CHAPTER 3.0
EXISTING ENVIRONMENT

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3.1 Study Area

The existing environment is described for the study area defined as the lower Colorado River watershed from O.H. Ivie Reservoir downstream through the Highland Lakes to the mouth of the river at Matagorda Bay. The lower Colorado River basin encompasses about 18,300 square miles of contributing drainage area. The total length of the lower Colorado River studied for this project is 482 miles. The lower portion of the basin contains several major tributaries to the Colorado River, most notably the Llano River, Pedernales River, San Saba River, Pecan Bayou, Sandy Creek, and Onion Creek.

For organizational purposes, some of the following sections will discuss the project in its entirety. As additional detail is required to discuss the environment of the study area, sections are sub-divided to more accurately address the different areas covered by the study. These subsections include the Highland Lakes Reach, Central Reach, and Coastal Reach (Figure 3-1). The Highland Lakes Reach extends from Longhorn Dam at the lower end of Town Lake upstream to the dam at O.H. Ivie Reservoir. The Central Reach extends from Longhorn Dam downstream to the Colorado County boundary. The Coastal Reach includes the portion of the basin from the upstream Colorado County boundary to the mouth of the Colorado River, including the eastern portion of west Matagorda Bay and its shoreline marshes, and the Matagorda peninsula and its marshes.

The only major metropolitan area in the lower Colorado River basin is the COA. Other cities along the mainstem of the river include Bastrop, Bay City, Columbus, LaGrange, Marble Falls, Smithville, and Wharton.

3.2 Existing Resources

3.2.1 Land Use

The distribution of level 1 land use / land cover (LU/LC) types is illustrated in Figure 3-2 (Anderson et al 1976). There are 6 LU/LC types in the lower Colorado River basin including Agricultural Land (23%), Barren Land (1%), Forest Land (46%), Rangeland (26%), Urban (2%), and Wetlands (<1%). LU/LC types classified as Agricultural Lands are predominant in the Blackland Prairies and Gulf Coast Prairies and Marshes regions of the lower Colorado River basin and common in the Rolling Plains region. Agricultural Lands include areas used primarily for production of food and fiber. Barren Lands are primarily represented by mines, quarries and gravel pits and are

predominantly found in central Brown County, around Lake LBJ and Lake Travis, and near the main channel of the lower Colorado River in Travis, Bastrop, and Colorado counties. Forest Lands are the predominant LU/LC type throughout the Edwards Plateau region of the lower Colorado River basin and are also found in the Oak Woods and Prairies, Blackland Prairies, and Gulf Coast Prairies and Marshes regions. Forest Lands include areas with a tree-crown aerial density of 10% or more and can be divided into three sub-levels within the lower Colorado River basin. Evergreen Forest Land occupies much of the southern half of the Edwards Plateau and an area of Colorado County north of the river. Mixed Forest Land covers much of the northern half of the Edwards Plateau region, is scattered throughout Bastrop County, and is found south of the river in Colorado County and along the river in Wharton County. Range Land is predominant in the Llano Uplift and is common throughout the Rolling Plains and Oak Woods and Prairies regions. This LU/LC type is represented by lands where the potential natural vegetation is predominantly grasses, grass-like plants, forbs, or shrubs and where fire and natural herbivory was an important influence prior to civilization. The majority of Range Land in the lower Colorado River basin is classified as Shrub and Brush Rangeland, but Herbaceous Rangeland can be found scattered throughout. Urban Lands and Wetlands comprise the last two LU/LC types in the lower Colorado River basin. The major urban areas of the basin include Marble Falls, Austin, Bastrop, Smithville, LaGrange, Columbus, and Wharton. Wetlands include forested and non-forested wetlands and these are concentrated along the Colorado River and its tributaries and along the coast as marsh.

3.2.2 Socioeconomic Setting

Primary Economic Activities. The Texas Comptroller of Public Accounts (TCPA) is the controlling authority of the state economy, audits accounts, and supervises financial affairs of Texas. TCPA has developed an economic model that divides the state's 254 counties into 13 regions based on similarity in socioeconomic indicators. The current study encompasses 34 counties in 7 different TCPA economic regions (Figure 3-3). Information provided by the TCPA (TCPA 2002) on a county and regional basis has been used to create a baseline of socioeconomic indicators summarized below and presented in detail as Appendix 2.

Employment in each of ten employment sectors is presented geographically as a percent of county employment in Figure 3-4. While agricultural (28.1%), forest (18.2%), and rangeland (48.1%) account for 94.4 % of land use within the Colorado River Watershed (USACE 2003b), employment in agricultural services, forestry, and fishing industries account for only 4% of all employment. These

