collection facilities (USACE 2001d). The USFWS has determined that this species has recovered to the point that it should be removed from the list of threatened and endangered species. The bald eagle is currently listed as Threatened, although it is proposed for delisting. However, the delisting process has not been completed, and the bald eagle currently remains on the list.

State listed species have no legal protection under the Endangered Species Act, as amended, and have been included within this document for planning purposes only. Several State of Oklahoma listed species have been identified as possibly occurring in the project area (Table 3-1). These include the Texas kangaroo rat (*Dipodomys elator*), which inhabits the mesquite grasslands on clay soils in the project area; the Snowy plover (*Charadrius alexanderinus*), whose range encompasses the upper portions of the project area; the Texas horned lizard (*Phrynosoma cornutum*), the blacksided darter (*Percina maculata*), and the shovelnose sturgeon (*Scaphirhynchus platorhynchus*), which all occur within the study area.

TABLE 3-1

STATE AND FEDERALLY LISTED SPECIES FOR THE PROPOSED PROJECT

Scientific Name	Common Name	Federal Status	Oklahoma State Status	Texas State Status
Mammals				
Dipodomys elator	Texas kangaroo rat		SS2	T
Birds				
Charadrius alexanderinus	Snowy plover		SS2	
Grus americana	Whooping Crane	E	E	E
Haliaeetus leucocephalus	Bald Eagle	T	T	T
Sterna antillarum	Interior Least Tern	E	E	E
Reptiles				
Crotalus horridus	Timber rattlesnake			T
Phrynosoma cornutum	Texas horned lizard		CS, SS2	T
Fish				
Cycleptus elongates	Blue sucker			T
Percina maculata	Blacksided darter		T	T
Polydon spathula	Paddlefish			T
Scaphirhychus platorhynchus	Shovelnose sturgeon		SS2	T

Federal Status
E - Endangered
T - Threatened
C - Candidate Taxa
SC - Species of Concern: Those species with insufficient data to make a decision regarding status.

Oklahoma State Status
E - Endangered
T - Threatened
SN – State nominated for listing as T or E
SS1 – Species of Special Concern that current evidence indicates especially vulnerable
SS2 – Species of Special Concern that have been identified by experts as possibly threatened or extirpated
CS – Statewide closed season

Texas State Status
E – Endangered
T – Threatened

A search of the Texas Natural Heritage Program's database revealed several State of Texas listed species that may occur within the project area (Table 3-1). These include the Texas kangaroo rat, the Texas horned lizard, the timber rattlesnake (*Crotalus horridus*), the blue sucker (*Cycleptus elongates*), the blacksided darter, the paddlefish (*Polydon spathula*) and the shovelnose sturgeon.

8. Cultural Historic Setting. The portion of northern Texas where the proposed project area is located generally falls within the Southern Great Plains culture area (Brooks and Hofman 1989, Wyckoff and Brooks 1983), although the project area falls within several different regions. The 1954 overview of Texas archeology by Suhm, Krieger, and Jelks placed the project area on the western edge of their north-central Texas regions (Suhm *et al.* 1954). In 1981, Lynott placed this area in what he called northern Texas, which included everything between the High Plains and east Texas and everything north of the Edwards Plateau (Lynott 1981). In its designation of archeological regions in Texas for comprehensive planning, the Texas Historical Commission (THC) placed the project area near the center of its Lower Plains region, falling between the High Plains, central Texas, and north-central Texas (Biesaart *et al.* 1985). Although unique in some respects, the Lower Plains area has strong similarities to the surrounding areas in both natural and cultural features (Wyckoff and Brooks 1983).

The general setting of the project area is the Central Rolling Red Plains physiographic region of Texas, which has been subjected to only minimal cultural resources investigations. Cultural chronologies based on investigations in the surrounding areas are often used to characterize the Central Rolling Red Plains. A cultural chronology for the region was developed during investigations for the RRCCP and is presented in Table 3-2. An extensive discussion of the stages presented in this chronology is presented in Schreyer *et al.* (2001) and is incorporated herein by reference.

(a) Area VII Collection Area and Pipeline Corridor. A total of six prehistoric sites dating to the Archaic period were found within the vicinity of Area VII during a preliminary cultural resource reconnaissance survey (Hughes 1972). All six sites were located within the proposed Y-Ranch low-flow dam project area along the North Fork of the Wichita River (Hughes 1972:2-30, 2-32 and V-18). One site was classified as a camp dating to the Archaic period (Hughes 1972: V-5), three were classified as camp-quarry stations, and the remaining site was classified as a quarry station.

(b) Area X Pipeline Corridor. Late in 1994, the proposed pipeline corridor connecting the Area X collection area and Truscott Brine Disposal Reservoir was inventoried for cultural resources, and two sites were identified within the corridor (Largent *et al.* 1995).

TABLE 3-2
CULTURAL CHRONOLOGY FOR THE SOUTHERN GREAT PLAINS AND LOWER PLAINS OF TEXAS

Cultural Stage	Approximate Date Range
Paleo-Indian	
Pre-Clovis?	Prior to 9,800 B.C.
Clovis	9,800-8,900 B.C
Folsom	8,900-8,200 B.C.
Late Plaeo-Indian	8,200-6,500 B.C
Archaic	
Early	6,000-3,000 B.C.
Middle	3,000-1,000 B.C
Late	1,000 B.C. – A.D. 1
Formative (Plains Woodland)	
Terminal Archaic/Late Prehistoric I	A.D. 1 – 800
Florescent (Plains Village)	
Late Prehistoric I	A.D. 800 – 1250
Late Prehistoric II	A.D. 1250 – 1450
Protohistoric/Early Historic	A.D. 1541 – 1875
Euro-American	A.D. 1875 – present

Source: Largent *et al.* 1995

(c) Area VII Pipeline Corridor. A cultural resources inventory of the proposed pipeline route between Truscott Brine Disposal Reservoir, Area VII, and the area surrounding the Truscott Brine Disposal Reservoir was performed in 2001 (Schreyer *et al.* 2001). A complete intensive survey of the area around the Truscott Brine Disposal Reservoir that would be impacted by an elevation of the lake level was also performed. Several limitations to this survey exist. Although field personnel walked over virtually the entire pipeline corridor, there was a 4.3-km section of the line that was difficult to access and not viewed in its entirety. Only high probability areas, based on proximity to drainages, were shovel tested. The line was not staked in the field and realignments during final engineering are likely. Nevertheless, the authors of the report believe that the level of sampling will provide a good basis for planning on the numbers and types of resources that exist within the final alignment. The inventory did result in the documentation of four prehistoric archeological sites that will require testing to reach a determination of eligibility for the National Register of Historic Places (NRHP) and seven prehistoric archeological sites and one historic farmstead that have been recommended to be not eligible for the NRHP.

(d) Area VIII Spray Field. The exact location for this spray field has not been identified. Once the location is known, and prior to construction, the area should be inventoried for cultural resources. If any resources were discovered in this area, in consultation with the THC they would be evaluated and impacts to them assessed.

(e) Chloride Control Projects. A Programmatic Memorandum of Agreement (PA) will be developed among the interested parties specifying which sites may be subject to unwanted effects and what actions should be taken to avoid or minimize those unwanted effects. This PA may also address the development of a Cultural Resources Management Plan for those cultural resources that are located on lands around Truscott Brine Disposal Reservoir that will not be affected by changes at the reservoir

9. Land Use. Land use was evaluated for each of the brine collection areas and the brine disposal site to be used under the proposed plan.

(a) Area VII. Current land use associated with the proposed collection facilities at Area VII consists primarily of rough, broken lands and mesquite and juniper grasslands utilized for grazing. Land use at Area VII has not changed since the original FES. Changes under the proposed plan would include installation of a 24-acre spray field in riparian habitat adjacent to the stream as well as installation of an inflatable dam, collection facilities, pump station, electrical power supply lines and pipeline conveyance to Truscott Brine Disposal Reservoir.

(b) Area VIII. Current land use associated with the collection facilities at Area VIII consists primarily of rough, broken lands and mesquite grasslands utilized for grazing alongside already constructed collection facilities. Land use at Area VIII has changed since the original FES as a specially authorized segment under the Flood Control Act of 1966, Public Law 89-789, and the Water Resources Act of 1976 for water quality control. Area VIII, with the exception of one spray field, is fully developed with respect to the proposed plan through these authorized projects. Facilities include an inflatable dam, collection structures, pump station, electrical pump station supply lines, and pipeline from Area VIII to Truscott Brine Disposal Reservoir. Additional structures proposed for Area VIII under the proposed plan include a 37-acre spray field in riparian habitat adjacent to the stream to reduce brine volume before pumping to Truscott Brine Reservoir.

(c) Area X. Area X is currently partially developed with respect to the proposed project. Previously constructed facilities at the site include an inflatable dam and pump station. Additional facilities that would be added by construction of the proposed plan would be a 32-acre spray field located in riparian habitat adjacent to the stream as well as electrical power supply lines and pipeline conveyance to Truscott Brine Disposal Reservoir. The surrounding area is currently used as cattle rangeland with a dirt road leading into the site.

(d) Truscott Brine Disposal Reservoir. Truscott Brine Disposal Reservoir currently receives brine from Area VIII, and with the proposed plan would also receive brines from Areas VII and X. Land use at Truscott Brine Disposal Reservoir has changed since the original FES in 1977 as a result of being a specially authorized segment of the Flood Control Act of 1966, Public Law 89-789, and the Water Resources Act of 1976 for water quality control. Truscott was completed in 1982 and has been collecting brines from Area VIII since 1987. The lake currently has a pool of approximately 1,700 surface acres.

Vegetation communities that were present within pool limits of Truscott Brine Disposal Reservoir are being covered by the brine pool. They are gradually being inundated with brine from the Area VIII pumping facility and would begin disappearing at an accelerated rate as other pumping facilities become operational. An evaporation spray field for Area VIII brine pipeline discharge has been installed to concentrate brine and reduce volumes prior to discharge into the reservoir. Additional facilities that would be added by the proposed plan include a 28-acre spray field for Area VII brine.

10. Environmental End Use by Reach. This Reevaluation used the economic reaches shown in Figure 4-1. Studies by Texas A&M University (2000) show a decrease in agricultural land use from 1977 to 1987, then an increase from 1987 to 1997 for an overall increase during the 20-year study period. National Agricultural Statistics Service (NASS) agriculture data show a similar trend in major agriculture crops for the same time period. However, overall land use in the study area has changed minimally since the 1976 FES.

Landsat imagery, 1997 aerial photography, and Natural Resources Conservation Service (NRCS) coordination were used to evaluate specific crop usage for areas serviced by irrigation from the Wichita and Red rivers in the study area. The areas served by river irrigation were limited to those within 50 feet of elevation above the rivers, the estimated extent of irrigation head capacity. This study was conducted by Texas A&M University and the Texas Agricultural Experiment Station. The primary reaches showing agricultural development were Economic Reaches 6, 7, and 9. The results of this analysis for May 1997 are shown in Table 3-3.

TABLE 3-3
MAY 1997 AGRICULTURAL DEVELOPMENT
BY ECONOMIC REACH IN ACRES

Crop (May 1997)	**Reach 6**	**Reach 7**	**Reach 9**	**Total**
Winter Wheat	48,683	30,624	15,971	95,278
Grassland	118,641	56,418	93,804	268,862
Bare Agriculture/Harvested Wheat	18,617	8,775	37,274	64,666

Source: Srinivasan *et. al.* 2000

Additional evaluations for the same year were also conducted in October. The results of agricultural land use for the October analysis is shown in Table 3-4.

TABLE 3-4
OCTOBER 1997 AGRICULTURAL DEVELOPMENT
BY ECONOMIC REACH IN ACRES

Crop (October 1997)	Reach 6	Reach 7	Reach 9	Total
Cotton	4,124	2,920	3,871	10,916
Winter Wheat	20,746	10,607	14,463	45,816
Unknown/Failed Cotton	9,909	9,236	18,199	37,346
Bare Agriculture/Grain Sorghum	43,124	31,135	43,476	117,735

Source: Srinivasan *et. al.* 2000

Land use in the region above Lake Texoma is devoted mainly to agriculture and consists of farming and cattle ranching. On a county-wide basis, the area is predominantly dryland crops and pastureland. For the nine Texas and eight Oklahoma counties in the region, about 6 million acres were pastureland, 4 million acres dry land cropland, and 160,000 acres irrigated cropland in 1996. While about 59% of agricultural land use is pasture, only about 4% of the cropland is irrigated. For the most part, land use in the proposed project area is essentially the same as reported in the 1976 FES.

11. Socioeconomic Setting. The area adjoining the proposed project facilities is composed of parts of eleven counties in Texas (Cottle, Foard, Wilbarger, Wichita, King, Knox, Baylor, Archer, Clay, Cooke, and Grayson) and three counties in Oklahoma (Love, Marshall, and Bryan) and is populated mostly with people living in towns of less than 10,000. Based on U.S. Bureau of Census population data, 383,935 persons lived in the area in 2000. The number of persons living in the area increased by an average of five percent between 1990 and 2000.

The immediate study area covers parts of seven counties (Cottle, Foard, King, Knox, Baylor, Cooke, and Grayson) in Texas and three counties in Oklahoma (Love, Marshall, and Bryan), including the Wichita Falls, Texas, metropolitan area. The 2000 Census data indicated that 104,197 persons lived in the Wichita Falls area, and 217,735 people lived in the ten county area. The number of persons living in the ten county area increased by an average of four percent between 1990 and 2000.

