

BASELINE ECOLOGY REPORT SUPPLEMENT 1:  
NORTH BOSQUE RIVER REGIONAL SURVEY  
for the  
LAKE BOSQUE PROJECT  
BOSQUE COUNTY, TEXAS

Prepared for  
The Brazos River Authority  
Waco, Texas

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## 1.0 Introduction

This document is intended to supplement the Lake Bosque Baseline Ecology Report (TCA, 1985) by providing additional regional information about the North Bosque River. It is to be used as background information for evaluating the potential impacts of the Lake Bosque project on the river reach from the proposed dam site to Lake Waco. In particular, Texas Water Commission (TWC) personnel have requested that this report address those factors affecting the human uses of the river.

This supplement is based on observations made on the North Bosque River during a brief survey 16-17 October, 1987, on observations made during numerous visits to the Bosque River, mostly in the vicinity of the proposed reservoir, and on literature reviewed pursuant to this and other environmental studies. Personnel from the U.S. Fish and Wildlife Service (USFWS) have visited Comanche Crossing, on the North Bosque River between Meridian and the proposed dam site, on three occasions (November, 1985; April, 1986; and April, 1987) to collect field data as input for their instream flow analysis and recommendations. The author assisted USFWS personnel in collecting the survey and hydrological data during all three studies. In April 1987, representatives of the Texas Water Commission (TWC) and Texas Parks and Wildlife Department (TPWD) were also present and assisted survey efforts.

During the October, 1986 survey all public access points between the proposed dam and Lake Waco were visited, limited water quality sampling was performed, and observations were made with regard to channel morphology, substrates, river discharge, aquatic vegetation, invertebrates and human uses of the river. Additional information on the North Bosque River and its surroundings is presented in the Baseline Ecology

Report (TCA, 1985), Baseline Ecology Report Supplement II: Important Species, Baseline Socioeconomic Report (Paul Price Associates, 1987), and Reservoir Operation Studies for Proposed Lake Bosque and Lake Waco Enlargement (HDR Infrastructure Inc., 1987).

## 2.0 Regional Setting

The Bosque River is a major tributary of the Brazos, which it joins at Waco, Texas. The Bosque is dammed a few miles upstream of its confluence, forming Lake Waco. Above this impoundment, the North, Middle and South Bosque Rivers occupy a 1670 mi<sup>2</sup> drainage basin extending about 90 miles to the northwest (USCE, 1982). The three forks of the Bosque River above the headwaters of Lake Waco constitute TWC Segment 1226 (TDWR, 1980). The North Bosque River is the most extensive portion of this Segment, having a drainage area of about 1290 square miles and occupying portions of McLennan, Bosque, Coryell, Hamilton, Somervell, and Erath counties (Figure 2-1; Procter, 1969).

Basin geology and geomorphology is described in Procter (1969), Baylor Geological Society (1966), and in numerous unpublished Baylor University Master's theses. The lowermost reach of the North Bosque, below Valley Mills, is located in the Washita Prairie physiographic region. This is a rolling prairie exhibiting little relief and a vegetational cover primarily of grasslands with scattered stands of oak. Although the soils of the Washita Prairie are considered reasonably fertile, they are used almost exclusively for grazing. The notable exception is the complex of alluvial soils adjacent to the North Bosque River channel that has been extensively developed as crop and improved pasture and is reported to be among the best agricultural land in McLennan county (SCS, 1958).

From the vicinity of Valley Mills to Iredell, the North Bosque River flows through the Lampasas Cut Plain, a region characterized by broad, level to rolling valleys separated by steep sided, flat topped divides. Local relief is much greater than in the Washita Prairie, with elevation