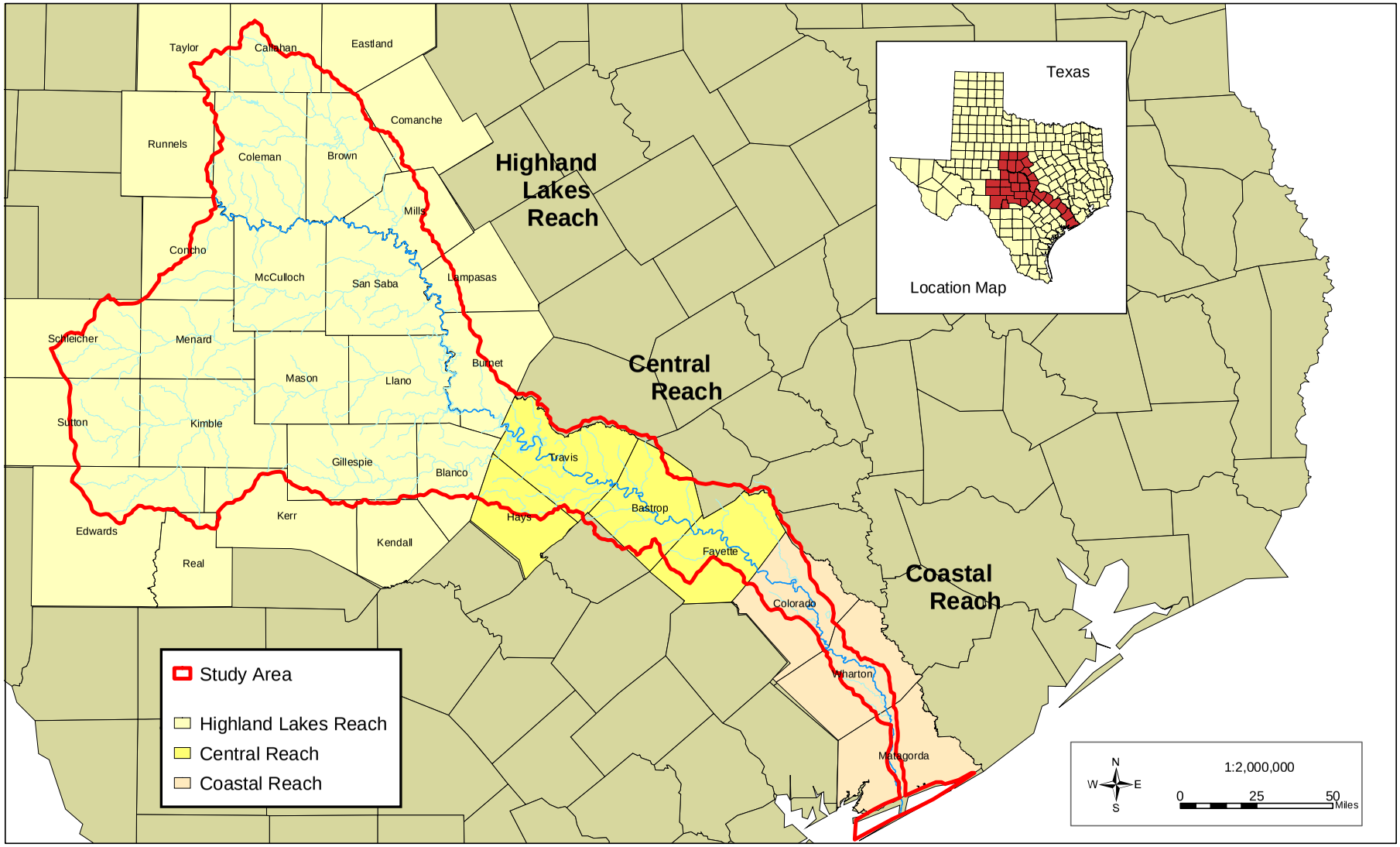

Figure 3-1: Lower Colorado River Basin Study Area

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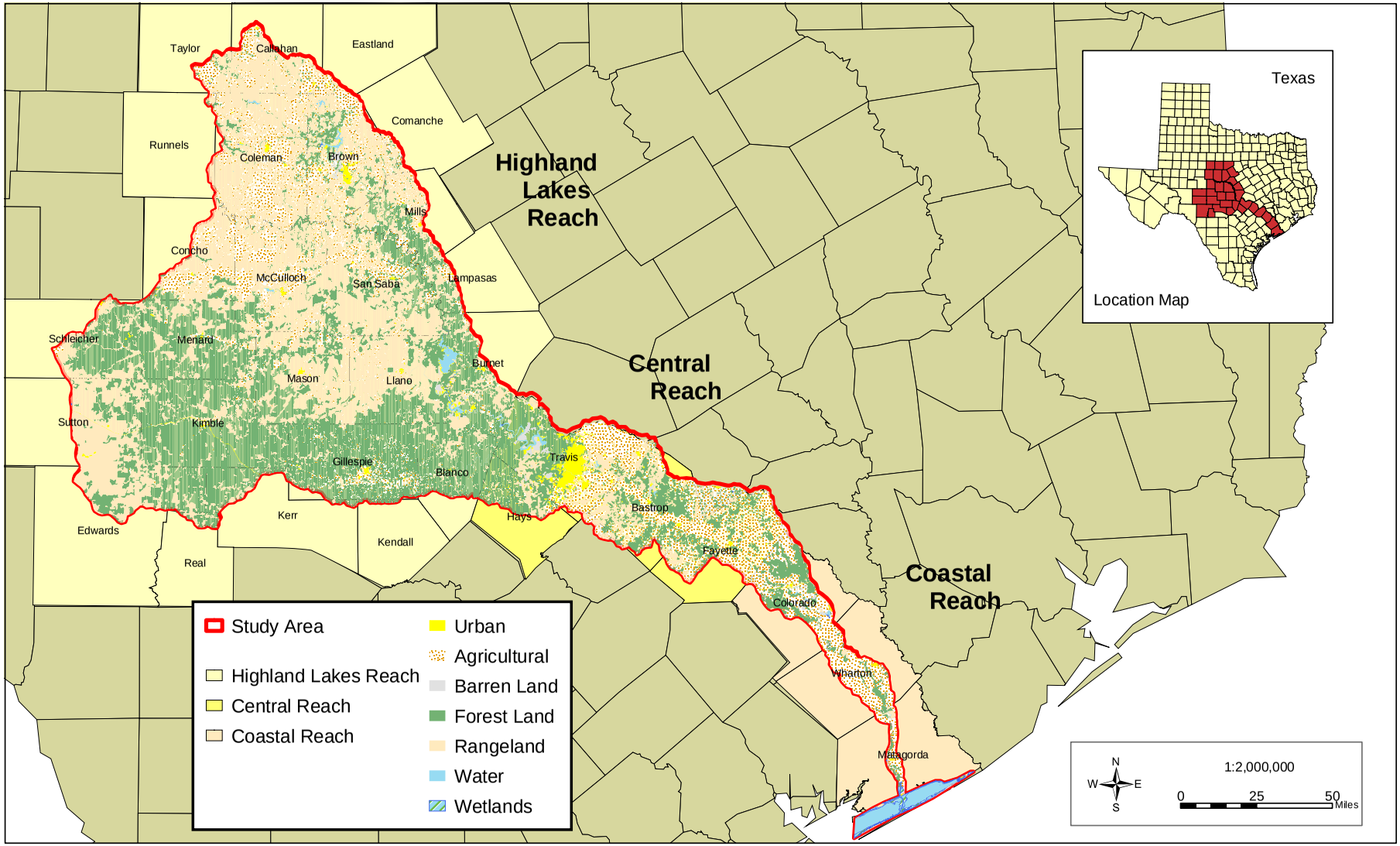

Figure 3-2: Land Use for the Lower Colorado River Basin

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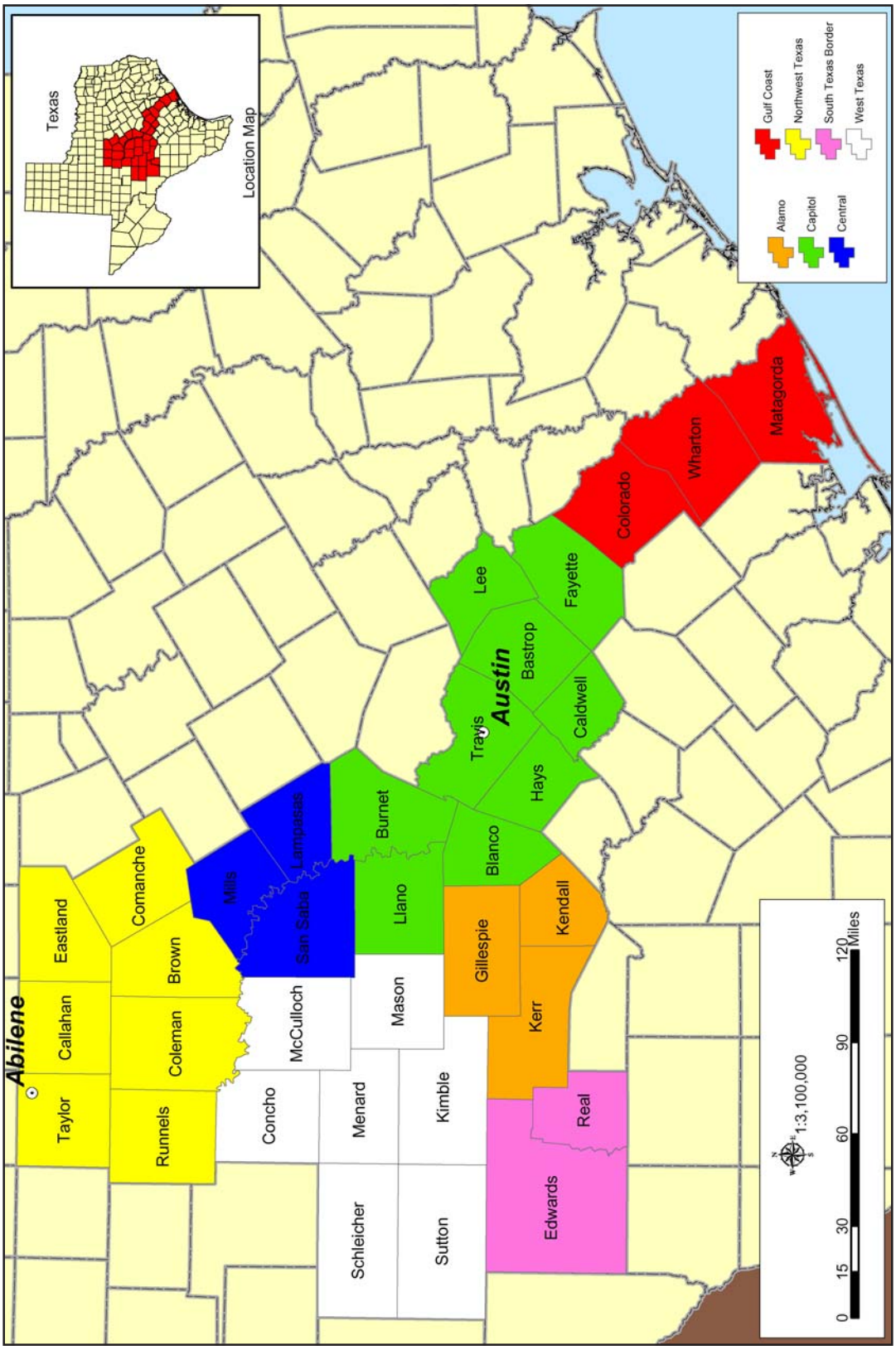