12. Hazardous, Toxic, and Radiological Waste (HTRW). An assessment of the potential for encountering HTRW on all lands associated with the proposed plan was conducted by the USACE. Assessment methods included aerial site surveys for most parcels, interviews with local authorities, interviews with contract personnel working in the area, and interviews with regulatory agency personnel combined with a review of files maintained by these agencies. Visual site surveys included a search for any visual evidence of past HTRW storage or release (e.g. abnormal soil staining, drums or chemical containers, above ground tanks, lagoons, landfills). Agency files and databases were likewise searched for reported spills or potential problem areas.

Lands associated with the proposed plan can generally be described as very remote and historically undeveloped. While land access is available to limited portions of these areas via farm and ranch roads, many of the tracts possess few roads or other means of easy land access. Accordingly, land use in these areas has been limited to ranching and cattle grazing. Development has been minimal in the area, minimizing the potential for HRTW-related concerns.

Regulatory agency personnel reported no knowledge of any historical spills or areas of potential contamination in the project area.

b. Wichita River Basin.

1. Geographic Location and Basin Boundary. The Wichita River is a south bank tributary of the Red River at about river mile 907 and as such is part of the Red River watershed. The long, narrow Wichita River Basin drains a subhumid area of 2,485 square miles in north central Texas. The Wichita River is formed by the North, Middle, and South Forks, which originate in rolling hills and proceed easterly into the rolling prairie lands of north central Texas. These streams develop from small intermittent gullies in the upper reaches to well-defined streams with narrow, high bank floodplains bordered by high bluffs in the lower reaches of the study area. The geographic boundary of the study area for the Wichita River encompasses all of the Wichita River Basin from the collection areas downstream to the Wichita River's confluence with the Red River. The study area also encompasses lands within 50 elevation feet of the Wichita River (riparian habitat) as well as agricultural lands within each hydrologic region affected by potential changes in irrigation.

2. Chloride Sources. Assessment of chloride source areas since 1957 has identified three major types of chloride contributions to the Wichita River: oil field brines, minor natural sources, and natural chloride seeps or springs.

(a) Oil Field Brines. The principal man-made sources of chloride in the study area have been identified as originating from oil field brine disposal operations and stormwater runoff. The production of oil and/or gas commonly includes chlorides, often referred to as oil field brine, as a byproduct which requires proper disposal. Previous brine disposal practices from the early 1900's through the 1960's were by discharge into open earthen evaporation pits or the nearest watercourse. This method continued as an acceptable practice by many independent oil operators until regulations prohibited the disposal of brine in open pits. The chloride concentration of disposed brines typically ranged from 3,000 mg/l to as high as 35,000 mg/l.

Recognizing the impact to the environment and both surface and groundwater supplies, the State of Texas, acting through the Texas Railroad Commission, promulgated regulations (State-wide No Pit Order) that resulted in the emptying and backfilling of brine disposal pits, and required that the brine be injected into authorized zones as the only accepted means of disposal. Since 1980, most oilfield brine has been properly disposed of by underground injection under permits issued by the Texas Railroad Commission and the Oklahoma Corporation Commission. The majority of oil field brine produced is being injected into the formations from which it originated or is used in secondary oil recovery operations to increase production of partially depleted oil fields.

Man-made brine still contributes to the watershed chloride load because residual chlorides contained in soils and alluvium deposits near previously abandoned disposal sites continue to permeate the basin's surface and groundwater resources. While there has been significant improvement in oil field operations to prevent oil field brine discharges, there continues to be considerable concern about the long-term impact of earlier practices and new contamination caused by occasional spills, which tend to originate from improperly plugged or abandoned wells, equipment malfunctions, and commingling of salt-bearing and freshwater aquifers.

Other man-made sources of chlorides entering the river system stem from municipal and industrial waste discharges. Since the 1970s, in response to the Federal Clean Water Act, the State of Texas has continued to force municipal and industrial waste dischargers to meet higher water quality standards with each new permit. Although chlorides are not normally a regulated parameter in waste discharge permits, advanced treatment techniques used to meet permitted parameters in conjunction with requirements to meet higher water quality stream standards have had, and will continue to have, a declining effect on chloride loads into the river system.

(b) Natural Chloride Sources and Associated Water Quality. Natural chloride areas occurring as seeps, springs, and salt flats are located in the basin study area. The sources identified for control in the proposed plan, Areas V, VII, VIII, and X, contribute about 791 tons/day of chlorides to the Wichita River. The Wichita River Basin is representative of several major river basins in the southwestern United States in regard to natural salt concentrations. Geologic formations underlying portions of Texas, Oklahoma, New Mexico, Kansas, and Colorado are sources of salt emissions to the rivers. In the past, this region was covered by a shallow inland sea. The salt-bearing geologic formations were formed by salts precipitated from evaporating sea water. Salt springs and seeps and salt flats in upstream areas of the basins now contribute large salt loads to the rivers. Chloride loads at each of the source areas are shown in Table 3-5.

Springs are natural groundwater seeps or flows, formed where underground water intercepts a low permeability material, such as rock or clay. Instead of filtering down, water moves horizontally, much like rain running off the roof of a house. This horizontal pooling of water forms the water table. In the project area, the water table typically follows surface topography. Springs, ponds, lakes, and streams mark places where the surface intercepts the water table. Salt seeps and springs are formed as the water table dissolves salt present in geologic formations as it flows.

TABLE 3-5
CHLORIDE LOADS BY SOURCE AREA

Salt Source Area	Contributing Stream	Natural Chloride Load (tons per day)
V[1]	Estelline Springs, Prairie Dog Town Fork	300
VII	North Fork, Wichita River	244
VIII[2]	South Fork, Wichita River	189
X[3]	Middle Fork, Wichita River	58
Total of Identified Major Natural Sources		791

Source: USACE 2001a
[1] Ring dike (operational since January 1964) controls 240 of the total 300 tons per day of chlorides.
[2] Operating since 1987.
[3] Partially completed, not operational.

Area V is a large spring in the floodplain of the Prairie Dog Town Fork of the Red River in Hall County, about 0.5 mile east of Estelline, Texas. Chloride control features at this site were implemented in 1964 and are still in operation. Because the facilities have been implemented, are still in operation, and are part of the authorized project, Area V is considered an existing condition and is expected to remain and be functional in the future. Area V produced 300 tons per day of salt. Of these, 240 tons/day are being controlled

Area VII is the designation given to the chloride-contributing portion of the North Fork of the Wichita River and Salt Creek, a tributary of the North Fork. The majority of surface flow, under normal conditions is approximately 5 to 6 cubic feet/second (cfs), with chloride loading coming from several springs in Salt Creek. The chloride concentration from one spring in Salt Creek has measured as high as 17,000 mg/l. As a result, Area VII is emitting approximately 244 tons of chlorides per day.

Area VIII springs contribute almost 189 tons of salt daily to the South Fork of the Wichita River. A low-flow dam has been constructed at this location which traps 85% of the brine. The brine is pumped to Truscott Brine Disposal Reservoir. The result is that 160 tons of salt are removed from the South Fork of the Wichita River daily by the constructed facilities at Area VIII.

Area X, on the Middle Fork of the Wichita River in northeastern King County, consists of three major salt springs approximately 11 miles from the mouth of the river. Springs in the source area are producing chloride concentrations from just over 3,000 to 6,200 mg/l. Mean flow and chloride loading for the river near the source area are 8.6 cfs and 58 tons/day, respectively.

3. Wichita River Water Quality. Water quality measurements have been made for the North, Middle, and South Forks of the Wichita River. Data presented here included both single points and modeled estimates based on three decades of data. In addition, data have been obtained for naturally occurring Se concentrations as well as anthropogenic biochemical constituents.

(a) Naturally Occurring Salt Concentrations. Flows from Areas VII and X are combined where the Middle Fork of the Wichita River joins the lower North Fork of the Wichita River. A U.S. Geological Survey (USGS) gaging station on the lower North Fork of the Wichita River is located near Truscott. This gage is approximately 9 miles downstream from the confluence with the Middle Fork of the Wichita River. The drainage area at this point is over 937 square miles. Statistical data from Hydrologic Reach 10, the North Fork of the Wichita River, Truscott Gage, indicates overall chloride concentrations of 4,965 mg/l, sulfates of 2,284 mg/l, and TDS of 11,455 mg/l, 50% of the time (USACE 2001a). For comparison, the TDS of seawater is approximately 42,000 mg/l.

Single point water quality data for the North and Middle Forks of the Wichita River is presented in Table 3-6 for low and high flow conditions.

TABLE 3-6
WATER QUALITY IN THE NORTH AND MIDDLE FORKS OF THE WICHITA RIVER (REACH 10)

River Section	Gage	Watershed (sq-mi)	Date	Flow (cfs)	Specific Conductance (µS/cm)	TDS (mg/l)	Chloride Conc. (mg/l)
North Fork	Paducah	540	1/24/95	13	20,900	13,100	5,900
North Fork	Paducah	540	6/16/95	31	15,600	9,900	4,200
Middle Fork	Guthrie	NA	1/24/95	4.4	13,400	8,780	3,300
Middle Fork	Guthrie	NA	8/16/95	8.4	11,500	7,780	2,900
Main Stem	Truscott	937	2/7/95	22	17,300	11,900	5,200
Main Stem	Truscott	937	8/15/95	80	9,260	6,200	2,100

Source: USACE 2001a

A USGS gaging station is located on the South Fork of the Wichita River in Knox County, Texas. This gaging station is downstream from Area VIII. Statistical data from Hydrologic Reach 11, the South Fork of the Wichita River, Benjamin Gage, indicates chloride concentrations of 7,437 mg/l, sulfates of 2,710 mg/l, and TDS of 16,025 mg/l, 50% of the time (USACE 2001a).

Downstream, near Lake Kemp, overall water quality has been assessed. Statistical data from Hydrologic Reach 9, the main stem of the Wichita River, indicates chloride concentrations of 1,312 mg/l, sulfates of 755 mg/l, and TDS of 3,254 mg/l, 50% of the time (USACE, 2001b).

(b) Selenium. Elevated concentrations of Se occur naturally in surface waters of the general proposed project area. While natural background concentrations of Se in freshwater environments are typically less than 0.2 micrograms per liter (µg/l) or parts per billion (ppb) (Skorupa *et al.* 1996), concentrations appear to be much higher in the Wichita River Basin. For example, detected total Se concentrations in samples collected by the USGS range from 3 to 17 and 4 to 17 mg/l on the North Fork (Area VII), and Middle Fork (Area X) of the Wichita River, respectively (USACE 2000a). The upper end of the naturally-occurring range exceeds concentrations reported as hazardous to health and long-term survival of fish and wildlife populations (Lemly 1993, 1995).

(c) Anthropogenic Influences. Human populations living in north central Texas extensively use the Wichita River. Uses include municipal and industrial water supply, recreation, flood control, wastewater disposal, agricultural activities, and petroleum exploration and production. Table 3-7 lists maximum permitted water discharges and major impoundments for the Wichita River Basin portion of the study area. Reaches of the river with no permitted wastewater discharges reflect the lack of human population. Though not required to have wastewater discharge permits, other activities such as agriculture, oil and gas exploration and production potentially impact water quality in the basin. Human activities, such as clearing and overgrazing, have erased much of the original native grasslands and allowed mesquite and juniper introduction to expand. Mesquite introduction in turn affects water quality and quantity by decreasing runoff. The brush management program, as detailed in other sections, attempts to restore some vegetational components of the basin to pre-settlement conditions.

According to the TNRCC 1996 Summary of River Basin Assessments, water quality screening data for the Wichita River indicates possible concerns for nutrients, fecal coliform bacteria, dissolved metals, and dissolved minerals. The minerals (salts) come primarily from springs in the upper reaches of the basin and are concentrated by low-flow conditions. Fecal coliform bacteria and nutrient problems are likely the result of municipal and industrial discharges into this and upstream segments.

TABLE 3-7
WICHITA RIVER WASTEWATER DISCHARGES AND WATER IMPOUNDMENTS

County	No. of Wastewater Permits	Maximum Permitted Wastewater Flow (mgd)	Major Impoundments
Cottle	1	0.24	
Foard	6	0.20	Chloride Control Structure Copper Breaks
Knox	0	0.00	Truscott
Wilbarger	8	3.05	Santa Rosa
Baylor	1	0.00	Kemp, Diversion
Wichita	8	28.66	
Clay	10	1.22	
Total	34	-	6

4. Water Quantity. The drainage area for the Wichita River above Lake Kemp Dam at river mile 126.7 is 2,086 square miles while the drainage area between Lake Kemp and Wichita Falls at the mouth of Holliday Creek is 1,240 square miles. Average annual rainfall ranges from 21 inches in the western part of the Wichita River Basin to 28 inches in the eastern part of the basin (Spatial Climate Analysis Service 2000). Stream flows have been analyzed for Reaches 8 (Wichita River downstream of Diversion), 9 (Wichita River main stem), Reach 10 (North and Middle Fork) and Reach 11 (South Fork) as presented in Table 3-8.

TABLE 3-8
WICHITA RIVER STREAM FLOW

Reach	USGS Gage	Average Flow* (cfs)
8	Wichita Falls	82.0
9	Seymour (Modified)**	42.6
10	Truscott	20.0
11	Benjamin	7.6

Source: USACE 2001a
*50% exceedence level
** Multiplied by 1.42 to simulate flows into Lake Kemp

In addition to average flow rates, low flow conditions in the North, Middle and South Forks of the Wichita River were of particular interest to this study. Low flow conditions, for the purpose of this study, have been evaluated for flows less than 1 cfs (limited flow) or less than 0 cfs (no flow but not dry). These scenarios intermittently exist in the Upper Wichita River under natural conditions as described in the following sections.