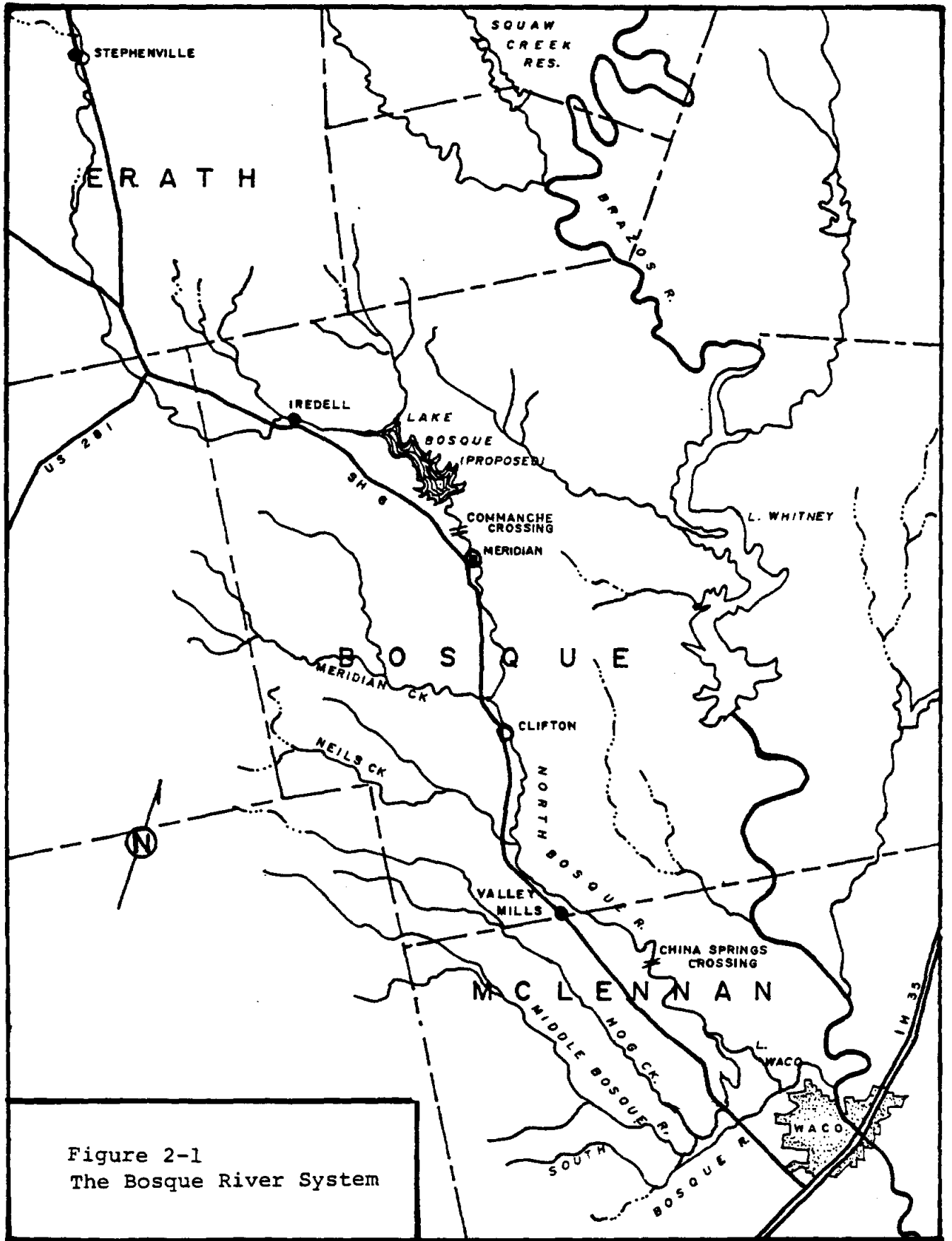


Figure 2-1  
The Bosque River System

differences of 150 to 200 feet between valley floors and divides common. The distinct topography is largely the result of the physical resistance to weathering and hydraulic properties of the Edwards Limestone formation which forms a resistant cap on the tops of the divides. The less resistant Comanche Peak Limestone and Trinity Clay formations, which form (respectively) the steep, upper slopes below the Edwards cap and the lower slopes and valley floors, are eroded much more rapidly than the Edwards producing the characteristic mesa dominated topography. Procter (1969) reports that the Edwards limestone here is a perennial aquifer, exhibiting a "spring line" of seeps and springs at its base that increases erosional activity on the underlying Comanche Peak and Trinity formations and contributes to area streamflow. The Paluxy Sand formation also outcrops in a relatively narrow band along the Bosque River channel in the reach beginning below Iredell and ending upstream of Clifton (see figures 2 and 3 in Procter, 1969).

In the Lampasas Cut Plain, only soils developed on the Trinity Clays and Paluxy Sands are utilized for agricultural activities other than grazing. As in the Washita Prairie, the most intense agricultural activity is concentrated along the river, resulting in nearly complete deforestation of the valley floor, with only riparian strips of woodland remaining. Here too, the bottomland soils are easily cultivated since even adjacent to the river channel they are only occasionally flooded (SCS, 1980). The characteristic land use, vegetation, habitats and faunal communities of the reservoir site are extensively discussed in TCA, 1985 and Paul Price Associates 1987.

Above Iredell (and the proposed reservoir site) the remainder of the North Bosque basin lies in the Paluxy Cross Timbers and Glen Rose Prairie physiographic regions. These are regions of lesser relief and greater aridity, constituting the edge of



the western grasslands. The Glen Rose formation begins to outcrop in the river channel in the vicinity of Iredell, above all but the extreme upper reach of the reservoir. This formation is known in particular for the dinosaur tracks that have been found at numerous outcrop locations from Glen Rose to Uvalde (EH&A, 1983).

### 3.0 The North Bosque River

The baseline Ecology Report (TCA, 1985) discusses in some detail the physical characteristics, hydrology, water quality, habitats, and biota of the North Bosque River reach between Iredell and Meridian. In general, the river all the way to Lake Waco appears much the same as it does in the lower portion of the proposed reservoir site. The channel is usually 75 to 150 feet wide, incised into an alluvial floodplain in which it is free to meander, typically with steep to vertical banks up to about 30 feet in height and bordered with a narrow strip of woodland. Except for these wooded strips, land adjacent to the river is almost exclusively cultivated (SCS, 1980).

#### 3.1 Morphometry

The river tends to exhibit a characteristic pool-riffle sequence throughout the survey reach that consists of elongated pools, commonly 200 to 1000 yards, or more, in length, often occupying the full width of the bed, that terminate in short boulder/cobble/gravel riffles (Figures 3-1, 3-2). These reaches alternate with those in which bed elevation appears to drop sharply in a series of short boulder/cobble riffles and deeper runs over gravel/cobble substrates as a narrow channel meandering among an extended reach of gravel bars. These reaches are either channel segments having large accumulations of sediments, commonly occurring below tributary confluences or are areas of increased stream gradient, often marked by acute channel bends. An example is shown in Figure 3-1 (Station 3 in the proposed reservoir site; TCA, 1985) and others occur in the reaches below the riffle shown in Figure 3-3 and below the mouth of Meridian Creek. More generally, runs are observed as the shallow upper ends of pools and as such may or may not



Figure 3-1. Riffle-pool sequences on the North Bosque River: within the proposed reservoir site (above) and at Clifton (below), 16 October 1986.



Figure 3-2. Deeper pools in the vicinity of Valley Mills.  
16 October 1986.



Figure 3-3. Ledge outcrop (above) and boulder riffle (below) in the high gradient reach between Meridian and Clifton.

exhibit perceptible flow at a given discharge or vary considerably in extent with changes in water level.

Pools terminate in riffles that are usually quite short (less than 50 yards) regardless of their composition. Ledge outcrops and boulder riffles occur occasionally, as in Figure 3-3, but riffles having gravel/cobble substrates are more common, particularly below Clifton, and these too can be relatively steep. For example, the riffle at Comanche Crossing (Station 1 in the Baseline Ecology Survey; Figures 3-4 through 3-7) drops nearly two feet in about 50 yards. Comanche Crossing can be considered a major riffle, since that drop occurs in a river reach having an average gradient of only about 5.5 feet/mile (Proctor, 1969; TCA, 1985). If we assume all changes in stream bed elevation occur in riffles, and that all riffles have the same gradient, we would expect about 150 yards/mile (8.5% of channel length) of riffle habitat in the low gradient reaches.

Figure 3 in Proctor (1969) is a longitudinal profile of the North Bosque River showing the geological formations traversed and their effect on stream gradient. This figure shows that except for two relatively short reaches (one between Meridian and Clifton and another just above Lake Waco), the river exhibits a relatively uniform, gentle gradient similar to that in the reservoir reach throughout its lower segment. This strongly indicates that the channel morphology and associated habitat types described for the lower portion of the reservoir reach (TCA, 1985) are also typical of the river all the way to Lake Waco, assuming that substrates and water quality are also similar. That it is, in fact, the case was confirmed by the observations made during the October, 1986 survey. Channel bottom substrates are overwhelmingly gravels throughout the survey reach, although pool bottoms may contain sand and silt deposits and boulders and slabs are present as local outcrops in numerous locations. There also appears to be a tendency



Figure 3-4. Comanche Crossing. 18 November 1987,  
Discharge 8.14 cfs.