Figure 3-3 Texas Comptroller of Public Accounts Economic Regions

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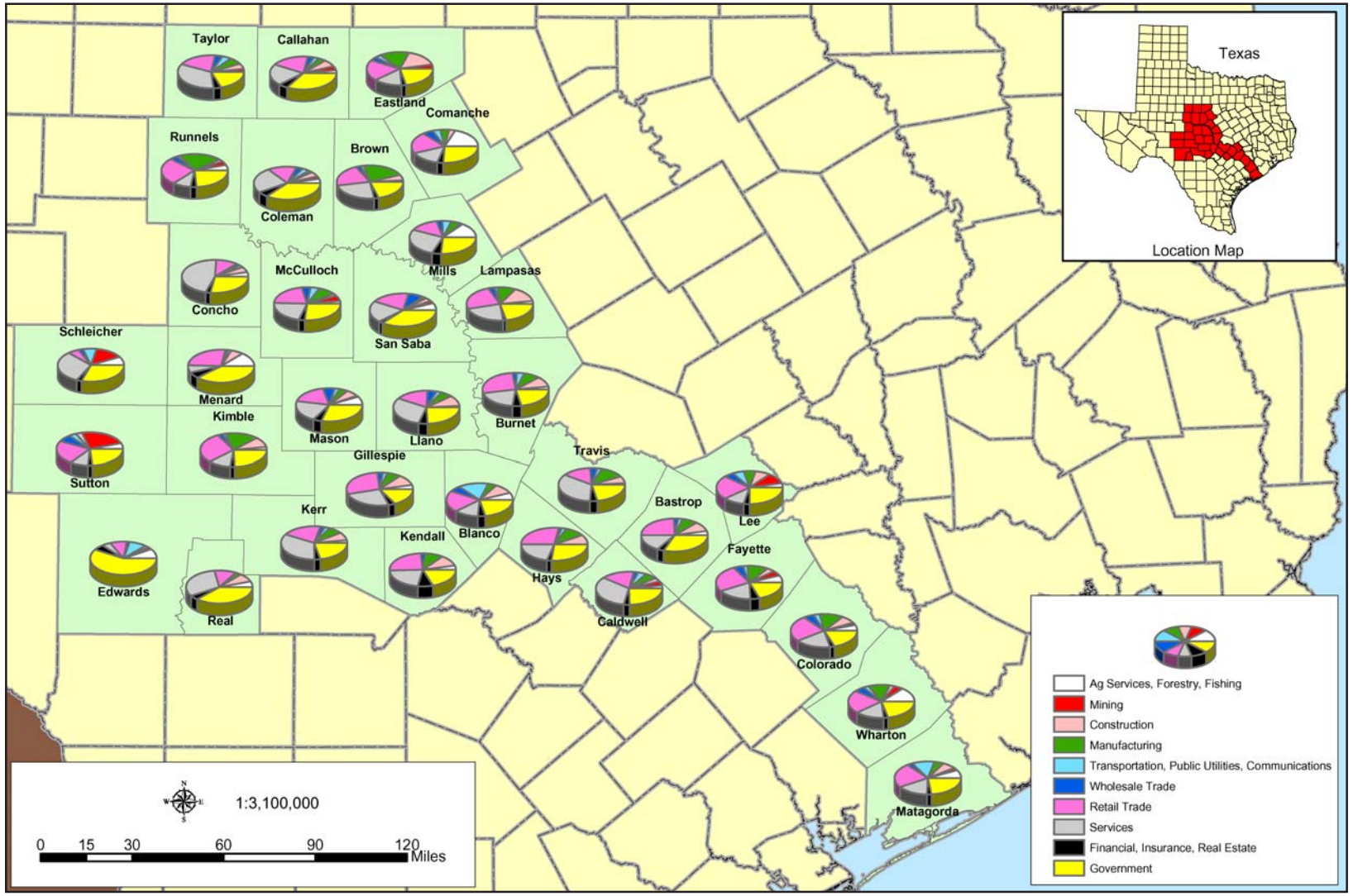

Figure 3-4 Employment Sectors

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industries are strongest in the Coastal Reach, where the majority of the land area is used for grazing with rangeland being more common to the west and improved pastureland more common along the coast, especially north of the Colorado River. Twenty-five to 50% of land in the Coastal Reach is used for cropland, with rice cultivation accounting for 30% of that use. Cotton, sorghum, corn, and soybeans are also common crops. These industries are also stronger than average in Comanche, Mills, and San Saba counties. Agricultural production in these counties is well balanced between farming and ranching. Cattle as well as sheep and goats constitute the majority of ranching operations while pecans, small grains and peanuts account for the majority of farming. A growing industry in these counties is recreational leasing for hunting and fishing. Finally, these industries are also important in the western extremity of the study area. The arid climate of Mason, Menard, Schleicher, Sutton, Edwards, and Real counties is suited to sheep and goat ranching and the area is a leading producer of wool and mohair in the state.

The mining industry accounts for only 3% of employment in the lower Colorado River basin. However, Schleicher and Sutton counties rely heavily upon the industry with 25.6% and 15.3% employment respectively. Revenues from the mining industry in these counties come primarily from oil and gas although dolomite, limestone, and industrial sand are also important. Lee County is also a strong producer of oil and gas within the mining industry accounting for 9.1% of employment.

Construction was the 5th largest employer in the lower Colorado River basin for 2001 and employment in the industry is evenly distributed throughout the region. This follows a statewide trend of industry growth over the last 20 years. In response to real growth in the high tech industry, construction in the state grew at an average annual rate of 10.7% from 1991 to 2000. Within the study area, only Eastland (16%) and Lampasas (12.6%) were significantly above the 8% regional average.

Employment in manufacturing has grown for much of the State of Texas over the last 30 years and the industry is the 4th largest employer for counties in the lower Colorado River basin. Individual industries show a considerable degree of geographic concentration. Petrochemicals and refining activity, as well as marine transportation manufacturing, are largely concentrated in counties along the Gulf Coast. In Fayette, Colorado, and Wharton counties manufacturing employment is 6% higher than the average of 8% for counties in the study area. Counties in the Austin metropolitan area, especially Travis and Hays, are the leading computer hardware and software development areas in the state. These two counties are the 1st and 3rd largest employers in the study area accounting for 73% of overall employment. Manufacturing employment holds an average of 11% in

these two counties with strong economies. The manufacturing industry accounts for the largest percent of employment in the northern counties of Eastland, Brown, and Runnels, as well as Kimble County to the southwest, and is highly diversified in these counties.

Employment in transportation, public utilities, and communications averages 5% in the counties of the lower Colorado River basin. Schleicher, Edwards, Matagorda and Blanco counties are the only counties with higher than average employment in this industry.

Wholesale Trade accounts for only 4% of employment in counties of the lower Colorado River basin. Employment in this industry is highest in the neighboring counties of Llano, Mason, and San Saba where it averages only 7.7%.

Retail trade and services each account for 20% of employment and are fairly evenly distributed throughout counties of the lower Colorado River basin. Goods and services are among the fastest growing industries in the area and this growth reflects increasing wealth throughout the state. Rising income drives increased expenditures on goods and especially on personal services. Leisure and entertainment account for a large portion of the service sector and rising real incomes are behind many of the gains in the entertainment and tourism and personal services industries. Dominated by national trends in income growth and population aging, health care services have also seen significant growth. The western counties of Concho, Schleicher, Edwards and Real have lower than average employment in the retail trade industry, while the service industry falls well behind the average in the western counties of Runnels, Menard, Kimble, Sutton, and Edwards. Financial, insurance, and real estate industries are following a similar growth trend, but account for only 4% of employment in the counties of the lower Colorado River basin.

Government is the largest employer among counties of the lower Colorado River basin with 26% of employment found in this sector alone. Employment in local, state and federal government follows a statewide trend. Growth in local government is driven by local population growth and administrative changes. Important in this regard is shrinking elementary and secondary class sizes, which serve to drive job growth even if the populations were to remain unchanged, which they did not. Growth in state government is driven by increased prison employment and growth at area higher educational institutions.

In 2001, unemployment rates for counties within the lower Colorado River basin averaged 3.5%, falling below the state unemployment rate of 4.9%. Although unemployment rates in the area fell an average of 0.9% from 1996 to 2001, 65% of counties experienced slight job losses from 2000 to 2001. Those counties experiencing job growth in 2001 are primarily found in the northern and

west-central portions of the study area. Unemployment rates in the lower Colorado River basin are highest in counties of TCPA's Northwest Texas, South Texas Border, and Capitol Regions (Figure 3-5). Matagorda County had the 9th highest unemployment rate in the state and the highest in the lower Colorado River basin for 2001.

Population and Income. Information pertaining to population and income for each of the 34 counties in the lower Colorado River basin was gathered from TCPA and the U.S. Census Bureau (U.S. Census Bureau 2004). Population and income figures for counties in which only part of the county lies within the basin boundary were included in all calculations and rankings. This information was used to create a baseline of population and income indicators on a county and regional basis, is summarized below, and is presented in detail as Appendix 2.

In 1970, counties in the lower Colorado River basin accounted for 6.8% of the Texas population and grew slightly, relative to the state population, through 1990. The State of Texas experienced dramatic population growth in the 1990s having an estimated average annual growth rate of 15% from 1990 to 2000. As a whole, counties in the lower Colorado River basin grew at a much slower rate of 2% and by the year 2000 accounted for only 3.8% of the state population. Within the basin, growth over the last 30 years was concentrated in the counties of the Middle Reach, primarily those within the Austin metropolitan area (includes Burnet, Blanco, Kendall) (Figure 3-6). Estimated average annual growth rates for these counties have climbed steadily since 1950, averaging 6.9% from 1970 to 2000 and 7.5% from 1990 to 2000. The majority of growth is attributable to Travis and Hays counties where population numbers have tripled since 1970. Growth rates for counties in the Coastal Reach have been less than 1% since 1970. Population densities in the Coastal reach rose by 4-persons/square mile in the 1970s, but gained less that 1- person/square mile over the next 20 years. The majority of this growth occurred in Matagorda County. Growth rates in the Highland Lakes Reach have averaged 1% annually over the last 30 years with the majority of growth occurring in Taylor, Kerr, Lampasas, and Brown counties.