The USACE performed a study to assess base flow conditions in Reaches 9, 10, and 11 of the Upper Wichita River. While natural conditions are synonymous with observed base flows in Reaches 9 and 10, natural conditions in Reach 11 were calculated based on observed flow plus the average pump rate from Area VIII since the time of construction. Therefore, the base flow for Reach 11 estimates stream flow prior to construction of Area VIII. Base flow rates were taken from data collected by USGS stream gages from October 1961 - September 1998 for Reaches 10 (Truscott Gage) and 11 (Benjamin Gage) while data from December 1959 - September 1979 were used for Reach 9 (Lake Kemp). These results are reported in Table 3-9.

TABLE 3-9
PERCENT OF LOW FLOW AT BASE CONDITIONS BY REACH*

	Reach 10		Reach 11	Reach 9
	cfs≤1	cfs≤0	cfs≤0	cfs≤0
Natural Conditions	1.5	0.0	8.9	1.4
50% Brush Control (27.6% Return)	NA	0.0	7.9	1.4
50% Brush Control (38.9% Return)	NA	0.0	7.8	1.4

Source: USACE 2001a
NA – Not Applicable
* Percentiles rounded to nearest tenth.

Due to growing concern in the Wichita River Basin about the availability of water and its effect on economic growth and development, the RRA in cooperation with the Texas State Soil and Water Conservation Board (TSSWCB) initiated a study to determine the feasibility of implementing a brush control and management program to increase water yield. The goal is to restore large areas of brush to native grasses, but leave brush buffers and habitat corridors. The results of the study revealed the implementation of the proposed brush control program may be expected to provide a net increase in overall watershed yield (measured at Lake Kemp) ranging from 27.6 % to 38.9 % based on the report's 119,100 acre-feet per year estimated average inflow for the lake (other studies cited in this document report higher inflows for Lake Kemp). The brush control program has currently been included in Texas Senate Bill 1 and the Region B (Red River Authority) Water Plan. Implementation is expected to occur regardless of the outcome of chloride control efforts. The Reevaluation assumed a brush management implementation factor of 50% as its future condition projection – with and without the proposed project. Low flow base conditions with and without brush management are also shown in Table 3-9.

5. Aquatic Invertebrates. Information regarding aquatic instream invertebrate communities within the Wichita River Basin is quite limited. West Texas State University (WTSU) observed invertebrate communities at specific RRCCP areas which included a limited amount of work on the Wichita River. Their observations are summarized below.

The Wichita River system has a relatively limited aquatic invertebrate population, possibly due to the high salt content of the water (WTSU 1972). Most of the invertebrate fauna consisted of crustaceans and insects. Crayfish and amphipods were found in the North and Middle Fork of the Wichita River and calanoid copepods in the Middle Fork of the Wichita River. The most common invertebrates in tributaries of the Wichita River were aquatic insects, including water scavenger beetles, damselflies, dragonflies, water striders, and midges. Horseflies and deerflies were common along the streams and probably breed along the stream shorelines.

6. Fish Resources in Wichita River Basin. Fish communities in the Wichita River Basin have been described by Lewis and Dalquest (1955, 1956, 1957), Dalquest (1958), Dalquest and Peters (1966), Echelle *et al.* (1972), Matthews (1991), Echelle *et al.* (1995), Gelwick, et al (2000), and Clyde (1996). Fish communities in the basin are often subjected to a high degree of variability in flow, temperature, turbidity, and salinity. Consequently, species composition and relative abundance can be highly variable among locations and seasons (Matthews 1991; Taylor *et al.* 1996) and may fluctuate widely over long periods of time (Wilde *et al.* 1996). Because of this, specific fish sampling events have been heavily influenced by the environmental conditions in the river that preceded the sampling events. Therefore, the results of fish collections must be interpreted with some level of caution regarding relative abundance (% of total catch) of various fish species.

Fishery resources in the upper Red River basin including the Wichita River system were described in detail by Wilde *et al.* (1996). Information contained in the 1976 FES was used to identify fish species that have been collected in four reaches of the Wichita River including two reaches on the Wichita River (Reaches 7 and 9), and single reaches on the North Fork of the Wichita River (Reach 10) and South Fork of the Wichita River (Reach 11). Each of these reaches is shown on Figure 3-2, and fish species that have been collected in the four reaches are shown in Table 3-10.

Overall within the Wichita River reaches, a total of 43 fish species were collected. Of these 16 species were collected in all four reaches. Fish species that were collected in all four reaches included:

- Gizzard shad
- carp
- plains minnow
- speckled chub
- Red River shiner
- red shiner
- sharpnose shiner
- fathead minnow
- Bullhead minnow
- Red River pupfish
- plains killifish
- mosquitofish
- green sunfish
- orangespotted sunfish
- bluegill
- longear sunfish

Although collected within one or more of the identified reaches within the Wichita River system, almost 50% (21 of 43) of the fish species collected had a low abundance (i.e., less than 1% of the fish collected in all stream reaches). Species with low abundance in the Wichita River system include:

- Paddlefish
- shortnose gar
- goldeye
- carp
- Silver chub
- chub shiner
- sand shiner
- blacktail shiner
- Suckermouth minnow
- black buffalo
- black bullhead
- yellow bullhead
- Inland silverside
- striped bass
- warmouth
- orangespotted sunfish
- Redear sunfish
- spotted bass
- largemouth bass
- bigscale logperch
- Freshwater drum

TABLE 3-10
COMMON AND SCIENTIFIC NAMES OF FISH SPECIES
COLLECTED FROM FISH REACHES IN THE WICHITA RIVER

Common Name	Scientific Name	Reach 7	Reach 9	Reach 10	Reach 11
Paddlefish	*Polyodon spathula*		X		
Longnose gar	*Lepisosteus osseus*	X			
Shortnose gar	*Lepisosteus platostomus*	X			
Gizzard shad	*Dorosoma cepedianum*	X	X	X	X
Goldeye	*Hiodon alosoides*	X			
Red shiner	*Cyprinella lutrensis*	X	X	X	X
Blacktail shiner	*Cyprinella venusta*	X			
Common carp	*Cyprinis carpio*	X	X	X	X
Plains minnow	*Hybognathus placitus*	X	X	X	X
Speckled chub	*Macrhybopsis aestivalis*	X	X	X	X
Silver chub	*Macrhybopsis storeiana*	X			
Emerald shiner	*Notropis atherinoides*	X	X	X	
Red River shiner	*Notropis bairdi*	X	X	X	
Ghost shiner	*Notropis buchanani*	X	X	X	
Sharpnose shiner	*Notropis oxyrhynchus*	X	X	X	X
Chub shiner	*Notropis potteri*	X	X	X	
Sand shiner	*Notropis stramineus*	X	X	X	
Suckermouth minnow	*Phenaeobius mirabilis*	X	X	X	
Fathead minnow	*Pimephales promelas*	X	X	X	X
Bullhead minnow	*Pimephales vigilax*	X	X	X	X
River carpsucker	*Carpiodes carpio*	X	X		X
Smallmouth buffalo	*Ictiobus bubulas*	X	X		
Black buffalo	*Ictiobus niger*	X			
Black bullhead	*Ameiurus melas*	X		X	X
Yellow bullhead	*Ameiurus natalis*			X	
Channel catfish	*Ictalurus punctatus*	X	X		
Red River pupfish	*Cyprinodon rubofluviatilis*	X	X	X	X
Plains killifish	*Fundulus zebrinus*	X	X	X	X
Mosquitofish	*Gambusia affinis*	X	X	X	X
Inland silverside	*Menidia beryllina*	X			
Striped bass	*Morone saxatilis*	X			
White bass	*Morone chrysops*	X	X		
Green sunfish	*Lepomis cyanellus*	X	X	X	X
Warmouth	*Lepomis gulosus*	X	X		
Orangespotted sunfish	*Lepomis humilis*	X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X
Lonear sunfish	*Lepomis megalotis*	X	X	X	X
Redear sunfish	*Lepomis microlophus*	X			
Spotted bass	*Micropterus punctulatus*	X			
Largemouth bass	*Micropterus salmoides*	X	X	X	
White crappie	*Pomaxis annularis*	X	X		
Bigscale logperch	*Percina macrolepida*	X			
Freshwater drum	*Aplodinotus grunniens*	X	X		

Source: Wilde *et al.* (1996)

Wilde *et al.* (1996) indicated that the sharpnose shiner and paddlefish might be extirpated from the basin as neither species has been collected in the basin since the 1960's.

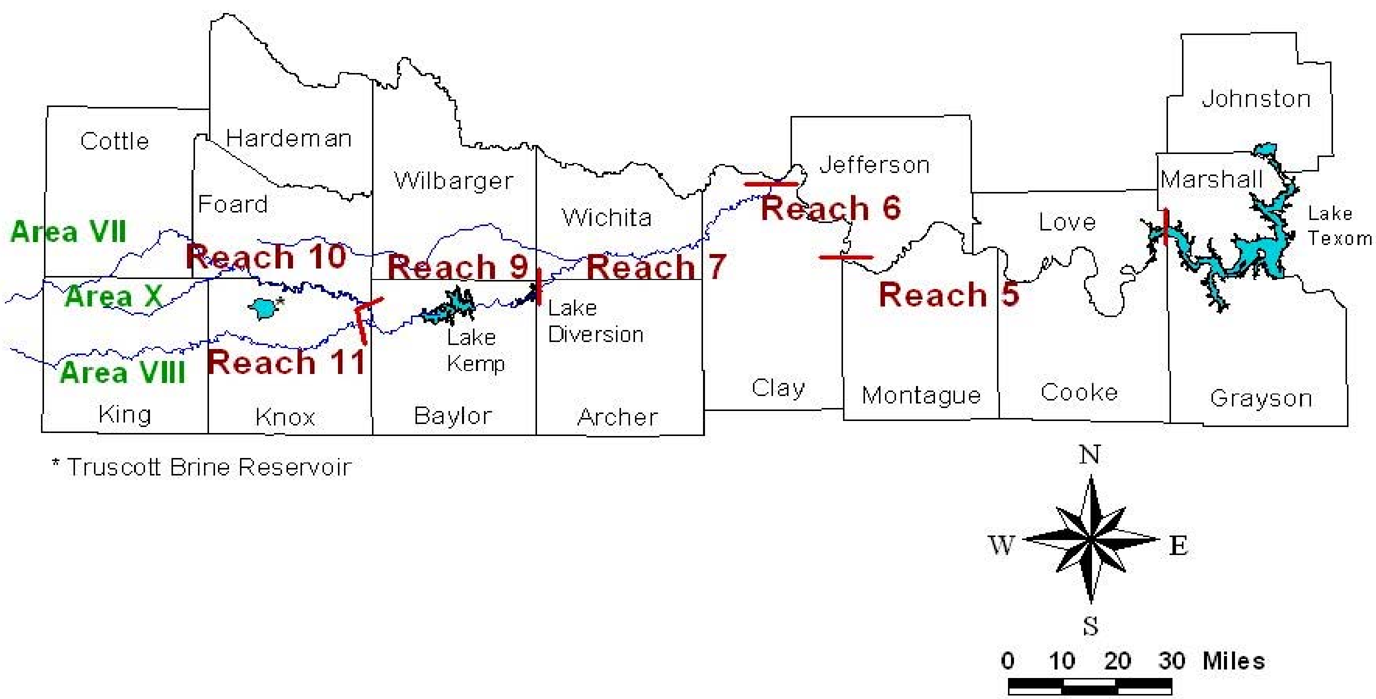
Generally, as one proceeds up the Wichita River system, fishery resources are subjected to harsher environmental conditions associated with lower flows including more frequent no flow periods, higher water temperatures during the summer, and increased levels of salinity. These harsher conditions in the upstream reaches of the river are reflected in the assemblage of fish species that have been collected in each of the stream reaches. On the main stem of the Wichita River, the lower reach (Reach 7) had 41 species and the upper reach (Reach 9) had 30 species. In comparison, sampling on the North Fork of the Wichita River (Reach 10) and the South Fork (Reach 11) recorded 23 and 19 fish species, respectively. In addition to more favorable living conditions, the fish population in Reach 7 is influenced by fish, especially game fish, such as striped bass, white bass, and spotted bass, that have migrated from Lake Texoma up the Red River to the lower reach of the Wichita River. Similarly, fish species sampled in Reach 9 are influenced by fish movement (upstream and downstream) from Lakes Kemp and Diversion.

The USACE provided information by stream reach for the most abundant fish species regarding each species' relative abundance in pre- and post-1970 collections. After reviewing this information for the Wichita River system, the following general observations can be made:

- The relative abundance of plains minnows has decreased throughout the basin,
- The relative abundance of red shiners has increased in the reaches of the Wichita and North Fork of the Wichita Rivers, and
- The relative abundance of Red River pupfish has increased in the North Fork and South Fork of the Wichita River.

Species composition appears to be frequently associated with habitat type and salinity. In regard to habitat, main stem habitat that is wide and shallow and has sandy substrate where turbidity and salinity are frequently high is primarily occupied by the plains minnow, Red River shiner, chub shiner, and speckled chub. In main stem and tributary streams, red shiners, sunfish species, fathead minnow, bullhead minnow, and mosquitofish frequently occupy habitat containing deeper water (flowing or pool areas), with silt bottom, and woody debris. Plains minnow, Red River shiner, mosquitofish, green sunfish, chub shiner, and speckled chub are tolerant of high salinity and are often found in areas with salinity as great as 20,000 mg/l to the exclusion of other species. In areas where salinity may exceed 20,000 mg/l (includes areas in Reaches 10 and 11), only Red River pupfish and plains killifish are found in abundance as both species have extremely high salt tolerance and may survive salinity concentrations as high as 100,000 mg/l (Wilde et al 1996). The fish species assemblage shown in Table 3-10 for the North Fork of the Wichita River and South Fork of the Wichita River does not reflect the harsh environment that occurs immediately downstream of the major sources of salinity.