Figure 3-5. Comanche Crossing. 29 April 1986,  
Discharge 1.7 cfs.



View of river rapids, near the mouth of the river, near the mouth of the river, near the mouth of the river.



View of river rapids, near the mouth of the river, near the mouth of the river, near the mouth of the river.



for average particle size to decrease in a downstream direction, including an apparent lack of slab and boulder riffles below Clifton. They are, however expected to occur in the downstream high gradient reach just above Lake Waco where the river channel cuts into the Edwards Limestone.

A portion of the higher gradient reach was examined during the October survey. That reach differs from other locations on the North Bosque in several ways. The pools tend to be shorter (less than 300 yards), the riffles are more frequent, and outcropping limestone ledges visibly control the occurrence of riffles. The riffle-run morphology was quantified by recording the lengths of successive pools and riffles in an approximately 1400 yard reach. Pools were generally less than 200 yards in length, but riffles were also shorter, ranging from single falls over ledges (Figure 3-3), through cobble/gravel runs up to 30 yards in length. Riffles are estimated to account for about 20% of channel length in the reach examined.

### 3.2 Hydrology

Hydrologic characteristics of the North Bosque River are discussed at length in the Baseline Ecology Report (ICA, 1985). During the field survey, river discharge recorded at Clifton was about 40 cubic feet per second (cfs), according to the U.S. Geological Survey (USGS, pers. comm.). This discharge is twice the median annual flow, and is equaled or exceeded, on the average, about one third of the time (eg, about 135 days per year). Median flow, or discharge, is the flow at which one half the daily flows are greater and one half are less. That is, on the average the daily average discharges at Clifton will exceed 20 cfs for 182.5 days per year and be less than 20 cfs for the remainder. The average discharge for the period of record (1927-1984) is about 187 cfs. That the median discharge is only 10.7% of the average

is a reflection of the statistical effect of infrequent, large flood flows and a rough indicator of the great variation in discharge regularly experienced at a given channel location.

The effect of discharge on Bosque River habitats is illustrated by the series of photographs in Figures 3-4 through 3-7. This series depicts a single location, Comanche Crossing, for which there is an extensive and varied data set, over a period of 17 months as discharge varied over two orders of magnitude. This location is about 15 miles upstream of Clifton and the confluence of Meridian Creek, a large perennial stream. Although this location encompasses about 80% of the drainage area above Clifton, the median annual flow here is about 11-12 cfs, based on the entire (1927-1984) period of record.

In November, 1985, at a very low flow of 0.14 cfs, the large riffle in the foreground (Figure 3-4) was nearly dry, the wetted channel only 2-3 feet wide. However, the shallow run (upper end of a pool) below the riffle was extensively inundated even at that low flow. The following April (Figure 3-5), at a discharge of 1.7 cfs, substantial inundation of the riffle area is evident (wetted channel 10-25 feet wide) and the run downstream inundates essentially the entire stream bed. The debris and the extensive vegetation visible in Figure 3-5 is the result of a low flow period of about eight months.

Figure 3-6 was taken during the October 1986 survey discussed in this report at a discharge of 20-30 cfs. The wetted area in the riffle was only a little wider than during the previous April but water depth and current velocity were both substantially greater. The run downstream was completely inundated to a maximum depth of about two feet. The channel had also been thoroughly scoured of debris and vegetation by flows high enough to rearrange the gravel bars and cause

noticeable bank erosion. The final figure (3-7) shows almost complete riffle inundation at a discharge of about 40 cfs in April, 1987. The upper end of the run was scoured to a depth of about 3 feet but downstream areas were generally only 1 to two feet deep. During this period, the pool that extends upstream of the riffle did not appear to perceptibly change in size, except in October, 1984 following several months of zero discharge.

Figure 3-8 shows the present relation between discharge at the proposed dam site and that at Clifton, the two curves being plots of median discharge, by month, at those locations. The proposed Lake Posque will generally reduce Clifton low flow discharges (less than median flows) by only one half to one fourth in the absence of any release program. (HDR Infrastructure Inc., 1987). Impacts due to changes in the low flow regime in the North Bosque River below Clifton are expected to be insignificant because of the degree of flow recovery. This situation is possible because of the large base flows available from the perennial tributaries, Meridian Creek and Neils Creek, whose drainage basins include significant areas of Edwards Limestone, and the broad, deep valley alluvium and Paluxy Sands that begin to be present below Iredell. Higher discharges are more dependant on runoff from the upper North Bosque basin and are expected to be more affected by reservoir operation..

### 3.3 Water Quality and Biology

Table 3-1 summarizes the water quality measurements made during the October, 1986 survey. These appear to be consistent with other water quality data available for the North Bosque River and Lake Waco (TCA, 1985; TDWR, 1980; TPWD, 1974; 1975; 1976).