Growth in Travis County is expected to stabilize over the next thirty years while counties of the middle reach and the surrounding metropolitan area will continue to grow at about half the rate of the last thirty years (Figures 3-7). Population growth in the Coastal Reach is projected to slow to less than 0.2% annually over the next thirty years with the population of Matagorda County growing slightly faster than the other two counties. Counties of the Highland Lakes Reach are expected to experience negative growth, on average, over the next 30 years. However, some growth is expected

in the Abilene area (Taylor, Callahan, Coleman, and Brown counties) and in counties nearer to the Austin metropolitan area (Lampasas, San Saba, Gillespie, and Kerr counties).

Counties with the highest personal incomes were centered around Travis, Taylor, and Kerr counties (Figure 3-8). Travis and Hays counties ranked 5th and 37th in the state and brought in close to $28 and $2 billion respectively. Taylor County ranked 24th in the state and personal income was more than $3 billion. Kerr County ranked 55th in the state and personal income was more than $1 billion. The remaining counties in the Highland Lakes Reach generally ranked in the lower third of the state and personal incomes were less than $200,000. Personal income ranked in the top third of the state for counties in the Coastal Reach totaling over $735 million.

Average per capita income was more evenly distributed among the counties of the lower Colorado River basin, yet followed trends similar to personal income (Figure 3-9). Incomes in the Coastal Reach averaged $22,230, in the Middle Reach and counties surrounding the Austin metropolitan area, incomes averaged $23,744. In the remaining counties of the Highland Lakes Reach, personal income averaged $19,616.

Poverty rates for counties in the lower Colorado River basin ranged from 10 to 28% (Figure 3-10). Counties with the lowest rates were centered around Travis County in the Middle and Highland Lakes reaches. The two counties with the highest poverty rates were Edwards and Real counties.

3.2.3 Physiography

The lower Colorado River basin is located within several different physiographical provinces. The Highland Lakes Reach lies within the North-Central Plains, Central Texas Uplift, and Edwards Plateau provinces; the Central Reach is located within the Blackland Prairies and Interior coastal Plains sub-provinces of the Gulf Coastal Plains province; and the Coastal Reach lies within the Interior Coastal Plains and Coastal Prairies sub-provinces of the Gulf Coastal Plains province (Bureau of Economic Geology [BEG] 1996) (Figure 3-11).

Highland Lakes Reach.

North-Central Plains. An erosional surface that developed on upper Paleozoic formations forms the North-Central Plains. Where shale bedrock prevails, meandering rivers traverse stretches of local prairie. In areas of harder bedrock, hills and rolling plains dominate. Local areas of hard sandstones and limestones cap steep slopes severely dissected near rivers. Lengthy dip slopes of strongly fractured limestones display extensive rectangular patterns. Western rocks and soils are