FIGURE 3-2
FISH ANALYSIS REACHES



c. Upper Red River Basin from Confluence with Wichita River to Lake Texoma

1. Description. The study area for the Upper Red River includes the basin from its confluence with the Wichita River at river mile 907 downstream to Lake Texoma. Overall, the Red River is an interstate stream, which originates in Curry County, New Mexico, as Tierra Blanca Creek and flows along the Texas/Oklahoma border into southwestern Arkansas and then turns south into Louisiana, where it discharges into the Mississippi near Simmesport, Louisiana. The main stem of the Red River has a total length of 1,217 river miles. The topography of the basin ranges from flat prairie in the western reach at an elevation of approximately 4,835 feet NGVD to rolling hills in eastern Texas at an elevation of approximately 495 feet NGVD.

2. Water Quality. Water quality in the upper Red River is influenced by both natural and anthropogenic discharges. Natural (no chloride control) chloride, sulfate, and TDS data for hydrologic Reaches 6 and 7 are shown in Table 3-11.

TABLE 3-11
WATER QUALITY IN UPPER RED RIVER HYDROLOGIC REACHES

Reach	Gage	Chloride (mg/l)	Sulfate (mg/l)	TDS (mg/l)
6	Gainesville	1,046	501	2,605
7	Terral	1,257	641	3,187

Source: USACE 2003a
*50% exceedence level

(a) Anthropogenic Influences. Human populations living in north-central Texas and south-central Oklahoma extensively use rivers in the study area. Uses include municipal and industrial water supply, recreation, flood control, wastewater disposal, agricultural activities, and petroleum exploration and production. Table 3-12 lists some uses, including maximum permitted water discharges and major impoundments for the states of Texas and Oklahoma in the study area. Wastewater discharges listed on Table 3-6 include discharges from industries, municipalities, and individual proprietors. Reaches of the river with no permitted wastewater discharges reflect the lack of human population. Though not required to have wastewater discharge permits, other activities such as agriculture and oil and gas exploration and production potentially impact water quality in the basin.

Additional Red River water quality data from upstream of its confluence with the Wichita River was provided by the TNRCC. According to the TNRCC data screening, concerns exist for nutrients and dissolved metals and a possible concern for fecal coliform bacteria. A possible source of the nutrients is municipal discharges. As a result, elevated levels of fecal coliform bacteria do not support contact recreation use.

TABLE 3-12
UPPER RED RIVER WASTEWATER DISCHARGES AND WATER IMPOUNDMENTS
STATES OF OKLAHOMA AND TEXAS

County	No. of Wastewater Permits	Maximum Permitted Wastewater Flow (mgd)	Major Impoundments
TEXAS			
Clay	10	1.22	Arrowhead
Montague	3	0.13	
Grayson	23	20.86	
OKLAHOMA			
Cotton	2	NA	
Jefferson	1	NA	Waurika

NA - Not available

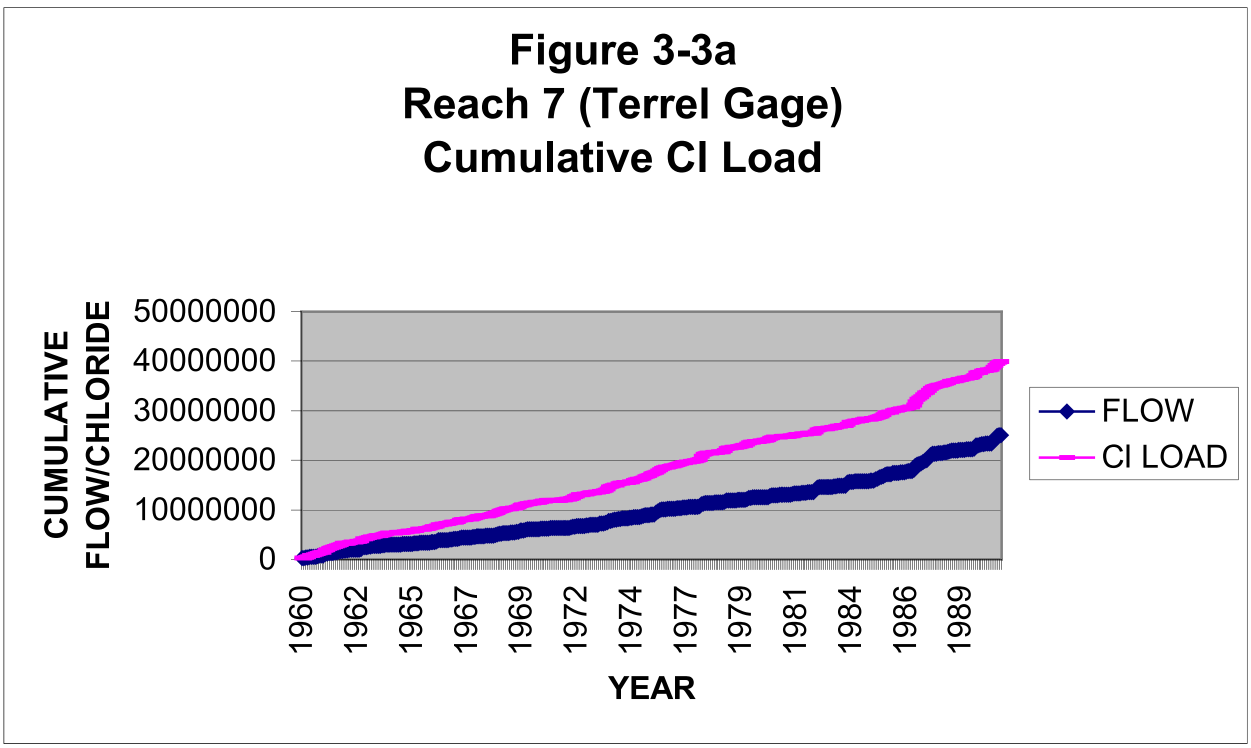
(b) Selenium. Elevated concentrations of Se occur naturally in surface waters of the general area. While natural background concentrations of Se in freshwater environments are typically less than 0.2 µg/l (Skorupa *et al.* 1996), concentrations appear to be much higher in the upper Red River Basin. For example, data from USGS gaging stations on the Salt Fork of the Red River near Elmer, Oklahoma, and near Wellington, Texas, indicate that total Se concentrations range from approximately 1 to 9 and 3 to 29 µg/l, respectively, at these locations, which are upstream of the Red River study area. The upper end of this naturally-occurring range exceeds concentrations of Se reported as hazardous to health and long-term survival of fish and wildlife populations (Lemly 1993, 1995).

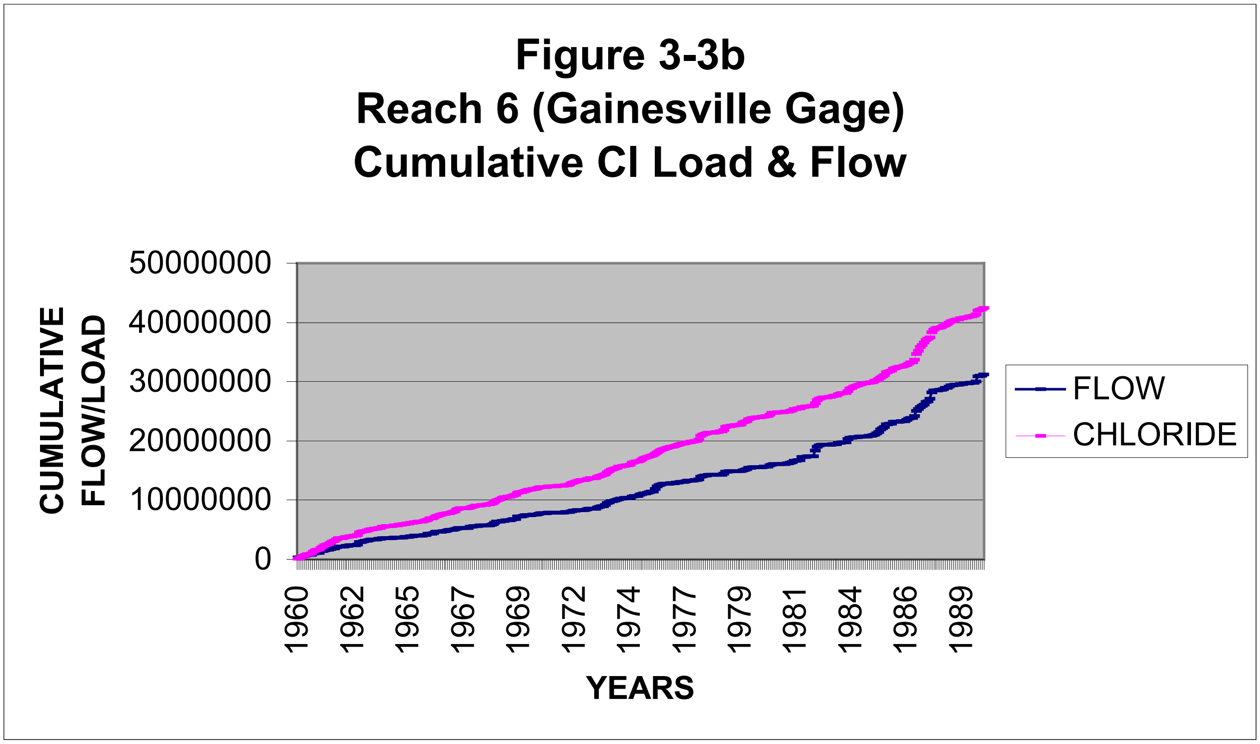
(c) Oil Field Brine. According to the RRA, efforts to control man made brine pollution began as early as 1960. By 1964, the RRA and other participating state agencies had identified over 220,000 wells producing brine in the basin. Brine production was estimated at over 9,000,000 barrels per day. The RRA, as the local sponsor for the chloride control project, agreed to lead efforts to control oil field brine pollution in the Red River basin. By 1980 over 36,000 earthen brine disposal pits had been inventoried and subsequently emptied and backfilled leaving an estimated 2,800 square miles contaminated by oilfield brine disposal techniques in the Red River watershed above Lake Texoma. By 1980, most oilfield brine was being properly disposed of by underground injection under permits issued by the Texas Railroad Commission and the Oklahoma Corporation Commission.

Since 1980, the majority of oil field brine produced is being disposed of by injection wells into formations from which it originated or is used in secondary oil recovery operations to increase production of partially depleted oil fields. In 1990, the RRA prepared a model to estimate the load and control effectiveness of oil field brine production and disposal operations in the Red River watershed above Lake Texoma. The 1990 model indicated there were 237,000 wells producing 9,324,200 barrels per day of brine. The model calculated the average daily chloride load being produced by oilfield operations at 1,143 tons per day with 968 tons per day disposed of by authorized injection resulting in a control effectiveness of man made brine pollution of 84.7%. This figure represents overall man made brine control, not the control of chloride load into the Red River.

Man-made brine still contributes to the watershed chloride load because residual chlorides contained in soils and alluvium deposits near previously abandoned disposal sites continue to permeate the basin's surface and groundwater resources. While there has been significant improvement in oil field operations to prevent oil field brine discharges, there continues to be considerable concern about the long-term impact of earlier practices and new contamination caused by occasional spills, which tend to originate from improperly plugged or abandoned wells, equipment malfunctions, and commingling of salt-bearing and freshwater aquifers.

To evaluate actual man-made chloride load to the watershed, the cumulative chloride load in Reaches 6 and 7 from Water Year (WY) 1960 through WY1990 were plotted and are presented as Figures 3-3a and 3-3b. If the man made load were significant, the decrease in man made brine would result in a decrease in slope in the cumulative load plot. As Figures 1 and 2 illustrate, no discernable decrease in slope is detected for the Red River. The cumulative load plots clearly illustrate the actual man made load in the Red River basin was not a significant portion of the total load.





To further evaluate man made chloride load contributions, the man made load in the Red River basin was estimated flow and cloride ions ratios. Excess Cl atoms not associated with Na can combine with available Mg to form $MgCl_2$. Magnesium is a product of oil field drilling and oil production and is therefore indicative of man-made brine pollution. Using USGS water quality data, the number of Cl atoms required to combine with the available Na atoms is determined. Any excess Cl atoms are considered available to combine with Mg. Using the period of record water quality data available, a flow/Cl weighted average was determined for each year. The flow/Cl weighted average represents the maximum daily man made load. Results of the analysis are listed in Table 3-13.

A review of the results indicate the average long term man made chloride load in the Red River basin appears to be an estimated 182 tons/day with daily averages reaching as high as 479 tons/day and as low as 17 tons/day. The annual variations in daily chloride loads are a result of alluvial loading of dissolved solutes, a natural process where dissolved solutes are stored in the alluvium during low flow periods and flushed out during high flow periods. The results of this study support the cumulative chloride load plots and indicate that man made chloride load has not been a significant portion of the total Red River chloride load. Accordingly, the majority of loading identified as “minor natural and man-made” results from “minor natural” sources rather than man-made.