Figure 3-8 Median Discharges, by Month

1975-1985 data set

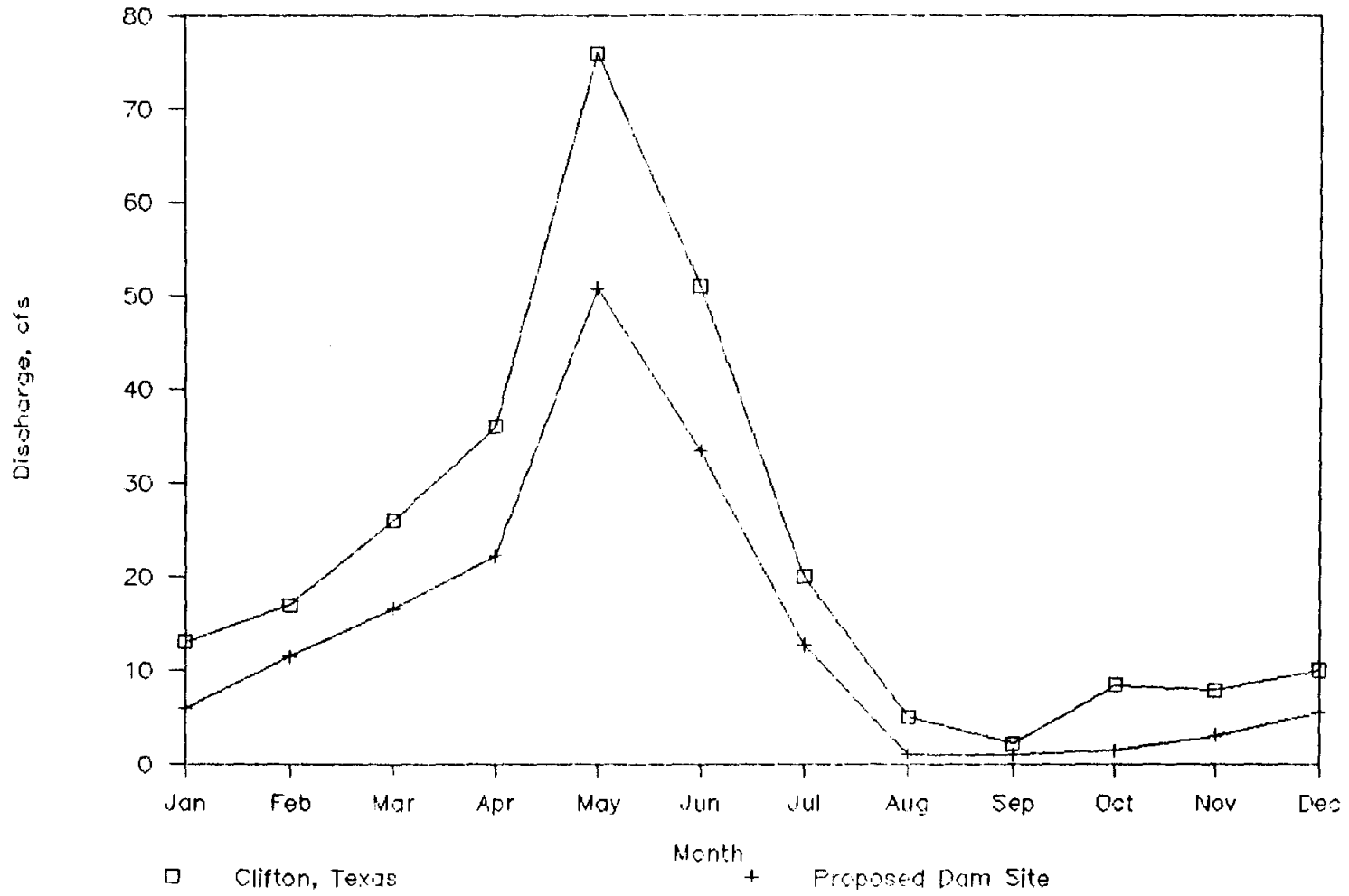


Table 3-1  
 Water Quality Data Collected 17 October 1986 from the  
 North Bosque River.

Location:	Comanche Crossing	Clifton	Valley Mills	China Springs Crossing
Time	1230	1630	1730	1900
Discharge (cfs)*	31.8	51.6	**	60.8
Temperature (C)	18.0	20.0	**	20.0
Oxygen (mg/l)	11.1	12.0	**	10.2
Conductivity (umho/cm)	455	475	**	490
pH	8.0	8.4	**	8.4
NH <sub>4</sub> -N (mg/l)	<0.03	<0.03	<0.03	<0.03
NO <sub>3</sub> -N (mg/l)	0.41	0.28	0.47	0.49
Kjeldahl N (total, mg/l)	2.21	0.88	0.83	0.46
Phosphorus P (total, mg/l)	0.19	0.06	0.1	0.21

\* Instantaneous flow measured in field; daily average flow from Clifton USGS Gage for 15, 16, 17 October: 54, 44, and 39 cfs, respectively.

\*\* Data not collected

Although dissolved oxygen (D.O.) depletion is not a general problem in the North Bosque River, it is in Lake Waco where an aeration system is operated to destratify and oxygenate the water in order to minimize potable water treatment costs. An intensive monitoring survey (TDWR, 1980) identified only the reach below Stephenville as a problem due to organic loading from the city's sewage discharge.

Data for Segment 1226 from 1 January 1980 through 1 January 1987 was obtained from the Texas Water Commission. Dissolved oxygen concentrations were consistently above 5.0 mg/l except in the few samples from stations below Stephenville.

Dissolved oxygen concentrations commonly exhibited 4-5 mg/l excursions in diel samples collected in October, 1983 throughout the North Bosque River.

Ammonia ( $\text{NH}_3\text{-N}$ ) was not detectable in about half of all measurements throughout the North Bosque River. The remaining values varied up to slightly above 0.5 mg/l, with most below 0.30 mg/l. Sixty-nine percent of all nitrate ( $\text{NO}_3\text{-N}$ ) measurements in the North Bosque River ( $n=113$ ) fell in the range 0.1 to 1.0 mg/l, with a further 26% falling below 0.1 mg/l. Chlorophyll a concentrations exceeded 0.02 mg/l in eight of 46 measurements (17.4%) throughout the North Bosque River..

Considering only Station 1226.0100, located just upstream of Clifton, during the period 1980 through 1983 33 to 82% of yearly total phosphorus (T-P) measurements were in the range 0.02-0.049 mg/l. Beginning in January, 1984, 54 to 75% of yearly T-P values exceeded 0.05 mg/l. Nearly all total phosphorus samples collected at China Springs Crossing October 1983 through November 1986 had concentrations in excess of 0.1 mg/l. Other locations on the North Bosque River, sampled 18 October 1983, also had high values but the two stations below Stephenville showed T-P concentrations of 1.59 and 4.40 mg/l.

Detectable levels of chlordane, DDT and its degradation products, phthalates and mercury are reported for a minority of sediment and tissue samples from Station 1226.0100. None of these materials were detected in North Bosque River water samples.

The water quality information, together with observations of consistently large filamentous algal biomass, dominance of the benthic invertebrate assemblage by detrital- and filter-feeding Collectors (Merritt and Cummins, 1978), and the conspicuous lack of significant numbers of forms such as

darters, psephenids, riffle beetles and hellgrammites is believed to indicate the North Bosque is substantially enriched, probably by a combination of agricultural runoff and domestic wastewater.

Considering the water quality and biological observations, and the experience of Lake Waco, it is likely that the proposed Lake Bosque will also exhibit hypolimnetic D.O. depletion during summer stratification. Impoundment of North Bosque water in Lake Bosque can be expected to result in improvements in downstream water quality to the extent that nutrients and dissolved organic materials are removed during detention.