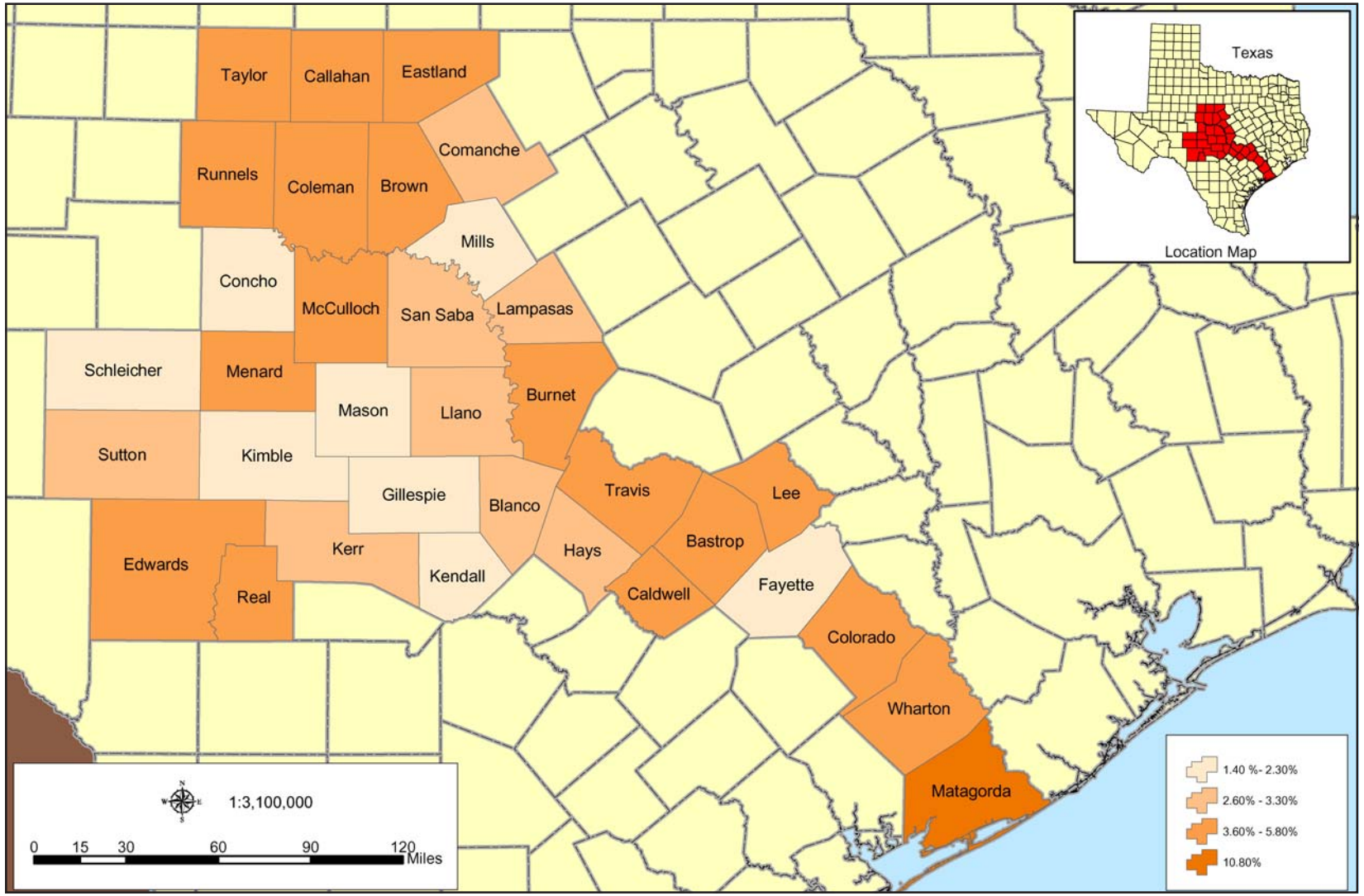

Figure 3-5 2001 Unemployment Rates

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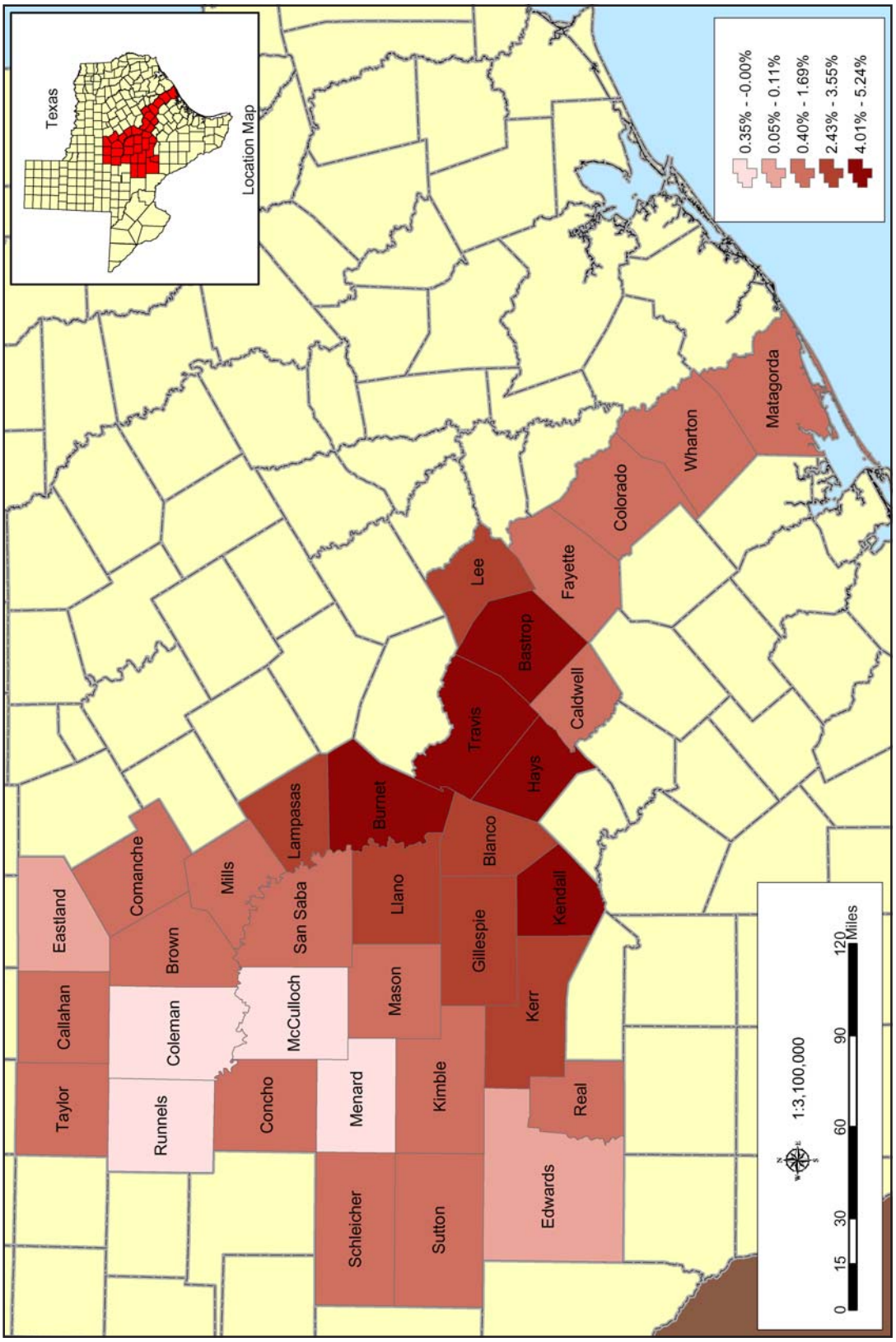

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Figure 3-6 Average Annual Growth Rate From 1970-2000

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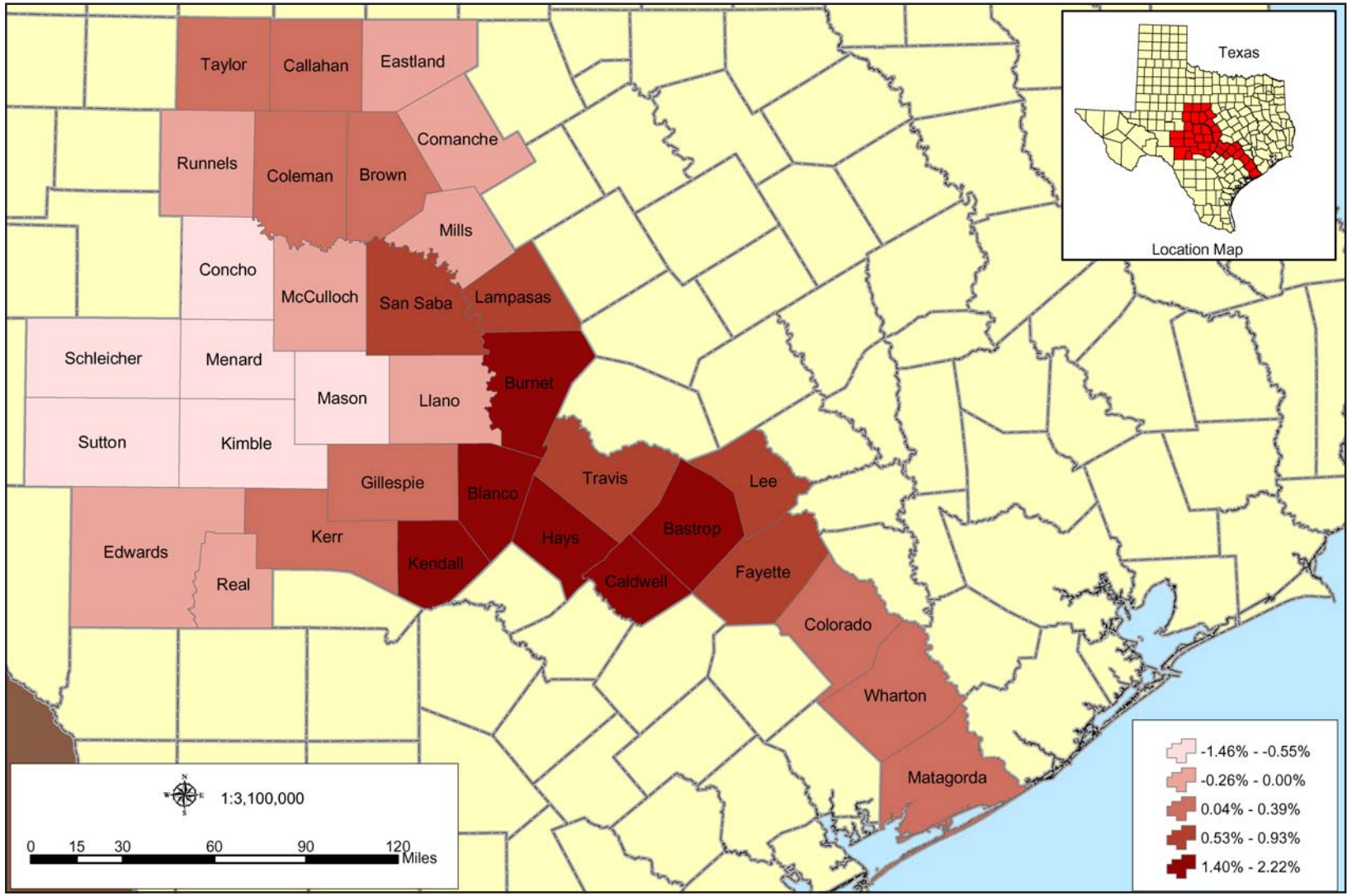

Figure 3-7 Average Annual Growth Rate from 2000-2030 (projected) Date: October 2004

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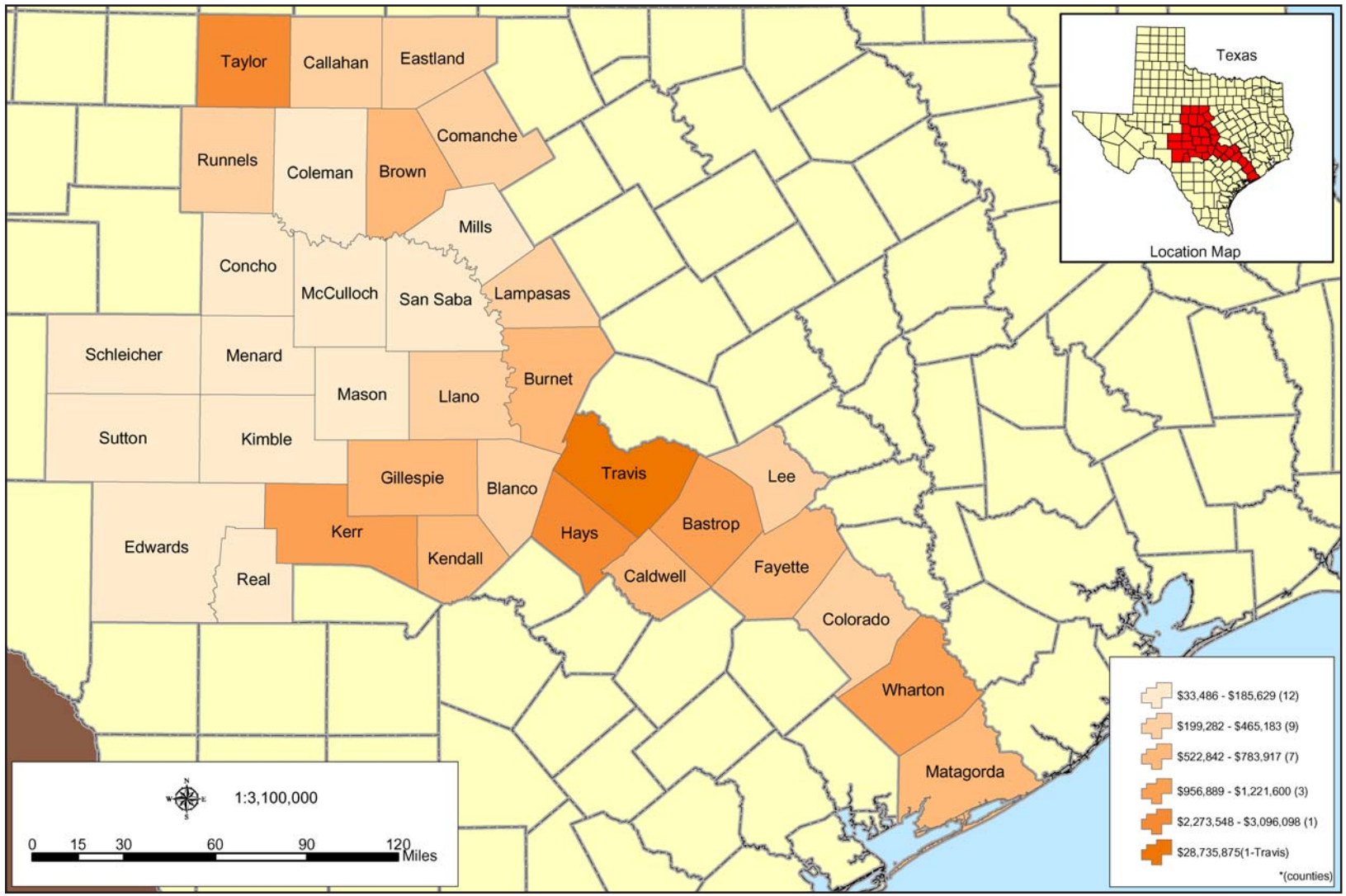