TABLE 3-13
GAINESVILLE GAGE
MAN MADE CHLORIDE LOAD ANALYSIS

Year	Estimated Max. Man Made Cl Load Avg (%)	Rolling 5Yr Avg (%)	Gaged Cl Load Tons/Day	Estimated Max. Man Made Cl Load Tons/Day	Avg Daily Flow CFS
1966	6.1		3176	194	1665
1967	7.6		1532	116	1160
1968	3.4		3766	128	2459
1969	3.4		3413	116	2451
1970	9.6	5.64	1505	144	1070
1971	8.0	5.8	2404	192	1182
1972	*				
1973	*				
1974	5.1		3798	194	2353
1975	3.9		4769	186	4428
1976	4.4		2684	118	1413
1977	2.9		4324	125	2589
1978	1.4	3.44	3429	48	1844
1979	4.6	3.34	3639	167	1816
1980	6.8	3.78	2420	165	1524
1981	6.7	4.16	2442	164	3262
1982	5.8	4.66	4373	254	5502
1983	9.9	6.0	4391	435	3325
1984	6.9	6.3	3017	208	1391
1985	7.6	6.54	6300	479	6014
1986	4.0	6.08	9527	381	6772
1987	3.3	5.68	9611	317	8367
1988	0.5	4.18	4110	21	2456
1989	3.7	3.68	4323	160	5713
1990	*				
1991	*				
1992	*				
1993	*				
1994	0.8		2118	17	
1995	2.1		9434	198	8833
1996	3.1		5037	156	2819
1997	2.0		7725	155	5376
1998	1.4	1.4	6138	87	4929
AVG	**4.63**		**4422**	**182**	**3128**

*Data not available

Another technique used to monitor effects of man-made chloride control is the sodium to chloride ionic ratio. This technique relies upon the chemical characterization of oil field brines versus natural salt sources. Previous studies have shown that oil field brines have a sodium to chloride ratio of less than 0.60, while natural salt sources typically maintain a ratio of 0.60 and greater. Recent analysis of USGS at the Burkburnett gage, representing the inflow into Lake Texoma, indicate the sodium to chloride ratio is continuing to increase above the 0.60 ratio. This indicates that man-made pollution control measures are working and that man made pollution is not a significant percentage of the total chloride load entering Lake Texoma as shown in Table 3-14.

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TABLE 3-14
Na/Cl IONIC RATIO IN REACH 5 (BURKBURNETT GAGE)

Year	Na/Cl Ionic Ratio Annual Average
1966	0.60
1967	0.59
1968	0.63
1969	0.66
1970	0.57
1971	0.59
1974	0.62
1975	0.62
1976	0.62
1977	0.62
1978	0.61
1979	0.61
1980	0.59
1981	0.55
1982	0.58
1983	0.59
1984	0.60
1985	0.60
1986	0.63
1987	0.62
1988	0.67
1989	0.62
1994	0.66
1995	0.65
1996	0.63
1997	0.63
1998	0.63

*Data unavailable 1972, 1973, 1990, 1991 1992, 1993

3. Water Quantity. The upper Red River Basin watershed receives an average annual precipitation varying from 34 inches near its confluence with the Wichita River to 38 inches at Lake Texoma. Stream flow in Hydrologic Reach 7, in the upper Red River study area has a flow rate of 653 cfs, 50% of the time. Similarly, the downstream Hydrologic Reach 6 has a flow rate of 971 cfs, 50% of the time (USACE, 2001b).

4. Aquatic Invertebrates. Information about aquatic invertebrates in the Red River upstream from Lake Texoma is scarce as long reaches of the river cross private lands and few roads exist. These reaches are basically inaccessible without permission from landowners. Stream margins throughout the basin provide breeding habitat for horseflies and deerflies, which become abundant at certain times of the year.

Other than the survey conducted in the early 1970's by WTSU under contract to the USACE for baseline information on streams that could be affected by the RRCCP, no other written information could be found about the structure of aquatic invertebrate communities upstream from Lake Texoma. The USACE reported that verbal communications with faculty members at the University of Oklahoma at Norman, Texas Tech University at Lubbock, and the University of North Texas at Denton produced no additional information. Neither the Oklahoma Biological Survey at Norman nor the TPWD had any aquatic invertebrate information for the project area.

5. Fish Resources in the Upper Red River Basin: The only portion of the upper Red River that could be affected by the proposed project is that portion between the confluence of the Wichita River and Lake Texoma and includes that portion of the Red River shown as Reaches 5 and 6 on Figure 3-2. Therefore, the discussion of fish resources within the Red River has been limited to these two reaches of the river. Although not to the extent that occurs in the Wichita River, fish in these reaches of the Red River are also subject to considerable variations in flow, temperature and salinity levels. As discussed for the Wichita River, environmental conditions in the river prior to a fish sampling event can have a large influence on the sampling results. Therefore, again, some level of caution should be exercised when evaluating changes in relative abundance (% of total catch) of different fish species.

The Wilde *et al.* (1996) identified fish species that have been collected in Reaches 5 and 6 of the Red River from Lake Texoma upstream to the confluence of the Wichita River. A list of fish species that have been collected in these reaches of the Red River is provided in Table 3-15. Of the species collected, the abundance of 49 of the species (80% of the species) had an individual abundance of less than 1%. Three species (red shiner, plains minnow, and emerald shiner) had relative abundance greater than 5% in both reaches of the Red River (Wilde *et al.* 1996). These three species comprised over 85 and 65% of the fish that have been collected from Reaches 5 and 6, respectively. With the exception of the sharpnose shiner, all 16 fish species that were collected in all reaches of the Wichita River were also collected in both reaches of the Red River. The larger assemblage of fish species in the Red River when compared to the Wichita River is likely attributable to being located immediately upstream from Lake Texoma and more desirable environmental conditions within the river. Three fish species collected in Reaches 5 and 6 (Red River pupfish, Red River shiner, and speckled chub) have been identified by resource agencies as being of special concern because of their limited distribution.

TABLE 3-15
COMMON AND SCIENTIFIC NAMES OF FISH SPECIES
COLLECTED FROM FISH REACHES OF THE UPPER RED RIVER

Common Name	Scientific Name	Reach 5	Reach 6
Shovelnose sturgeon	*Scaphirhynchus platorynchus*		X
Longnose gar	*Lepisosteus osseus*	X	X
Shortnose gar	*Lepisosteus platostomus*	X	X
Gizzard shad	*Dorosoma cepedianum*	X	X
Threadfin shad	*Dorosoma petenense*	X	X
Goldeye	*Hiodin alosoides*	X	X
Stoneroller	*Campostoma anomalum*	X	
Red shiner	*Cyprinella lutrensis*	X	X
Blacktail shiner	*Cyprinella venusta*	X	X
Common carp	*Cyprinis carpio*	X	X
Silvery minnow	*Hybognathus nuchalis*	X	X
Plains minnow	*Hybognathus placitus*	X	X
Speckled chub	*Macrhybopsis aestivalis*	X	X
Silver chub	*Macrhybopsis storeiana*	X	X
Golden shiner	*Notemigonus crysoleucas*	X	X
Emerald shiner	*Notropis atherinoides*	X	X
Red River shiner	*Notropis bairdi*	X	X
Ghost shiner	*Notropis buchanani*	X	X
Chub shiner	*Notropis potteri*	X	X
Sand shiner	*Notropis stramineus*	X	X
Suckermouth minnow	*Phenaeobius mirabilis*	X	X
Fathead minnow	*Pimephales promelas*	X	X
Bullhead minnow	*Pimephales vigilax*	X	X
River carpsucker	*Carpiodes carpio*	X	X
Smallmouth buffalo	*Ictiobus bubulas*	X	X
Bigmouth buffalo	*Ictiobus cyprinellus*	X	X
Black buffalo	*Ictiobus niger*	X	
Golden redhorse	*Moxostoma eythrurum*	X	X
Black bullhead	*Ameiurus melas*	X	X
Yellow bullhead	*Ameiurus natalis*	X	X
Blue catfish	*Ictalurus furcatus*	X	X
Channel catfish	*Ictalurus punctatus*	X	X
Tadpole madtom	*Noturus gyrinus*		X
Freckled madtom	*Noturus nocturus*		X
Flathead catfish	*Pylodictis olivaris*	X	X
Red River pupfish	*Cyprinodon rubofluviatilis*	X	X
Blackstripe topminnow	*Fundulus notalas*	X	
Plains killifish	*Fundulus zebrinus*	X	X
Mosquitofish	*Gambusia affinis*	X	X
Brook silverside	*Labidesthes sicculus*	X	
Inland silverside	*Menidia beryllina*	X	X
Striped bass	*Morone saxatilis*	X	X
White bass	*Morone chrysops*	X	X
Green sunfish	*Lepomis cyanellus*	X	X
Warmouth	*Lepomis gulosus*	X	X

Table 3-15 continued

Common Name	Scientific Name	Reach 5	Reach 6
Orangespotted sunfish	*Lepomis humilis*	X	X
Bluegill	*Lepomis macrochirus*	X	X
Lonear sunfish	*Lepomis megalotis*	X	X
Redear sunfish	*Lepomis microlophus*	X	X
Spotted bass	*Micropterus punctulatus*	X	
Largemouth bass	*Micropterus salmoides*	X	X
White crappie	*Pomaxis annularis*	X	X
Black crappie	*Pomaxis nigromaculatus*	X	X
Mud darter	*Etheostoma asprigene*	X	
Orangebelly darter	*Etheostoma radiosum*	X	
Orange throated darter	*Etheostoma spectabile*	X	
Logperch	*Percina caprodes*	X	X
Bigscale logperch	*Percina macrolepida*	X	X
Sauger	*Stizostedion canadense*		X
Walleye	*Stizostedion vitreum*	X	
Freshwater drum	*Aplodinotus grunniens*	X	X

Source: Modified Wilde et at. 1996

Of the species that have been reported to have been collected from these reaches of the Red River, Wilde *et al.* (1996) identified three species (sharpnose shiner, freckled madtom, and shovelnose sturgeon) that are possibly extirpated from the basin. All three of these species have not been collected from the basin since the 1960's (Wilde *et al.* 1996).

The upper Red River supports a commercial bait minnow fishery that appears to be highly variable. The USFWS (1994) reported 49,000 pounds (lbs) of minnows commercially harvested from the upper Red River in 1991. The ODWC (Wallace and Driscoll 1994) reported the commercial minnow harvest from the upper Red River in Oklahoma to be considerably less for 1993, with a total of 27,350 lbs. Commercial bait minnows consisting primarily of "River shiners" were reportedly harvested from the North Fork of the Red River (18,500 lbs), the Red River (7,850 lbs), and the Salt Fork of the Red River (1,000 lbs). No data are available regarding the impacts of commercial minnow harvest on fish communities, but it could be a factor in the general decline of some minnow species throughout the upper basin .

d. Truscott Brine Disposal Reservoir. Truscott Brine Disposal Reservoir was designed as a brine disposal site, receiving collected brines from the collection sites. The economic life of the lake is 100 years for evaluating costs and benefits. The functional life of the reservoir is indefinite. The lake is located on Bluff Creek, a south bank tributary of the North Fork of the Wichita River, at river mile 3.6. The drainage area of the basin is 26.2 miles and begins approximately 2 miles west and 2.5 miles south of Truscott, Texas. The drainage area extends approximately 6 miles northeastward to the dam site and ranges in width from 7 miles at the upper end of the basin to approximately 3 miles at the dam site. The project has been collecting brine since 1987.

1. Water Quality. The water quality of Truscott Brine Disposal Reservoir is influenced by the brine collection areas, evaporation, and contributions from stormwater (freshwater runoff in the Bluff Creek watershed). Water quality data have been collected as part of the Wichita River Basin monitoring program. Baseline Se data for Truscott Brine Disposal Reservoir was collected in 1992. Data collected during reservoir filling indicated overall selenium concentrations of 2 μg/l. Additional monitoring was conducted in 1997 and 1998 (USACE 2001c). This monitoring for Truscott Brine Disposal Reservoir included four sampling sites ranging from Truscott Dam to

the extreme upper end of the impoundment and occurred over a range of seasons. Water samples were collected in both surface and near-bottom waters and analyzed for total Se concentration. Total Se concentrations for the 1997-1998 monitoring were below analytical detection limits (ranging from 0.5 to 1.0 ug/l). The last samples, collected in September 1998, indicated that waterborne total selenium concentrations were still less than the 0.5 ug/l detection limit after approximately 11 years of project operation collecting brine from Area VIII only.

Mass balance analysis of the reservoir Se concentrations shows that a significant portion of the incoming Se has been lost to volatilization and sediment adsorption (USACE 2000a). Volatilization of methylated Se compounds has been demonstrated to be a significant source of Se mass loss in a number of systems (USACE 1993a). Cooke and Bruland (1987) reported that outgassing of Se may have been substantial in Kesterson Reservoir and estimated that roughly 30% of Se introduced to the system was volatilized to the atmosphere. Similarly, Thompson-Eagle and Frankenberger (1990) reported a 35% loss of the total Se inventory of pond water from Kesterson reservoir after 43 days of incubation. Changes in water column and sediment partition coefficients are also known to be a process of major importance in lakes (Bowie *et al.* 1996). Incorporation of these factors into Se modeling for the reservoir has been shown to accurately reflect Se losses from the time of impoundment to the sample collection dates (USACE 2000a).

2. Fish and Wildlife Resources of Truscott Brine Disposal Reservoir. Only a limited amount of information is available regarding fish resources in Truscott Brine Disposal Reservoir. Echelle *et al.* (1995) reported on a sample of fish collected from the reservoir at a time when the salinity in the reservoir was 18,000 mg/l. As would be expected with this level of salinity, fish present in the sample were limited to three salt tolerant species including Red River pupfish (49%), plains killifish (43%), and mosquitofish (8%). This data would indicate that Truscott Brine Disposal Reservoir is presently providing additional habitat for salt tolerant fish species. However, the desirability of this habitat even for the salt tolerant fish species is dependent on salt concentrations in the reservoir. Salinity in the reservoir would change if the reservoir receives additional brines from operation of project components.

A total of three freshwater ponds are located on the north side of Truscott Brine Disposal Reservoir and provide a total of approximately 200 surface-acres of freshwater. An additional pond has been constructed but has not filled with water due to recent drought conditions in northern Texas. The freshwater ponds have been stocked with largemouth bass, channel catfish, blue catfish, and crappie.