Nearly all the species known to inhabit the North Bosque River are capable of survival and reproduction in a reservoir habitat. They are presently resident in and adapted to a river that experiences low (and zero) flows such that aquatic habitat consists only of isolated pools. Population sizes, particularly of large organisms like fish, are very likely limited by these periodic minima in physical habitat.

#### 4.0 Human Use of the North Bosque River

Direct uses of the river appear to be limited to disposal of municipal wastewater, recreation, primarily fishing, and agricultural uses such as stock watering. Treated wastewater is presently discharged into the North Bosque River at Meridian, Clifton and Valley Mills. If segment standards are not being violated during naturally occurring low flow periods, they are not likely to be violated as a result of operation of the proposed reservoir, particularly as waste treatment facilities are upgraded by better operation, or with construction of new facilities in response to public demand and regulatory requirement. Meridian, where flow reductions as a result of Lake Bosque operations will be most pronounced, recently completed construction of a new wastewater treatment plant.

Recreational use of the North Bosque River is sharply limited by access. There is no public access to the river within the reservoir site. Between the proposed dam site and Lake Waco there are six public access points. Two, Comanche Crossing and China Springs Crossing, are unimproved fords and a third (above Valley Mills) is a county bridge crossing where it appears that private property must be crossed to reach the stream bed. The remaining three public access locations are in the three riverside communities. Although public parkland is located adjacent to the river in these communities, little or no provision for river access or recreation has been made.

Recreational use of the river is also limited by channel morphology. Where pools occupy the entire width of the river bed a boat may be required, but getting one in and out can be difficult. Boating is also limited by the shallow riffles that punctuate the stream. In May 1985 it was necessary to drag an unloaded canoe through the riffles between the proposed dam site and Comanche Crossing. This was during a



period when the USGS reports that discharge at Clifton was 44 cfs. China Springs Crossing could be traversed without crossing water more than a foot deep in October 1986 when discharge was about 60 cfs.

Local fishermen and TPWD personnel report that fishermen (and women) most often fish for channel and yellow catfish using trotlines and simple poles. Bass and crappie are also sought, often incidentally to catfishing, and rough fish such as buffalo, carp and gar, are sometimes fished for. While Lake Waco supports a substantial fishery for white bass (*Morone chrysops*), this species is not believed to run upstream even as far as China Springs Crossing, and no other strongly migratory fish is known from the Bosque River. None of the species fished for, nor the assemblage reported in TCA, 1985, would experience substantial adverse impacts as a result of construction and operation of Lake Bosque.

## 5.0 Literature cited

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BASELINE ECOLOGY REPORT  
SUPPLEMENT II: IMPORTANT SPECIES  
for the  
LAKE BOSQUE PROJECT  
BOSQUE COUNTY, TEXAS

Prepared for  
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## 1.0 Introduction

Ecological baseline studies of the Lake Bosque project area were conducted during 1984 and 1985 (Technical Consulting Associates 1985). This supplemental report updates and elaborates on information regarding important species that occur, or potentially occur, in the project area.

Important species are defined as those which (a) are commercially or recreationally valuable, (b) are threatened or endangered, (c) affect the well-being of some important species within criteria (a) or (b), or (d) are critical to the structure and function of the ecological system.

## 2.0 Recreationally or Commercially Valuable Species

### 2.1 Vegetation

Commercially important tree species in the Lake Bosque project area include ash juniper (*Juniperus ashei*) and hardwoods including cedar elm (*Ulmus crassifolia*), green ash (*Fraxinus americana*), pecan (*Carya illinoensis*), Shumard red oak (*Quercus shumardii*), plateau live oak (*Q. fusiformis*), and others, which may be used for fence posts or firewood. In addition, pecans may be sold for profit or used for personal consumption. The regional diversity in soils and range sites leads to wide variations in the density and relative importance of tree species.

Both native and improved forage grasses and row crops are also of commercial importance as livestock feed and for profit from sales. Common and coastal bermuda grass (*Cynodon dactylon*), King Ranch bluestem (*Eothenochloa ischaemum* var. *songaricus*), and Kleingrass (*Paspalum coloratum*) are most important in the area's extensive improved pastures. Common and coastal bermuda grass and Johnson grass (*Sorghum halepense*) are the most important species in the hayfields, which are largely limited to bottomland areas. In addition, commercially important row crops such as oat (*Avena fatua*), sorghum (*Sorghum bicolor*), and wheat (*Triticum aestivum*) also are restricted to the bottomlands.

Numerous plant species on the site are ecologically important as browse and forage materials for important wildlife species. Examples include various grape species (*Vitis* spp.), cat-brier (*Smilax* spp.), common elderberry (*Sambucus canadensis*), numerous oak species (*Quercus* spp.), possum-haw (*Ilex decidua*), yaupon (*Ilex vomitoria*), rough-leaf dogwood (*Cornus drummondii*), common buttonbush

(*Cephalanthus occidentalis*), American beautyberry (*Callicarpa americana*), pecan, black hickory (*Carya texana*), black willow (*Salix nigra*), cedar elm, Texas sugarberry (*Celtis laevigata*) southern dewberry (*Rubus trivialis*), poison ivy (*Rhus toxicodendron*), Texas persimmon (*Diospyros texana*), red ash (*Fraxinus pennsylvanica*), and various sedges and grasses. Of particular importance to deer is oak mast (Halls and Ripley 1961, Martin et al. 1961).

## 2.2 Wildlife

Several species of game mammals and birds have geographic ranges that encompass Bosque County. The fact that such species are hunted and/or trapped indicates that they are an economic and recreational resource to the area. The status of each of these species in the region of the Lake Bosque project area is presented below.

Mourning Dove. The mourning dove (*Zenaida macroura*) is considered by many to be the most important game bird in Texas. More hunter-days are spent annually (1,749,856 in 1982-83) in Texas in pursuit of the mourning dove than any other species (TPWD 1985a). The mourning dove is a habitat generalist, and part of its popularity stems from the fact that it is so widely distributed across the state. In fact, Oberholser (1974) states that it "...is the only native Texas bird with written occurrence records in every one of the state's 254 counties...".