Figure 3-8 2000 Personal Income

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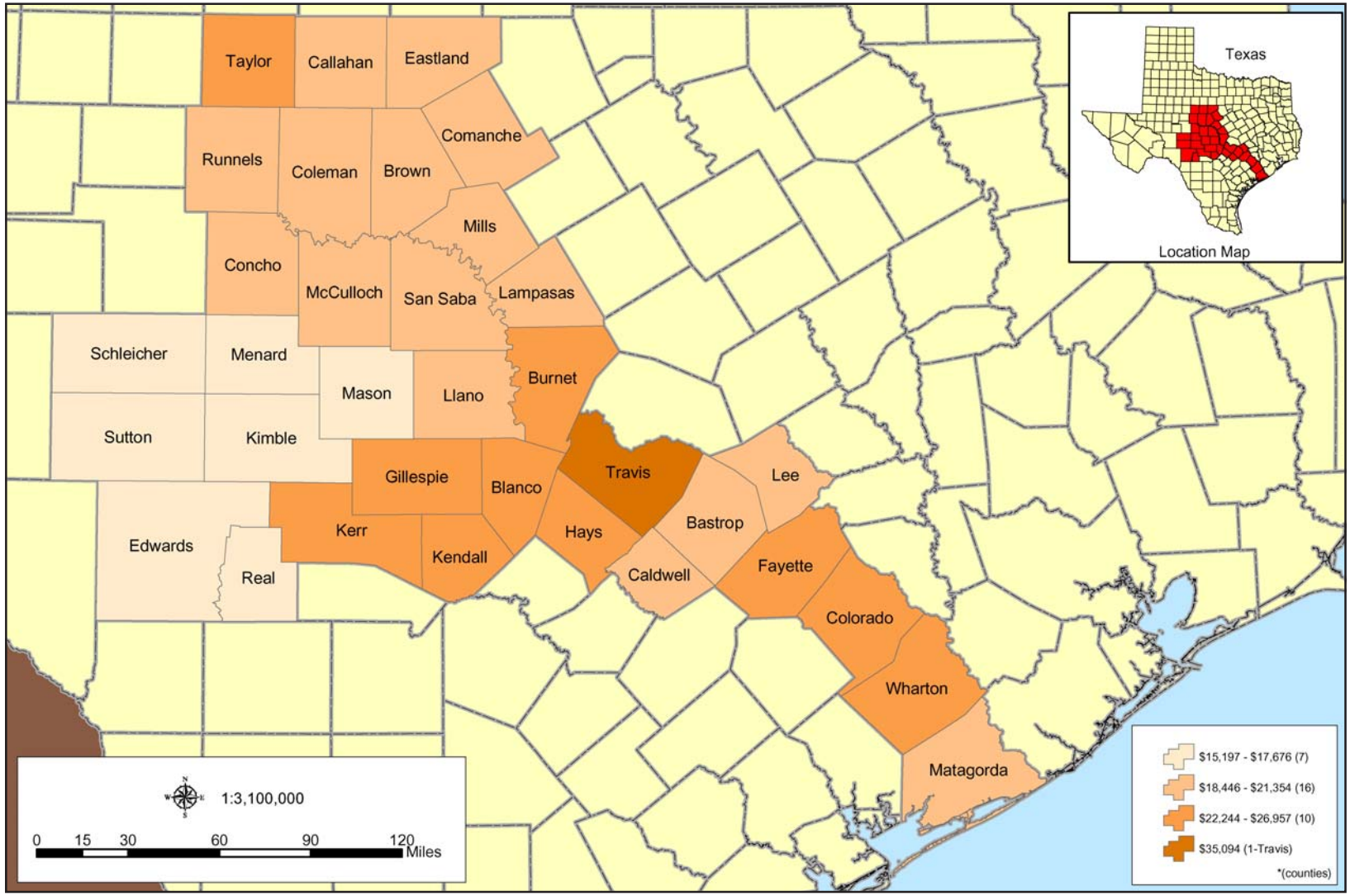

Figure 3-9 2000 Average Per Capita Income

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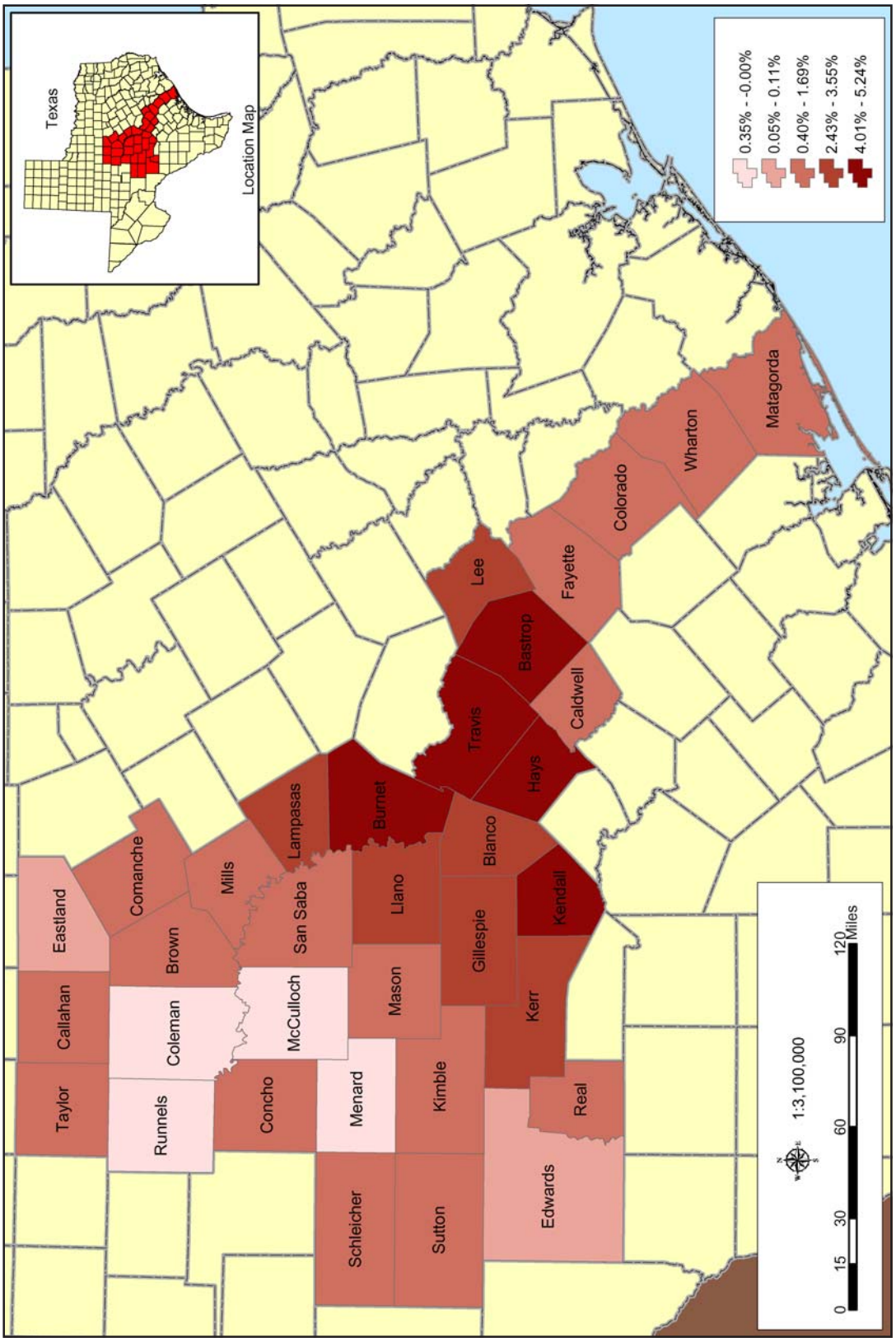