4. Recreation. Truscott Brine Disposal Reservoir is located within Texas Planning Region 7 (West Central). Region 7 is composed of 19 counties totaling 16,936 square miles. The population in 2000 was 320,648. According to the 1990 Texas Outdoor Recreation Plan (TORP), Region 7 has a total of 21,000 acres of recreation land, including 7,565 acres of developed recreation land and 57,041 surface acres of lakes. The region has 58 acres of recreation land per thousand people, well below the statewide average. According to the 1990 TORP, facilities needed include off-road vehicle riding areas, softball fields, tennis courts, fishing structures, and boat ramp lanes.

Freshwater ponds associated with Truscott Brine Disposal Reservoir provide additional recreational resources for Region 7. The fishing resource attracts local sportsmen.

According to the USACE Research and Development Center, Truscott receives approximately 7,500 visitors annually that primarily boat and hunt at the facility. The 2,300 surface-acre Truscott Brine Disposal Reservoir is not stocked with fish and, therefore, does not provide fishing at the present time. The area provides hunting of wild hogs, ducks, quail, turkey, dove and the

30-40,000 geese that winter on the reservoir and ponds. Other recreational opportunities include a 7-mile nature trail that surrounds the freshwater ponds, four primitive camp sites, a restroom, and a group picnic shelter located near the reservoir.

e. Lake Kemp and Lake Diversion.

1. Description. Lake Kemp, located 6 miles north of Seymour, Texas, is formed by the Wichita River, which is dammed in north-central Baylor County at river mile 126.7. The lake is used for irrigation and serves as a backup water supply for Wichita Falls. Its elevation is 1,144 feet above sea level and the dam elevation is 1,183 feet. The total drainage area for the lake is 2,100 square miles, and the lake covers an area of 16,540 acres. Maximum lake depth from streambed to conservation elevation pool is 76 feet. The local, deep, loamy soil supports grasses and wild upland plants. There are more than 100 miles of shoreline that furnish a variety of recreation opportunities.

2. Water Quality. Data from Hydrologic Reach 9, which includes Lakes Kemp and Diversion, indicate chloride concentrations of 1,312 mg/l, sulfates of 755 mg/l, and TDS of 3,254 mg/l, 50% of the time (USACE 2001a). Data from the TNRCC for Lake Diversion (at the outlet of Lake Kemp) indicates that even the minimum TDS values are greater than the EPA secondary drinking water standards (250 mg/l). Chlorides originating from natural sources are significant enough to prohibit use of the lake for domestic water supply without advanced treatment.

Wilde (1999) sampled Lake Kemp in 1997. In general, sampling was conducted in accordance with the monitoring plan developed by Burks (1996). Lake Kemp was sampled during April through December 1997. Sampling sites were chosen to include two locations representative of limnetic conditions, two locations that were transitional between riverine and limnetic conditions, and two locations that were riverine in nature, for a total of six sampling sites, as opposed to the five sites originally recommended by Burks (1996). Based on a comparison of his results with those of previous studies, Wilde suggested that chloride loading into the lake may have decreased by as much as 33% between 1992 and 1997.

Wilde sampled Lake Kemp again in 1999 - 2000. Again, sampling was conducted in accordance with the monitoring plan developed by Burks (1996), with the exception of the number of sites sampled. Sampling was conducted from June 1999 through February 2000 at approximately the same six locations on Lake Kemp as Wilde's previous study in 1997. Compared with the 1997 results of Wilde (1999), concentrations of TDS, calcium, potassium, sodium, chloride, and sulfate increased in Lake Kemp in 1999 – 2000 as shown in Table 3-16. Except for potassium, which was present in low concentrations, the increase in concentrations from 1997 to 1999 - 2000 ranged from 6 to 19%. The increase between studies is probably due, at least in part, to low runoff into Lake Kemp in 1999 - 2000 (Wilde 2000). As a result of reduced inflows into Lake Kemp during 1999 - 2000, the overflow, observed in 1997 and indicated by low conductivity waters, did not develop in 1999.

TABLE 3-16
LAKE KEMP WATER QUALITY, 1997 TO 1999-2000

Parameter	1997 Concentrations (mg/l)	1999-2000 Concentrations (mg/l)	Percent Change (rounded)
TDS	2,781	3,131	13
Calcium	250	297	16
Potassium	8.1	12.0	32
Sodium	635	675	6
Chloride	1,021	1,170	13
Sulfate	791	867	9

Source: Wilde 1999, 2000

Wilde (1999) suggested that several lines of evidence indicated that chloride concentrations in Lake Kemp had decreased since the mid-1980s, but that the available evidence was not conclusive because variation in sampling and analytical protocols and seasonal and inflow (dilution) related variation in chloride concentrations might account for some of the observed temporal differences in chloride concentrations. Results of the present study, showing a lake-wide increase in chloride concentrations between 1997 and 1999-2000, further complicate any attempt to determine whether chloride concentrations in Lake Kemp have decreased since operation of the Bateman chloride control facility began in 1986. Monitoring of the lake would continue assessing the actual impact of chloride control.

3. <u>Water Quantity and Use.</u> Lake Kemp currently is utilized for the following purposes:

- Irrigation – 80,000 acre-feet per year
- Municipal – 0 acre-feet per year
- Industrial – 10,000 acre-feet per year
- Recreation – 5,850 acre-feet per year
- Dundee Fish Hatchery – 2,200 acre-feet per year

Drought contingency plans are based on water usage from the lake. These plans were developed as a result of State Senate Bill 1. The drought contingency plan created action levels that required reductions in water usage at specific elevations. The action levels included in the drought contingency plan are shown in Figure 3-3.

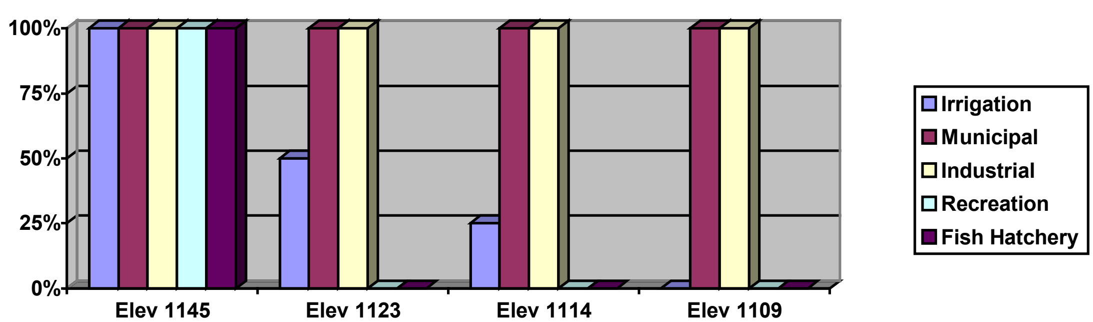

FIGURE 3-4
DROUGHT CONTINGENCY PLAN CONDITIONS

Data from the USACE 2000 Annual Report (USACE 2000b) show the long term average inflow for Lake Kemp to be 188,600 acre-feet per year for the period of record from 1924-2000. A review of inflows for Lake Kemp for 1988-2000, the period of record after construction of Area VIII, shows an average annual inflow of 186,952 acre-feet per year. This may indicate that the removal of brine flows from the upper reaches of the basin has had minor effects on inflow into Lake Kemp or may reflect different weather conditions. The difference is less than 1%.

Concern over decreases in Lake Kemp elevations have been voiced by the TPWD, which operates the Dundee Fish Hatchery below Lake Diversion. Lake Diversion is a downstream extension of Lake Kemp. Under the current Drought Contingency Plan, the hatchery below Lake Diversion will not receive water when the Lake Kemp elevation is below elevation 1,123. Under existing conditions and existing conditions with brush control, the lake is above elevation 1,123 almost 100% of the time.

4. Fish Resources of Lake Kemp and Lake Diversion. Lake Kemp was surveyed in 1990-1991, 1992, and 1998 (TPWD 1993, 1999) using gill nets, trap nets, and electroshocking. Fish species collected during each of the surveys is shown in Table 3-17.

TABLE 3-17
FISH SPECIES COLLECTED IN LAKE KEMP DURING FISH SURVEYS IN 1990-1991, 1992, AND 1998

Species	1990-1991	1992	1998
Spotted gar	X		X
Gizzard shad	X	X	X
Common carp	X	X	X
River carpsucker	X	X	X
Smallmouth buffalo	X	X	X
Blue catfish		X	X
Channel catfish	X	X	X
Flathead catfish	X	X	
White bass	X	X	X
Striped bass	X	X	X
Redbreast sunfish		X	X
Green sunfish	X	X	X
Warmouth	X	X	
Bluegill	X	X	X
Longear sunfish	X	X	X
Spotted bass	X	X	X
Largemouth bass	X	X	X
White crappie	X	X	X
Logperch		X	
Freshwater drum	X	X	X
Total Number of Species	17	19	17

Source: TPWD 1993, 1999

As would be expected with a large main stem reservoir, the overall fish population was composed of sportfish species (e.g., catfish, bass, crappie, etc.), forage species (e.g., shad, bluegill, etc.), and non-game fish species (e.g., gar, carp, suckers, etc.). Species composition was quite similar between the three years with a total of 20 species being collected the first year and 17 species the second year and 19 species the third year. Sixteen of the 20 species were collected in all three years. The TPWD (1999) reported on the results of the 1998 survey and provided the following general information:

- Forage fish were abundant and consisted primarily of gizzard shad and bluegill that could be highly utilized by most sport fish. Due to their small size, bluegills are a valuable forage species, but they provide an insignificant sport fishery.
- Catch rates for blue and channel catfish were both low in 1998 and could have been attributable to colder water temperatures during the survey period. From a historical perspective, the catfish populations in the lake remain stable and continue to provide recreation for catfish anglers.
- The striped bass population in Lake Kemp remains strong with a large number of individuals just below the legal size (18 inches) for harvest. The high number of individuals just below the minimum size limit suggests that many of the fish are being harvested soon after they reach 18 inches and that an excellent sport fishery will be maintained as these fish grow into harvestable size. Growth rates of striped bass remained slow and this suggests that the forage base in the lake is controlling growth. In response to this concern, threadfin shad were stocked in Lake Kemp in 1999 (TPWD 1999).
- White bass catch rates have decreased over the last four fish surveys. It is possible that the relatively large striped bass population is adversely affecting the white bass population in Lake Kemp.
- The catch rate of spotted bass in 1998 was much higher than in previous years and was at least partially due to a more powerful electroshocker. The majority of the spotted bass collected was less than 12 inches in size and none were over 14 inches in size. Spotted bass are not highly sought or valued by Lake Kemp anglers (TPWD 1999).
- Although the catch rate of largemouth bass was substantially higher in 1998 than in previous years (at least partially attributable to a more powerful electroshocker), the catch rate was still less than the historical average of lakes in the district. Most of the largemouth bass collected were young-of-the-year fish. Overall, the lake does not provide a high quality sport fishery for largemouth bass.
- The white crappie population remained stable, but is not an exceptionally strong population. Reproduction and recruitment appear to be adequate to maintain the existing sport fishery.

Fish species that have been collected in Lake Diversion in recent years (1997 and 2000-2001) using gill nets, trap nets, and electroshocking are shown in Table 3-18 (TPWD 1998, 2001a). As shown, the species composition in both years was quite similar, with 19 and 22 species being collected in 1997 and 2000-2001, respectively. Similar to Lake Kemp, the fish population is comprised of sportfish species (e.g., catfish, bass, crappie, etc.), forage species (e.g., shad, bluegill, etc.), and non-game species (e.g., gar, carp, suckers, etc.). TPWD (1998) provided the following comments regarding the lake's fishery (primarily sport fishery):

- The catch rate for forage species was below historical average catch rates for the district, but forage species was higher in 1997 than in previous years.
- The abundance of forage fish in the lake appears to be adequate to support the existing sport fishery as all sportfish were in good body condition and growth rates were within acceptable levels (TPWD 1998).

- Lake Diversion continues to provide a good sport fishery for blue and channel catfish. Blue catfish numbers in recent surveys have increased while channel catfish numbers have decreased.
- Striped bass are not directly managed in Lake Diversion, but a population exists in the lake due to downstream movement of individuals from Lake Kemp. Striped bass provide a bonus fish for anglers in Lake Kemp. White bass catch rates in the lake in 1997 were less than the catch rate for striped bass.
- The catch rate of largemouth bass in 1997 was higher than previous years and was attributed to a strong young-of-the-year class in the lake in 1997. Overall, the lake does not provide a high quality largemouth bass fishery.
- The 1997 sample reflected a well-balanced white crappie population including abundant numbers of young-of-the-year and juveniles and adequate numbers of harvestable sized adults. Reproduction and recruitment appeared to be adequate to maintain the existing sport fishery.
- A few (i.e., 10) walleye were collected during the 2000-2001 fish survey, and the presence of these individuals indicates some level of success of the walleye fingerling stocking program that was initiated on Lake Kemp after the 1997 fish survey. Over the 3-year period (1998-2000), the Texas Parks and Game Department stocked in excess of 280,000 walleye fingerlings in Lake Diversion (TPWD 2001a).