Data for the Cross Timbers and Prairies Ecological Region (which encompasses the project area) indicated a 1985 call count average of 19.3 doves heard per route, and a 15-year mean for the 1971-1986 period of 20.6 doves heard/route. These ranked fifth and fourth, respectively, among the ten ecological regions in Texas (TPWD 1987). In terms of birds per three-minute route stop, the 1985 figure for the Cross



Timbers and Prairies Ecological Region was 0.96 compared to 0.75 birds per stop during site-specific call counts of the project area conducted on 29 May 1985 (TCA 1985). Thus, mourning dove populations in the Lake Bosque seem to be typical for the region.

Northern Bobwhite. Like the mourning dove, the northern bobwhite (*Colinus virginianus*) is a very popular game bird in Texas. This species is most common in grasslands with scattered brush and along grassy fence rows. Diet of the bobwhite varies somewhat depending on such factors as season and range conditions (Campbell-Kissock et al. 1985), though important foods include the seeds of plants such as doveweed, ragweed, and sumac (*Rhus* spp.), leaves and fruits of plants, and insects (Martin et al. 1961).

The Cross Timbers and Prairies Ecological Region supported 0.53 quail per one mile interval in 1984 (TPWD 1985a). This was well below the 1976-1984 average of 0.91 birds per station, but still ranked second out of eight ecological areas in Texas which support populations of this species (TPWD 1985b). The results of the May 1985 survey of the project area showed a count of 1.05 birds per call count stop (TCA 1985). The single TPWD sampling route located in Bosque County showed a 1976-1984 average of 0.60 birds per interval in August when singing activity is likely to be lower (TPWD 1985a).

Wild Turkey. The wild turkey (*Meleagris gallopavo*) inhabits woodlands in the Cross Timbers and Prairies Ecological Region, where it roosts in large trees and nests on the ground. Food habits vary in relation to such factors as reproductive condition of females and food availability. Oak mast (*Quercus* sp.), sumac and hackberry are common plant foods according to Martin et al. (1961); however, during the breeding season, females consume increased quantities of

snails and insects. Bottomland forests seem to provide the most attractive habitat for the wild turkey, although other habitats are utilized.

TPWD (1985b) reported an estimated post-hunting season turkey population of 1872 in Bosque County in 1985. This was 15th of the 25 counties in the Cross Timbers and Prairies Region and only 21.8% as much as the high county count in the Cross Timbers (8583 in Brown County). Two gobbler count sites (31° 58' N, 97° 50' W and 32° 00' N, 97° 50' W) used by TPWD in 1983 were located near the upper end of the project area. Results from these sites yielded 6.00 and 8.50 birds per count and 5.00 and 4.67 poults per count, respectively (TPWD 1984). In 1984, TPWD did not report figures for these sites, but the average number of birds per count for sampling sites in Bosque County (N = 10) was 10.7 (TPWD 1985b).

Waterfowl. Many species of waterfowl winter in or migrate through the Cross Timbers and Prairies Ecological Region. Approximately 19.9% of the total 1984-1985 Texas duck harvest was within the north-central reporting zone which includes the project area (TPWD 1986a). However, goose populations in this region are minimal (TPWD 1986a).

Waterfowl prefer bodies of water with abundant aquatic vegetation on which to feed. Green-winged teal (*Anas crecca*), mallard (*Anas platyrhynchos*), pintail (*Anas acuta*), lesser Scaup (*Aythya affinis*), and other species may be found in these areas while enroute to more favorable wintering grounds in Mexico and along the Texas Gulf Coast. The 1984-85 TPWD statewide midwinter waterfowl survey indicated the most common overwintering species in north central Texas to be the mallard (118,600 birds), pintail (8,800), American wigeon (*Anas americana*) (8,900), scaup (4,100), and ringneck (2,400) (TPWD 1986a). The wood duck

(*Aix sponsa*) is a potential nesting species in the region; other occasional nesters include the blue-winged teal (*Anas discors*) and mallard (Oberholser 1974).

Figures indicated that the most commonly harvested species in the North Central reporting region were the wood duck, mallard, gadwall, and green-winged teal (TPWD 1986a). No county specific figures for waterfowl were given in the TPWD reports; however, the project area did not appear to provide much habitat for these species. Farm ponds and the Bosque River are the primary areas where these species might be found.

White-tailed Deer. The white-tailed deer (*Odocoileus virginianus*) is the most important big game mammal in Texas. The Cross Timbers and Prairies supported approximately 7.8% (287,308) of the state's deer population in 1985, ranking fifth among 10 ecological areas (TPWD 1986b). Deer densities averaged one deer per 23.5 acres for the Cross Timbers and Prairies Ecological Region (1986b). Based on sampling in 6269 of 533,339 acres of deer range, TPWD (1986b) estimated a deer population in Bosque County of one deer per 11.1 acres. A nighttime spotlight survey of the Lake Bosque project area revealed 0.63 deer per km (TCA 1985). Many general observations of deer in the project area were in the bottomland woodlands; however, the species was widespread at various upland sites as well.

Rabbits. Large populations of eastern cottontail (*Sylvilagus floridanus*) and black-tailed jack rabbits (*Lepus californicus*) are present in the Cross Timbers and Prairies. The 1981-1984 average number of cottontails observed per 32-km route in the Cross Timbers and Prairies was 5.8 rabbits per route, which was first of all ecological regions in Texas (TPWD 1985b). Nineteen eighty-four was a low year at 2.0 cottontails per route, but was still the highest in

Texas that year (TPWD 1985b). Jack rabbits were detected at an average rate of 1.1 per route during 1981-1984, tied for third of ecological regions in Texas. The statewide high for this species, 7.9 per route, was on the Edwards Plateau. Cottontails and jack rabbits feed almost entirely on vegetation. In north central Texas, the leaves and green pods of mesquite (*Prosopis* spp.), various grasses and forbs, and the bark and twigs of shrubs comprise the bulk of their diet (Davis 1974). Competition between these two species is minimal because the black-tailed jack rabbit prefers sparsely vegetated areas such as overgrazed pastures, while the cottontail frequents brushland and marginal areas. Good habitat for both species existed in the Lake Bosque project area at the time of the baseline studies. The spotlight survey of the project area indicated 0.15 jack rabbits per km.