Figure 3-10 1999 Poverty Rates

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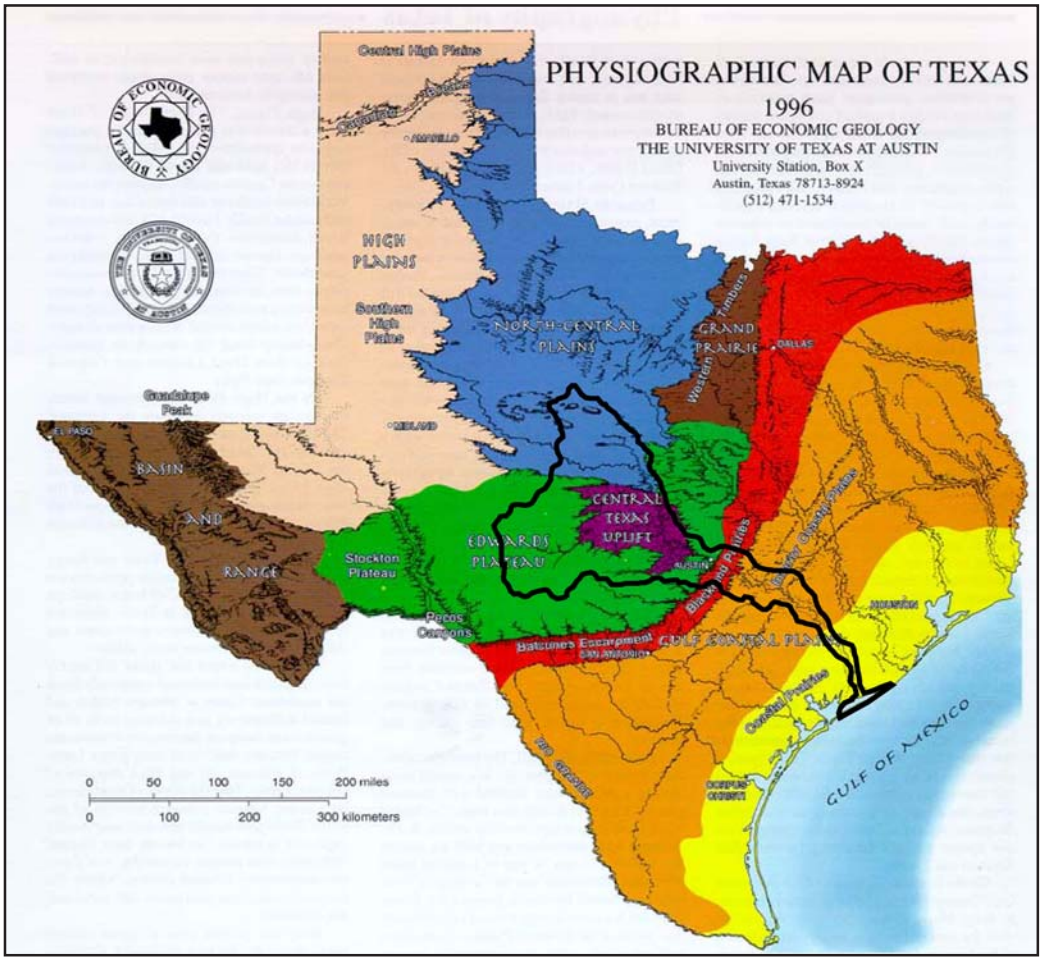

Figure 3.11 Physiographic Provinces of Texas Date: October 2004

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oxidized red or gray where gypsum dominates, whereas eastern rocks and soils weather tan to buff.

Central Texas Uplift. The most characteristic feature of this province is a central basin having a rolling floor studded with rounded granite hills 400 to 600 ft high. Enchanted Rock State Park is typical of this terrain. Rocks forming both basin floor and hills are among the oldest in Texas. A rim of resistant Lower Paleozoic rock surrounds the basin. Beyond the Paleozoic rim is a second ridge formed of limestone deposited on the flanks of these previously existing hills. These rocks are represented by those of the Edwards Plateau.

Edwards Plateau. The Balcones Escarpment is formed by a curved band of major normal faults created by the extensional growth of the Gulf of Mexico. These faults form the boundary of the eastern and southern Edwards Plateau. Its principal area includes the Hill Country and a broad upland plateau.

Stream erosion of the fault escarpment sculpts the Hill Country from Waco to Del Rio. Hard Cretaceous limestone caps the Edwards Plateau. Local streams cut into the softer sediments of the plateau as much as 1,800 ft in 15 miles. The upper drainages of streams are waterless draws that open into box canyons where springs may provide permanently flowing water. Sinkholes commonly dot the limestone terrain and connect with a network of caverns. Alternating hard and soft clay rich limestone forms stair-step topography in the central interior of the province.

Central Reach. The Gulf Coastal Plains contain three sub-provinces: the Blackland Prairies, Interior Coastal Plains, and the Coastal Prairies. Two of these sub-provinces extend through the Central reach: the Blackland Prairies and the Interior Coastal Plains.

On the Blackland Prairies of the innermost Gulf Coastal Plains, chalks and marls weather to deep, black, fertile clay soils, in contrast with the thin red and tan sandy and clay soils of the Interior Gulf Coastal Plains. The Blackland Prairies have a gentle undulating surface, cleared of most natural vegetation and cultivated for crops.

The Interior Coastal Plains comprise alternating belts of resistant uncemented sands among weaker shales that erode into long sandy ridges. This region is characterized by pine (*Pinus* spp.) and hardwood forests and numerous permanent streams. West and south, tree density continuously declines and various brush and sparse grasses dominate between San Antonio and Laredo.

Coastal Reach. The Coastal Reach includes a portion of the Interior Coastal Plains and the Coastal Prairies sub-provinces. The Coastal Prairies extend from the Interior Coastal Plains in Colorado County to the Gulf of Mexico shoreline. Young deltaic sands, silts, and clays erode to nearly flat grasslands that form almost imperceptible slopes to the southeast. Trees are uncommon

except along streams and in oak (*Quercus* spp.) mottes, growing on coarser underlying sediments of ancient streams creating or supporting unique bottomland hardwood ecosystems. Minor steeper slopes, from 1 ft to as much as 9 ft high, result from subsidence of deltaic sediments along faults.

3.2.4 Geology

The geology of the lower Colorado River basin reflects the geologic history of Texas, having rocks dating from more than 2 billion years ago to the most recent sediments deposited by the floods of today. The Llano Uplift, centered in Llano County, is a structural dome of igneous and metamorphic rocks formed in the Precambrian and early Cambrian. As the dome was eroded down, shallow seas covered Texas from the Cambrian Period into the Pennsylvanian, primarily depositing carbonates and sandstones over most of the Highland Lakes Reach. In the Pennsylvanian Period, the Ouachita Mountains developed across the southwestern part of Oklahoma and northwest Texas, angling through the Llano Uplift region, and extending to the Trans Pecos. Through structural down-warping, behind this mountain range to the northwest formed the Permian basin. The Permian Basin was filled with sediments from the Pennsylvanian into the Triassic, both through sedimentation as the Ouachita Mountains were eroded, and through buildup of reefs in shallow marine environments (Spearing 1991).

The Gulf of Mexico began to form in the Triassic, with Triassic and Jurassic marine deposits laid down in its basin to the southwest of the remnants of the Ouachita Mountains. A broad sea then inundated most of Texas during the Cretaceous, resulting in deposition of thick layers of carbonate rocks that covered all previously deposited sediments. Since that time, sea levels have generally retreated to the southeast to the present-day location of the Gulf Coast (Spearing 1991).

Highland Lakes Reach. Erosional processes have removed the thick Cretaceous deposits of carbonates from most of the northern third of the Highland Lakes Reach, exposing the Pennsylvanian and Permian deposits that filled the Permian Basin (BEG 1976). Remnants of Cretaceous deposits are present on high ridges that form the northern boundary of the Colorado River watershed. Outcrops of the Pennsylvanian and Permian rocks continue south to the Llano Uplift region, which through erosion is now physiographically a basin. The area is extremely faulted with the major trend in a northeast-southwest direction. In this region, erosion has cut deep enough to expose outcrops of sedimentary rocks deposited in the Cambrian, Ordovician, Silurian, Devonian, and Mississippian Periods (Spearing 1991). All of this erosion carried downstream vast quantities of sand and gravel that continue to be reworked and redeposited within the basin to this day. These deposits

form an economically important resource in many of the counties within the lower Colorado River basin.