TABLE 3-18
FISH SPECIES COLLECTED IN LAKE DIVERSION DURING FISH SURVEYS IN 1997 AND 2000-2001

Species	1997	2000-2001
Spotted gar	X	X
Longnose gar	X	X
Shortnose gar	X	X
Gizzard shad	X	X
Threadfin shad		X
Common carp	X	
River carpsucker	X	X
Smallmouth buffalo	X	X
Blue catfish	X	X
Channel catfish	X	X
Flathead catfish		X
White bass	X	X
Striped bass	X	X
Green sunfish		X
Warmouth	X	X
Orangespotted sunfish	X	X
Bluegill	X	X
Longear sunfish	X	X
Spotted bass	X	X
Largemouth bass	X	X
White crappie	X	X
Walleye		X
Freshwater drum	X	X
Total Number of Species	19	22

Source: TPWD 1998, 2001a

5. Dundee State Fish Hatchery. Information on the Dundee State Fish Hatchery has been developed from the TPWD (2001b) website. The Dundee State Fish Hatchery was built in 1927. It originally consisted of 44 ponds (32.9 surface acres of water) which included a fish holding house. In 1978, the hatchery was expanded to 91 ponds (78.3 surface acres of water). A new spawning building was added to the facility in 1986 and is used mainly for the spawning of striped bass brood fish. In September 1993, construction was completed on 73 new "state-of-the-art" ponds with polypropylene membrane liners and improved water, electrical, and air supplies. With the new ponds, the Dundee Hatchery has a total of 97 ponds, with 73 lined ponds totaling 59.5 surface acres of water and 24 earthen ponds totaling 23 surface acres of water.

In recent years, the hatchery has been significantly impacted by blooms of a toxic alga which has entered the hatchery system. The golden alga, *Prymnesium parvum*, is a flagellated yellow-green alga of the class Prymnesiophyceae, is a common component of marine phytoplankton, and is typically associated with estuaries. This toxic alga has been associated with numerous fish kills in many parts of the world and was first documented as the cause of fish kills in Texas in 1985. The TPWD have reported approximately 20 fish kills attributed to *P. parvum* since 1985. Estimated fish mortality ranges from 20-30 million individuals since 1985. Currently the range of *P. parvum* has extended into the Pecos, Colorado, Brazos, and Red River systems. Lake Diversion supplies the source water and is the site of the TPWD's Dundee Fish hatchery, which supplies considerable quantities of striped and largemouth bass to stock the states lakes and rivers. In 2001, a *P. parvum* bloom at the hatchery caused the death of the entire year's production of striped bass and most of the brood stock of largemouth bass in the hatchery (TPWD 2001c).

This facility is currently the largest Texas state hatchery in operation. The Dundee State Fish Hatchery produces 25 to 30 million fish annually, including northern largemouth bass, smallmouth bass, channel catfish, white crappie, walleye, sunfish, striped bass, hybrid striped bass, rainbow trout, and yellow perch. Forage fish are also produced for the largemouth bass, and smallmouth bass programs throughout the state. Specific data on hatchery production includes.

- The Dundee Hatchery produces millions of striped bass (*Morone saxatilis*) and hybrid striped bass (*Morone saxatilis x Morone chrysops*) fingerlings annually for stocking into Texas waters. In addition to fingerling production, fry are produced to be utilized in trades with other states. The hatchery produces almost 100% of striped bass for stocking in Texas lakes.
- Koi carp are raised at the Dundee Hatchery for the sole purpose of forage for the state hatchery systems' black bass brood fish. The Dundee Hatchery produces approximately 6 million koi fingerlings yearly for the black bass program statewide.
- The Dundee Hatchery keeps approximately 1,500 adult smallmouth bass brood fish on the hatchery year round. The Dundee Hatchery annually produces between 500,000 and 1 million smallmouth fingerlings.
- The Dundee Hatchery produces approximately 100,000 eight-inch channel catfish for the urban fisheries program each year. Dundee also produces 13,000 one-pound channel catfish annually for the statewide Kidfish program.
- The Dundee Hatchery normally distributes 37,500 rainbow trout during December, January, February, and March.

6. Lake Kemp/Lake Diversion Recreation. Lake Kemp and Lake Diversion are privately owned lakes with limited fee-based public access. These lakes are located in Texas Planning Region 3 (North Texas) which is composed of 11 counties totaling 9,460 square miles. The population was 224,366 in 2000. In 1990, Region 3 was listed as having a total of 40,808 acres

of recreation land, 2,839 acres of developed recreation land, and 57,092 surface acres of lakes. The region has 170 acres of recreation land per thousand people, which falls slightly below the statewide average of 209 acres per thousand people. Projected additional outdoor recreation facilities needed in Region 3 include boat ramp lanes, camp sites, hiking trails, horseback riding trails, off-road vehicle areas, playgrounds, team sports facilities, and multi-use trails.

The W.T. Waggoner Estate (Waggoner Ranch) owns the land surrounding Lake Kemp and Lake Diversion and leases property around both lakes for cabins and temporary structures. Visitors use Lake Kemp and Lake Diversion primarily in the spring and summer months for recreational activities, including boating, fishing, swimming, primitive camping, and other water-based activities. Lake Kemp has six public boat ramps with three entrance points, Pony Creek, Moonshine, and Flippen Creek. Only one of these ramps is accessible during drought conditions. Lake Kemp does not have a marina or access to boat fuel or fishing supplies. Lake Diversion has one public boat ramp and a small marina that has fishing supplies but no watercraft fuel.

According to Waggoner Ranch representatives, during the spring and summer months it is estimated that an average of 100 people visit Lake Kemp per day and an average of 10 people visit Lake Diversion per day. During 2000, Lake Kemp had approximately 16,000 visitors. During the cooler fall and winter months, an average of 25 people visit Lake Kemp per weekend day and 3 people visit Lake Diversion per weekend day, while fewer people visit on weekdays. Visitors pay a fee for access to the lake area, which is limited to paying users.

f. Lake Texoma. With its dam located at river mile 725.9 on the Red River between Oklahoma and Texas, Lake Texoma is an 89,000 surface-acre impoundment. Completed in 1944 by the USACE, the lake occupies portions of both south-central Oklahoma and north-central Texas. At normal pool elevation, 617.0 feet, maximum depth is 112 feet and mean depth is approximately 30 feet . Lake Texoma drains an area of approximately 39,719 square miles, with 5,936 square miles non-contributing, most of which is pasture and cropland.

The lake was constructed for flood control, regulation of Red River flows, improvement of navigation and hydroelectric power. Water supply, and recreation were added later as project purposes. Based on a 1985 sediment resurvey, the conservation pool is projected to contain 1,114,909 acre-feet of storage in 2044. The conservation storage pool includes 150,000 acre-feet of water supply storage (150.0 mgd yield). Section 838(a) of the Water Resources Development Act of 1986 (Public Law 99-662) authorizes the Secretary of the Army to reallocate an additional 300,000 acre-feet of hydropower storage to water supply, allowing up to 150,000 acre-feet each for Oklahoma and Texas municipal, industrial, and agricultural water users.

Lake Texoma is a major resource for recreational activities and potable water to residents in the surrounding areas of Texas and Oklahoma. Because of its resource importance, Lake Texoma, more than any of the water bodies in this study, has been thoroughly investigated by many parties over many years. This section summarizes research that has been completed for the lake.

1. Water Quality. General water quality is characterized by moderate to high levels of salinity with a predominance of sodium and calcium salts of chloride and sulfate (Leifeste *et al.* 1971). Chloride and sodium are the most abundant ions in Lake Texoma. From historical data the lake has been classified as mesotrophic based on chlorophyll *a* concentrations (Ground and Groeger 1994). Based on chlorophyll *a* concentrations for the Main Lake Zone (near dam) from Atkinson *et al.* (1999) during the summer months trophic status ranged from mesotrophic to hypereutrophic with a mean trophic classification of slightly eutrophic.

In a report by Atkinson *et al.* (1996), selected water quality data from Lake Texoma were reviewed to provide background information in developing a water quality monitoring program for Lake Texoma. Historical data relating to chloride and sulfate concentrations throughout the lake defined four zones; the Upper Red River Arm (lotic zone), the Red River Transition Zone, the Main Body (lacustrine zone), and the Washita Arm (lotic zone). It was hypothesized that a Washita River Transition zone existed, however, monthly data from Stanford and Zimmerman (1978), Stanford *et al.* (1977), Perry *et al.* (1979), and Atkinson *et al.* (1999) did not delineate such a zone. Stanford and Zimmerman (1978), Stanford *et al.* (1977), Perry *et al.* (1979), and Atkinson *et al.* (1999) all indicate that chloride and sulfate concentrations are highest in the Upper Red River Zone and are more variable than in other zones. The Red River Transition Zone shows decreasing concentrations from west to east and is influenced by loadings from Big Mineral Creek. The Main Lake Zone is relatively homogenous in surface layers in terms of chlorides and sulfates and shows much less variability than the other zones. The Washita River Arm is lowest in its concentration of chlorides and sulfates but shows considerable variability attributable to fluctuating loadings from the Washita River.

Temporal (seasonal) variability of chlorides and sulfates in the four zones appears to be a direct function of discharge from the Red River and the Washita River. Maximum chloride concentrations in the Upper Red River Zone are typically observed during seasons of low discharge (winter and late summer) and minimum chloride concentrations are generally observed following late spring/early fall periods of high discharge. By contrast, chloride loadings were maximal during high discharge periods and lower during low discharge periods. Atkinson *et al.* (1996) determined that the influence of river discharge was most apparent in the zones proximate to each river and less apparent in the Main Lake Body Zone based on historical water quality studies. Stanford and Zimmerman (1978), Stanford *et al.* (1977) Perry *et al.* (1979) found that late spring/early summer periods of high river discharge only occurred in the latter 2 years of their 3-year monitoring period, indicating a considerable degree of inter-annual variability. The degree to which inter-annual variability and river discharge can influence all zones of the lake was observed in the Main Lake Zone in August 1996 when chloride concentrations there were comparable to chloride concentrations in the Red River Zone (423 mg/l and 535 mg/l, respectively) (Atkinson *et al.*, 1999) following a period of increased discharge from the Red River.

Additional studies addressing the spatial and temporal variability of Lake Texoma water quality parameters were examined by contrasting the results of Stanford and Zimmerman (1978), Stanford *et al.* (1977), and Perry *et al.* (1979) to three other studies: Pettitt (1976), USACE (1989), and Matthews and Hill (1988). A comparison of chloride and sulfate data from Pettitt's study conducted December 2-3, 1975, with results of the Stanford *et al.* December 18-20, 1975 study showed similar zonational trends in the lake but consistently higher chloride and sulfate concentrations in early December (Pettitt) versus late December (Stanford *et al.*). This comparison demonstrates the variability that can exist between two sets of data collected in the same month at similar locations.

Comparing water quality results from the USACE study conducted in 1987 through 1989 in the Rock Creek tributary to results from a similar station gathered by from Stanford and Zimmerman (1978), Stanford *et al.* (1977), and Perry *et al.* (1979) showed considerably lower chloride and sulfate concentrations in Rock Creek during the 1987-1989 study versus the 1975-1978 study. However, comparisons between the USACE (1989) study and the Atkinson *et al.* (1999) study indicates that chloride concentrations in Rock Creek have increased slightly in the 1990s, and that sulfate concentrations have increased to levels comparable to those present in the 1970s.

A third study by Matthews and Hill (1988) in the summer of 1982 and 1983 provides insight into the behavior of vertical stratification in Lake Texoma. Comparing results from their study to the 1975-1978 study demonstrated that the deep sample sites showed similar patterns of stratification. Stations in the Main Lake Body developed a relatively stable thermal stratification during early summer months (May-June) of 1976-1978. Thermal stratification did not exhibit a sharp thermocline in the traditional sense but apparently was stable enough to isolate the hypolimnion long enough to develop anoxic conditions. During summer conditions, establishment of a "traditional" thermocline does not appear to occur in the transition zones of either the Red River or the Washita River arms. Instead, a gradual decrease of temperature with depth occurs with surface temperatures of approximately 32 ^{o}Celsius (C) and bottom temperatures around 20 ^{o}C.

A "chemocline" based on dissolved oxygen and pH appears to gradually develop around a depth of 10 meters. Below the "chemocline", dissolved oxygen is low (< 2.0 mg/l) indicating that much of the hypolimnion is relatively anoxic. Vertical stratification of inorganic salts is not as distinctive as that of oxygen and pH. There appeared to be a general increase in specific conductance in the hypolimnion but no distinct zone of demarcation in the Red River arm (Matthews and Hill, 1988). Data from the 1975-1978 study (Stanford and Zimmerman 1978; Stanford *et al.* 1977; and Perry *et al.*1979) indicated that during that period the lake exhibited similar vertical gradients in temperature, dissolved oxygen, and pH, but that vertical gradients of specific conductance were more sporadic with higher values in the epilimnion and lower values in the hypolimnion.

Several factors have been reported to influence the vertical stratification of Lake Texoma. Hubbs *et al.* (1976) reported the presence of a "halocline" in the Red River arm of the lake below which total dissolved solids were found to substantially increase. During periods of stratification, "halocline" development would begin in the old river channel of the Red River in early summer and then move out into the old floodplain during extended periods of "warm, quiet weather" (Hubbs *et al.*, 1976). Matthews and Hill (1988) concluded that although chemical gradients are present in the lake during periods of stratification, these chemical gradients (e.g., salinity) do not contribute to stratification stability to the degree that water temperature does. In contrast, using techniques described by Matthews and Hill (1988), Clyde (unpublished data) evaluated stratification intensity and stability data during two separate study periods (August 1996 - September 1997 and March 1999 - March 2000). Analysis of thermal and salinity density differences across the epilimnion-hypolimnion boundary in the summer of 1997 and 2000 indicated that both thermal and salinity densities contributed equally to stratification stability. Although there was no clear spatial trend in thermal versus salinity stratification stability, a temporal trend was evident and appeared to be correlated with discharge from the Red River.