Furbearers. In addition to the game species discussed above, the range of several furbearers include Bosque County. Population index values (TPWD 1986c) for the Cross Timbers and Prairies Ecological Area indicate that in 1984, the following species were most common (in decreasing order): northern raccoon, skunks (species combined), Virginia opossum, ringtail (*Bassariscus astutus*), gray fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), and bobcat. Habitat for all of these species was present in the project area, and northern raccoon, Virginia opossum, gray fox, and bobcat were all observed during the surveys. County specific harvest figures for bobcat showed a 1984-1985 harvest of 40 males and 24 females in Bosque County (TPWD 1985d). Signs of the beaver were also observed during reconnaissance of the Lake Bosque project area.

### 3.0 Endangered, Threatened and Protected Nongame Species

#### 3.1 Endangered and Threatened Plants

No threatened or endangered plant species of federal concern have been recorded from Bosque County or adjacent counties (USFWS 1986). Also, no plants of concern to either the Texas Department of Parks and Wildlife (Potter 1986) or Texas Organization for Endangered Species (1984) are known to exist in these counties.

#### 3.2 Endangered and Threatened Wildlife Species

Twelve species of endangered, threatened or protected nongame wildlife species listed by the U. S. Fish and Wildlife Service (USFWS 1986) or the Texas Parks and Wildlife Department (TPWD 1977) potentially occur in Bosque County (Potter, 1986a; Landgowski, 1986; USFWS, 1984). These species and their status as determined by each organization are discussed in the following paragraphs. While the geographic range of these species encompasses the project area, the actual likelihood that they occur on the site or that suitable habitat is even present, varies depending on the biological requirements of each individual species. Thus, the following discussion is presented in order to give more realistic view of the value of the project area to these species of concern.

##### 3.2.1 Federally Listed Species

Five species considered endangered or threatened by the U. S. Fish and Wildlife Service potentially occur in Bosque County. These are the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), whooping crane (*Grus americana*), piping plover (*Charadrius melodus*) interior least tern (*Sterna albifrons athalassos*)

and the black-capped vireo (*Vireo atricapilla*) which is currently proposed by USFWS for listing as endangered and is thus protected (Hoffman 1986). Aspects of the biology of these species and the potential value of the project area to them are discussed below.

Bald Eagle. The bald eagle is one of the largest birds of prey in North America and is considered endangered in Texas by both the USFWS and TPWD. The preferred habitat of the species can be described as large bodies of relatively clear water with nearby wooded areas containing tall trees (Oberholser 1974). Fish compose 50-90% of the bald eagle's diet, the balance of which consists of ducks, coots, other birds, rabbits, rodents, and carrion (Reilly 1968, Oberholser 1974).

Bald eagle breeding is mostly limited to the northern United States and to Canada; however, nesting occurs rarely at scattered localities in east Texas and at a number of sites on the central and upper Texas coastal plain (Johnsgard 1979, USFWS 1984) Oberholser (1974) reported a breeding record for McLennan County which borders Bosque County to the southeast. No nesting attempts have been reported for other bordering Texas counties, and the closest county in which recent breeding has been reported is Limestone County to the east (Oberholser 1974, USFWS 1984). Based on these facts alone, it is highly improbable that the bald eagle would nest in the project area even if suitable habitat were present.

The bald eagle has become an increasingly common winter resident at numerous sites with good habitat in Texas and Oklahoma. Large bodies of water throughout Texas (especially in the eastern half) often support from one to several winter resident bald eagles. The author of this section regularly sees from one to a few bald eagles on or

near Tishomingo National Wildlife Refuge adjacent to Lake Texoma, an impoundment of the Red River between Texas and Oklahoma.

The USFWS (1984) lists Bosque County and bordering McLennan County as having wintering areas for the bald eagle, presumably around reservoirs in these counties. Considering this, it seems possible that bald eagles could occasionally pass through the project area and might find some feeding habitat along the Bosque River during periods when the river has low turbidity. However, no sightings have been reported for nearby Meridian State Park which has a small lake that could provide some potential habitat (Pulich 1980).

Peregrine Falcon. The peregrine falcon is a medium to large falconid whose populations were decimated largely due to the effects of environmental pollutants such as DDT (Farrand 1983). One of the two subspecies found in Texas (*Falco peregrinus tundrius*) is considered endangered by both the USFWS and TPWD, while the other subspecies (*F. p. anatum*) is listed as threatened by the USFWS and endangered by TPWD.

The peregrine falcon is a swift raptor which feeds almost exclusively on birds ranging in size from that of small passerines to ducks (Bent 1938). Peregrine falcons occur only as migrants in north Texas (USFWS 1984). During this time almost any area with trees or other perch structures and an adequate supply of prey might be considered potential habitat for this species. Thus, the importance of relatively small acreages considered individually in terms of peregrine falcon value is small.

There is at least one sight record for McLennan County which borders Bosque County to the southeast; however, no records are reported for Bosque County, including Meridian State Park (Oberholser, 1974; Pulich, 1980). The project area

does contain some areas of habitat that could be occupied briefly by migrating peregrine falcons.

Whooping Crane. To the American public, the whooping crane is perhaps the best known of America's endangered species. The species is extremely rare with just over 90 individual birds existing in the traditional wild flock (Johnson 1986). It is listed as endangered by both USFWS and TPWD.

The whooping crane is the tallest native avian inhabitant of Texas where it is a winter resident of shallow wetland habitats of the Aransas National Wildlife Refuge and surrounding areas of the Gulf Coast (Farrand 1983). Oberholser (1974) described the whooping crane as an omnivore that feeds on crabs, shrimp, frogs, crawfish, plant roots and tubers, acorns, and sorghum and other grains.

Portions of north Texas including Bosque County lie within the migratory corridor that whooping cranes follow enroute to their nesting grounds in Wood Buffalo National Park, Canada (Whooping Crane Recovery Team, 1980). However, in Texas, there are no known regular migration stopover points such as are found in certain areas in Nebraska; in fact, there are only a few scattered confirmed ground sightings of whooping cranes anywhere in Texas other than on the wintering grounds on the coast (Whooping Crane Recovery Team, 1980; 1981). None of these are for Bosque County, and the likelihood of the whooping crane using the project area habitats is slim.

Interior Least Tern. The least tern is a miniature member of the family Laridae which includes (among others) the gulls, terns and skimmers. Like other members of the family, the least tern is an excellent flier and is found in association with aquatic habitats and their margins, especially in coastal regions. It feeds by hovering above the water and



then diving for small fish and invertebrates at or near the surface (Oberholser 1974).

Inland breeding populations of the least tern are considered by some to be taxonomically distinct at the subspecific level from the more common coastal breeding populations; however, not all workers agree (Endangered Species Division 1986). The interior form breeds locally in the Missouri Valley along the larger streams from North Dakota south to the Brazos River system of north Texas. Here it nests in pairs or small colonies on river sandbars or sandflats, but is otherwise similar in behavior to the coastal subspecies (Johnsgard, 1979; Oberholser, 1974). Nesting and/or summer occurrence has been confirmed for areas along the Red River between Texas and Oklahoma (Ducey, 1981). During winter the interior least tern ranges from south Texas to Oaxaca, Mexico (Oberholser 1974). Alterations in its preferred riverine habitat due to such activities as reservoir construction and operation have apparently caused a decline in populations. This decline has led to the listing of the interior least tern as endangered by both the USFWS and TPWD.

Oberholser (1974) reported a summer specimen record of the interior least tern from Palo Pinto County (well to the northwest of Bosque County) and unconfirmed summer and breeding records for McLennan County. No sight or specimen records are reported for Bosque County or other bordering counties by Oberholser (1974). Inasmuch as there appears to be little, if any, preferred habitat for the least tern in the project area, it appears unlikely that the species would occur there, except perhaps as an extremely rare migrant.

Black-capped Vireo. The black-capped vireo is an inhabitant of well-drained bushy or thicket covered hills typical of many parts of the Edwards Plateau (Oberholser 1974). The

species has become very rare in parts of its historic range, partly (or perhaps largely) due to the heavy strain of brown-headed cowbird (*Molothrus ater*) nest parasitism (Grybowski, 1986). Oberholser (1974) reports specimen and/or sight records for three counties bordering Bosque County. The species has been reported for Meridian State Park in Bosque County to the south of the Lake Bosque project area (Marshall et al., 1985), but despite having what appeared to be prime habitat, the area did not harbor the species during 1984 and 1985 surveys (Grybowski, 1986; Marshall et al., 1985). The upper slopes of the project area appeared to provide some potential habitat for the black-capped vireo; however, no individuals of the species were seen during the breeding season baseline surveys. Perhaps the high populations of the brown-headed cowbird prevent the occupation of these areas by black-capped vireos.

### 3.2.2 State Listed Species

Seven species in addition to the first five discussed above are listed as either endangered or protected nongame by the TPWD. The following paragraphs present a brief statement of the expected status of each species in the project area.

The Harter's Water Snake (*Nerodia harteri*) is listed as endangered by the TPWD. Potter (1986a) lists the species as "confirmed" in Bosque County. The Harter's water snake is a riverine species limited in distribution to the upper Concho and Colorado rivers (*N. h. paucimaculata*) and the upper Brazos River drainage (*N. h. harteri*). The former subspecies is listed as a "Category 1" species by USFWS (1985) and should be proposed for listing in the near future. The latter subspecies is the one that is known from Bosque County. Intensive surveys in its range indicate that it is highly unlikely to be found in the Bosque River (Scott

and Fitzgerald, 1985; Maxwell, 1982). Further, the Brazos River subspecies is not currently believed to be in danger of extinction (USFWS 1985).

The white-faced ibis (*Flegadis chibi*) and the wood stork (*Mycteria americana*) are threatened avian species that do not breed in or near Bosque county (in the United States the latter nests only in Florida); however, both species often exhibit a postnesting wandering period during which they may occur very irregularly at inland locations (Oberholser, 1974). Based on past records of occurrence in north Texas, their presumed ranges include Bosque County. Potter (1986a) lists the wood stork as "probable" and the white-faced ibis as "confirmed" for the county.

The golden-cheeked warbler (*Dendroica chrysoparia*) is a state-listed threatened species that is endemic to central Texas where it nests in very old juniper (*Juniperus* spp.) woodlands (Pulich, 1976). This warbler species is also under review as a "Category 2" species by USFWS. With regard to Bosque County, Pulich (1976; 1980) reported a population in Meridian State Park, and he thought it probable that potential habitat might occur in upland cedar brake areas in other parts of Bosque County. Surveys of the project area did not reveal habitat that appeared likely to provide nesting habitat for the golden-cheeked warbler. Potter (1986a) lists the bird as being "confirmed" for Bosque County due to its known occurrence in Meridian State Park.

The American swallow-tailed kite (*Elanoides forficatus*) is currently considered threatened by TPWD, and is under review by USFWS as a "Category 2" species (further biological research needed to evaluate its status). The species is associated with wetland woodlands and associated native prairie type habitats and is not expected to nest in Bosque

County, nor are there any sight or specimen records for Bosque County. Based on the presumed potential migration range, TPWD lists the kite as "possible" for Bosque County.

The Texas horned lizard (*Phrynosoma cornutum*) has been recorded from Bosque County and is listed as "confirmed" for the county by TPWD. Individuals of this species have been observed in the northeastern portion of the project area on the arid upland terraces overlooking the alluvial valley floor. These sites are located at or above the conservation pool elevation (830 feet MSL), but individuals of this species may occur within the reservoir site, although none were collected with the 19 species of reptiles identified during the 1984-85 baseline ecology survey.

The Timber Rattlesnake (*Crotalus horridus*) is listed by TPWD as "confirmed" for Bosque County. A southeastern species typically inhabiting heavy cover, it has been reported from riparian environments on the Trinity and Brazos Rivers as far west as Bosque and McLennan Counties. None were observed on the reservoir site during either the Ecology or the Cultural Resources surveys.

#### 4.0 Other Important Species

Species that can be considered critical to the well being of an endangered or commercially important species (see Section 1.0) include the abundant forest and grassland species used as forage or cover that are discussed in Section 2.1. Although sole or nearly sole dependence of one species on another is very rare among those species abundant enough to be useful to humans, major changes in the abundance of forage or cover vegetation would be expected to affect area carrying capacity to at least some extent. Conversion of forest to grassland is an obvious example that has extensive effects on resident populations but generally not because of single species interactions. The more abundant species tend to be resilient in the face of environmental change because they tend to have broad food and cover requirements.

Rare species, whether officially endangered or not, may not have the characteristics outlined above. For example, the golden-cheeked warbler is absolutely dependant on the presence of mature stands of large *Juniperus ashei*. The cedar is therefore an important species without which the bird cannot survive (and does not on the proposed reservoir site). None of the other endangered species discussed for Bosque County appear to exhibit this type of dependence, although it is not uncommon.

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