2. Aquatic Invertebrates. Atkinson *et al.* (1999) analyzed zooplankton samples collected between August 1996 and September 1997. The zooplankton community in Lake Texoma during this study consisted of 72 species within 39 genera. The Rotifera exhibited the largest number of species (44) and the Harpacticoida the smallest number of species (1). Of the remaining crustacean species, the Cladocera exhibited the largest number of species (18) followed by the Cyclopoids (6) and the Calanoids (3). Historically, 28 zooplankton species had been reported from the lake (Crist, 1980). A comparison of the Atkinson *et al.* (1999) study with the Crist (1980) study revealed that the most dramatic change in the zooplankton community was due to the addition of new Cladoceran species. Within the Cladoceran group three new genera were identified (i.e., *Alona, Chydorus¸* and *Leydigia*), as well as new species identifications within the genera *Ceriodaphnia* and *Moina*. Within the genus *Daphnia*, four new species were identified in samples taken from Lake Texoma (i.e., *D. lumholtzi, D. longiremis, D. pulex, D. cawtaba*).

J. Franks (2000) addressed the relationship between zooplankton populations and physical/chemical water characteristics from August 1996 to September 1997. The results of the study indicated that a strong chloride gradient exists within the lake as well as a weaker turbidity gradient. This conclusion has been confirmed by other studies as well (Atkinson *et. al.* 1996). Physical-chemical factors alone were found to explain on average 90% more of the variation in the zooplankton community than seasonal factors. The Red River arm of the lake was found to exhibit the greatest zooplankton density as well as the greatest diversity. This same pattern was reported by Crist (1980). However, the two contributing river systems, including the Red River and Washita River, though varying by an order of magnitude in chloride concentrations, each harbor significant populations of zooplankton which contribute to lake conditions.

Temporal variability in zooplankton abundance followed the typical seasonal pattern represented by a major pulse in the spring (May and June) and a second smaller pulse in the fall (September) as zooplankton populations recovered from the summer die-off. Zooplankton densities, as well as species diversity (i.e., Shannon diversity index), were greatest in the Red River and Washita River arms and generally tended to decrease through the transitional zones and Main Lake Zone. Analysis of community similarity (i.e., Bray-Curtis Similarity Index) between the reservoir zones revealed that within each arm of the lake (i.e., Red River and Washita River), species composition was similar between the river zone and transition zone, and the species composition in the Main Lake Zone was similar to the Red River Transition Zone twice as often as it was similar to the Washita River Zone.

3. <u>Fish Resources of Lake Texoma.</u> A description of fishery resources in Lake Texoma was prepared Wilde, *et al.*, (1996). Lake Texoma provides habitat for at least 73 species of fish (University of Tulsa 1971). Species popular for recreation and fishing include channel, blue, and flathead catfish; white and black crappie; temperate basses such as largemouth, smallmouth, and spotted bass; and true basses including white and striped bass. Gizzard shad, threadfin shad, and inland silversides are important forage species in the lake. Drum, carp, gar, buffalo, and river carpsucker make up the bulk of the non-game fish in the lake. An important tailwater fishery also exists for striped bass and channel, blue, and flathead catfish. The striped bass and smallmouth bass fisheries were developed in Lake Texoma after the initial FES (1976) was prepared for the RRCCP.

Reservoir strain smallmouth bass were stocked in Lake Texoma in 1981, and natural reproduction was confirmed in 1985 (Hysmith 1988). Since that time, populations have been expanding and growth rates have equaled or exceeded most of those reported in the literature (Gilliland and Horton 1989).

Striped bass were initially stocked in Lake Texoma by the ODWC from 1965 until 1974 (Harper and Namminga 1986) and have successfully spawned annually since 1973 (Mauck 1991). Since the initial stocking, the striped bass fishery in Lake Texoma has developed into an extremely popular fishery and is considered one of the most successful striped bass fisheries in the nation (U.S. Fish and Wildlife Service 1989). Mauck (1991) estimated that from 1987 through 1990, the annual harvest of striped bass ranged from 630,000 to 930,000. The abundance and size of the striped bass has varied between specific years in response to strength of year classes and availability of forage species.

Striped bass are known to spawn in both the Washita and Red rivers and in the Red River striped bass have been caught near Spanish Fort, Texas which is greater than 30 miles upstream from the I-35 bridge upstream from Lake Texoma. Viable striped bass eggs floating down the Red River have been collected at the I-35 bridge. As discussed previously, under existing conditions, the salinity of the Red River flowing into Lake Texoma exceeds 500 mg/l, 95% of the time and 250 mg/l, 99% of the time. These high salinity concentrations may affect striped bass usage of the Red River.

An economic study and analysis of the value of the Lake Texoma sport fishery indicated that the indirect and direct effect of angler expenditures is $28.1 million, with striped bass fishing accounting for over 60% of the expenditures (Schreiner 1995). This reported maximum value of the fishery represents 0.8% of the income of the seven-county region and indicates that angler expenditures associated with the Lake Texoma sport fishery have an insignificant effect on the region's overall economy.

Vertical stratification in Lake Texoma is well documented (Schorr *et al.* 1993, Matthews and Hill 1988, and Hubbs *et al.* 1976). Stratification has a negative impact on freshwater species, especially striped bass. Striped bass have narrow tolerance ranges for dissolved oxygen and temperature. During periods of stratification, striped bass concentrate near the themocline where dissolved oxygen levels are low and this can result in summer die-offs (especially larger fish) due to stress induced by stratification. The ODWC has reported that smaller stripers are not as readily subjected to thermal stress and this tolerance allows them to occupy the shallow upper reaches of the reservoir during the summertime.

4. <u>Recreation</u>. Lake Texoma is located within Texas Planning Region 22 (Texoma). Region 22 is composed of three counties totaling 2,699 square miles, and the population for this region in 2000 was 178,200. According to the 1990 TORP, it has 44,844 acres of recreation land, 6,874 acres of developed recreation areas, and 92,713 surface-acres of water. The TORP lists water resources and developed recreation land as Region 22's most abundant assets. The region ranked the highest in acres per thousand people for the state in 1990. Additional outdoor recreational facilities/resources needed in this region include boat ramp lanes, fishing structures, hiking trails, horseback riding trails, team sport facilities, swimming, tennis courts, and multi-use trails.

Lake Texoma is located within Oklahoma Planning Region 4 (Southern Oklahoma Development Association). This planning region is composed of 10 counties having an area of 4,293,760 acres. The total population in 2000 was 209,569. It has a number of rivers and land recreation opportunities, as well as significant water resources. According to the 1987 Oklahoma Statewide Comprehensive Outdoor Recreation Plan (SCORP), Region 4 has a well-developed recreation base; however, the SCORP identifies needs for tennis courts, golf courses, swimming pools, bicycling and horse riding trails, and additional hunting areas.

Lake Texoma is widely recognized as a top fishing lake, primarily for striped bass, and is one of the most popular recreational destinations in the southwestern United States. Recreational opportunities include camping, fishing, hunting, waterskiing, swimming, jet skiing, hiking, horseback riding, and wildlife watching (USACE 2002).

The USACE manages 54 parks on the lake including 40 miles of equestrian/hiking trails, 15 campgrounds for a total of 800 campsites near the lake, and other water-related activities. Two State Parks, two National Wildlife Refuges, and several local parks are also located on the lake and provide recreational activities (USACE 2002).

Eisenhower State Park, located in Grayson County, Texas on the southern portion of Lake Texoma, provides picnic sites, five camping areas with 165 campsites, restrooms, a recreation hall, a fish-cleaning facility, a boat launching ramp, a courtesy boat dock, a lighted fishing pier, and 4.5 miles of hiking and mountain biking trails. Lake Texoma State Resort Park, located in Marshall County, Oklahoma on the northern portion of Lake Texoma, provides a resort lodge, cottages, three camping areas with 517 campsites, an RV rally group campground, a nature center, an indoor fitness and recreation center, a swimming beach and pool, a miniature golf course, a go-cart track, two 18-hole golf courses, an air strip, and hiking trails.

The Hagerman National Wildlife Refuge, located in Grayson County, Texas, on the southern portion of Lake Texoma, offers fishing, bird watching, hiking, interpretive trails, nature study, and limited hunting of deer, dove, quail, squirrel, rabbit, and feral hogs. The Tishomingo National Wildlife Refuge, located in Johnston County, Oklahoma, on the northern portion of Lake Texoma, offers fishing, bird watching, hiking, nature trails, and limited hunting of waterfowl, deer, dove, rabbit, squirrel, quail, and turkey.

As previously mentioned, Lake Texoma is well known for its sport fishing. Sport fish occupying the lake include largemouth, spotted, and smallmouth bass, white bass, striped bass, walleye, white crappie, black crappie, channel catfish, flathead catfish, blue catfish, bullhead, and sunfish. Approximately 30 fishing guide services are available on the lake that offer a variety of guided trips on the lake.

The 26 marinas and resorts located near the lake offer a variety of recreational activities including RV and tent camping, fishing and fishing supplies, motor boat, sailboat and watercraft rentals, canoe rentals, swimming beaches, tennis courts, horseback riding, restaurants, and hiking trails.

5. Water Supply. As a water supply, Lake Texoma serves north Texas and south-central Oklahoma. The total water supply storage available is about 158,060 acre-feet, with a dependable yield of 150 million gallons per day (mgd). Water supply storage in Texoma Lake is under contract to specified users as shown in Table 3-19.

TABLE 3-19
LAKE TEXOMA WATER SUPPLY ALLOCATIONS

User	Allocated Storage (Acre-Feet)	Yield (mgd)
City of Denison	21,300	20.224
TX Power & Light	16,400	15.564
Red River Valley	2,736	2.597
North Texas MWD	95,023	90.178
Buncombe Creek	1	.001
GTUA for Sherman	11,000	10.433
Not Under Contract	11,600	11.003
Total	158,060	150.0

In 1986, Section 838 of Public Law 99-662 gave the USACE the authority to reallocate an additional 300,000 acre-feet of hydropower storage to water supply. This authority did not preclude all the NEPA, cultural, and socio-economic studies necessary to change storage from one project purpose to another. Of the 300,000 acre-feet, 150,000 acre-feet is for Texas and of that 150,000 acre-feet the Greater Texoma Utility Authority (GTUA) is granted the use of 50,000 acre-feet. The other 150,000 acre-feet is allocated to Oklahoma. In FY 2002, a study was initiated to start the reallocation process of the 300,000 acre-feet of storage.

In 1990, the Lake Texoma Advisory Committee was established by Public Law 100-71. The purpose of the Committee is advisory only and shall provide information and recommendations to the USACE regarding the operations of Lake Texoma for its congressionally authorized purposes.

6. Denison Dam Hydropower. The powerhouse contains two 35,000-kilowatt generators, with provisions for three additional 43,000-kilowatt units. One 20-foot-diameter, steel-lined conduit provides water for each power unit. Each of the power conduits is equipped with two 9- by 19-foot vertical life gates located in the intake structure. The powerhouse and power conduits are located adjacent to the outlet works near the right abutment of Denison Dam.

At full power pool, Lake Texoma has 103.2 feet of water depth available for power production. Section 838(a) of the Water Resources Development Act of 1986 (Public Law 99-662) authorizes the Secretary of the Army to reallocate an additional 300,000 acre-feet of hydropower storage to water supply which could affect the pool volume available for long-term power supply. The lake's current dependable capacity for the hydropower production is rated at 54,000 kW, with an average annual firm energy output of 126,470,000 kW-hrs .

g. Other Recreational Resources.

1. Crowell Mitigation Area/Copper Breaks State Park. The Crowell Mitigation Area encompasses approximately 10,000 acres and is located within Texas Planning Region 3. The mitigation area is immediately south of Copper Breaks State Park, approximately 7 miles north of Crowell, Texas. The State Park includes a small fishing lake, visitor center, campsites, and hiking trails. The lake is used as a warm water fishery during warmer months and is stocked with rainbow trout during winter months to provide a put-and-take trout fishery. The Crowell Mitigation Area would provide additional recreation opportunities including both consumptive and non-consumptive activities. These activities would include fishing, hunting, sightseeing, hiking, and nature photography.

2. Matador Wildlife Management Area. In Cottle County, the TPWD administers the 28,183-acre Matador Wildlife Management Area where public hunting for dove and quail is permitted. On this refuge, the demand for quail hunting is such that a permit drawing system must limit it. Extensive upland game habitat provides the potential for expanded hunting activity, although such expansion would require greater hunter access to private farm and ranch lands or additional public lands being opened to hunting.

3. Texas Planning Region 2. Texas Planning Region 2 (South Plains) is composed of 15 counties totaling 13,605 square miles. The South Fork of the Wichita River is located in Region 2. According to the U.S. Census Bureau, the population for Region 2 in 2000 was 377,871. According to the 1990 TORP, Region 2 ranks well below the statewide average for acres of recreation land per capita. Region 2 has 21,749 acres of recreation land in 211 parks, averaging 53 acres of recreation land per thousand people. This includes a total of 5,803 acres of developed recreation land and 2,673 surface acres of lakes. Projected outdoor recreation facilities/resources needed include freshwater swimming, horseback-riding trails, softball fields, playground areas, campsites, off-road vehicle riding areas, and multi-use trails.

4. Southern Oklahoma Development Association Region 9. Southern Oklahoma Development Association Region 9 is composed of eight counties having an area of 4,648,320 acres. The total population in 2000 was 278,400, with a household population of 101,279. The primary outdoor recreation resource is the Wichita Mountains Wildlife Refuge. Water-based recreational facilities and state parks and recreations areas are limited. The Oklahoma SCORP identified needs in the area for basketball, tennis, golf, swimming, bicycling, hunting and fishing areas, canoeing, and horseback riding facilities.