Thick deposits of Cretaceous carbonates remain to the west and southwest of the Llano Uplift, forming the Edwards Plateau. The Balcones Escarpment, a fault system that developed as the growth of the Gulf of Mexico placed stress on the southern portion of Texas, marks the eastern and southern limits of the Edwards Plateau and the downstream extent of the Highland Lakes Reach. The faults formed parallel to the ancient Texas coastline as the floor of the Gulf subsided. The faults delineate a distinct change in both the geology and the climate of central Texas and play a large role in the development and behavior of the lower Colorado River basin.

This is a region of moderately rugged, rocky terrain founded on a highland that follows the trend of the ancient Ouachita Mountains. In Blanco County, igneous and metamorphic rocks crop out along the valley formed by the Pedernales River, while Cretaceous limestone beds form the uplands. Similarly, in Burnet County, the Colorado River has stripped away the Cretaceous limestone beds in the western half of the county, exposing the faulted metamorphic and igneous rocks beneath.

Lake Buchanan, the largest lake by surface area in the Highland Lakes system, is situated mostly in the broad outcrop area of the Town Mountain Granite of Precambrian age (BEG 1981a). Faulted sandstones, formed as erosional products of older rocks, and marine limestone of Cambrian age occur at the upstream end of the lake (BEG 1992). Downstream, Inks Lake and Lake Lyndon B. Johnson (LBJ) are located on the Burnet-Llano County line and are situated on Precambrian rocks. Closer to the COA, the Colorado River follows a deeply incised meandering valley cut in flat-lying Cretaceous limestone strata of the Comanche series.

In Travis County, Cretaceous beds outcrop and dip gently eastward from the basal Hensell Sand on the western edge of the county to the uppermost Cretaceous beds, the Navarro Group, at the eastern edge of the county. The northeast-southwest trending Balcones Escarpment, also known as the Balcones fault zone, diagonally traverses Travis County. The fault zone consists of numerous normal faults, downthrown to the south and east. Total stratigraphic displacement is about 1,000 ft at Austin.

Central Reach. Extensive deposits of sedimentary rocks, principally sandstone and shale, characterize this reach of the basin. Ancient rivers that drained the center of the high plains and traveled through the Highland Lakes region toward the Gulf of Mexico carried the sediments. The sediments were deposited in expansive fluvial and deltaic environments.

The age of the sediments grows younger toward the Gulf of Mexico, indicative of consistent retreat of sea level in the gulf. In Travis and Hays counties, the age of the upland sediments is mostly Cretaceous, with some younger Eocene outcrop at the Bastrop County line in Travis County (BEG 1981b). Progressively younger Eocene formations occur from west to east across Bastrop and Lee counties, including the Wilcox Group, Carrizo Sand, Reklaw Formation, Queen City Sand, Weches Formation, and Sparta Sand. Many of the sandstone formations form regionally or locally important aquifers, and the Wilcox Group contains some of the most commercially valuable lignite deposits in Texas (Thorkildsen and Price 1991). Scattered throughout eastern Travis and portions of Bastrop and Lee counties, Quaternary gravelly alluvial deposits laid down by the ancestral Colorado River and its Tributaries cap these older formations. From west to east in Fayette County, sedimentary formations present include the Eocene Yegua, Caddell, Wellborn, Manning, and Whitsett Formations, and the Miocene Catahoula Formation, Oakville Sandstone, and Fleming Formation (BEG 1974). Many of these formations, notably the Catahoula and Oakville Formations, form locally important aquifers (Rogers 1967). Along the corridors of the Colorado River and its larger tributaries throughout the reach, Quaternary and recent sediments deposited by these waterbodies cover the older rocks, with these sediments representing a re-deposition and mixing of previously deposited sediments.

The sandstones and shales of the Central Reach are generally less erosion resistant than those present upstream. As a result, the Colorado River and it's tributaries more easily remove sediments, valleys tend to be broader, sediment loads are greater, and the river flow is more distributed in broad flood plain valleys with well-developed levees and braided channels.

Coastal Reach. Regional geology of the Coastal Reach largely reflects depositional events that occurred and are occurring during the Quaternary Period (BEG 1992). Throughout this period, east Texas is believed to have looked much as it does today and rock units of the Gulf Coastal Plains province were formed by southeastward transportation and deposition of sediments from inland locations. The predominant landform consists of a flat, weakly dissected alluvial plain formed by deposition of continental sediments onto a submerged, shallow continental shelf, which was later exposed by sea level subsidence. Along the coast, fluvial deposition and shore-zone processes are active in developing and maintaining beaches, marshes and mud flats.

The Miocene Fleming Formation is exposed in portions of western Colorado County and southwestern Austin County (BEG 1974). Pliocene sediments were deposited to the southeast, but these were later covered by Quaternary sands, clays and gravels that get progressively younger to

the southeast. These sediments were deposited in the last 1.8 million years as fluvial deltas discharged to the Gulf of Mexico in response to changes in sea level during the Ice Ages of the Pleistocene Period. In turn, these sediments have been covered within the Colorado River floodplain by recent alluvial deposits.

3.2.5 Climatology

The climate of the lower Colorado River basin is generally mild and varies from semiarid in the upper reaches to subtropical along the Gulf Coast. Topography is such that the transition from semiarid to subtropical is gradual and uniform. Long, hot summers and mild winters characterize seasons within the basin.

Highest average high temperatures occur between July and August and range from about 95° F in Austin to about 92° F in Matagorda. Average low temperatures are coldest in January with average lows of 38° F in Austin and 40° F in Matagorda.

The basin stretches from arid and rocky Hill Country counties that receive an average of 24 inches of rainfall annually to the humid Coastal Plain, which receives an average of 44 inches of rain per year. Average annual storm water runoff ranges from about 350 acre-ft per square mile near the mouth of the Colorado River to less than 50 acre-ft per square mile in the western portion of the basin.

The prevailing winds of the lower Colorado River basin are from the south or southeast, except for portions of the winter months. During this time, occasional high-pressure polar air masses from the northwest result in north winds over most of the basin.

Destructive winds and torrential rains often accompany occasional tropical disturbances during summer and fall. Tropical cyclone damage is caused by high winds (including tornados) and by flooding due to heavy rainfall. In Matagorda County, the additional threat of high storm-surge tides is present throughout the Texas hurricane season from June through October. Based upon data compiled since 1871, there is a 41% chance that in any one year a tropical storm or hurricane will make landfall on the Texas Gulf Coast. Also, since 1871, on the average there has been three years between hurricanes, with two or more hurricanes occurring in the same season once every five years.

3.2.6 Hydraulics and Hydrology

Basin Description. The entire Colorado River basin extends northwest to southeast from New Mexico and the High Plans to the Gulf of Mexico near Matagorda, Texas. The basin is bounded by the Rio Grande, Nueces, Guadalupe, and Lavaca River basins to the south, and west; the Brazos River basin bounds the Colorado River basin to the north and east. Total area drained by the Colorado River is 42,240 square miles with 30,837 square miles actually contributing to stream flow. The length of the watershed within the study area is over 480 miles and its maximum width is approximately 150 miles. The upper part of the watershed has a width of approximately 80 miles and decreases to 30 miles at Austin, maintaining this width to Columbus; below Columbus the width gradually diminishes toward the Gulf of Mexico.

The elevation of the upper portion of the lower Colorado River basin decreases gradually from +2,000 ft mean sea level (msl) in the Central Texas Uplift section to +1,000 ft msl in the Balcones Escarpment above Austin. Between the escarpment and the coastline, the land elevations decrease to +1 ft msl near the coast.

The entire Colorado River basin consists principally of the main stem and 6 major tributaries. The major tributaries are Beals Creek, Concho River, Pecan Bayou, San Saba River, Llano River, and Pedernales River. The contributing area above Mansfield Dam (Lake Travis), the major flood control structure on the Colorado River main stem, is approximately 27,565 square miles. In the Colorado River basin above Austin, there are four Federal and 15 Non-Federal reservoirs with an individual capacity greater than 5,000 acre-ft (Table 3-1).

There are no substantial structures (levee/reservoir) in place to control the Colorado River or its contributing waters below Austin. A levee system and seawall was constructed in Matagorda County in 1942 and has recently been improved. Hydraulic structures at the mouth of the Colorado River include navigation features with related recreation facilities and features diverting flows of the Colorado River into Matagorda Bay. The navigation features consist of a harbor and turning basin at Matagorda, a navigation channel extending from the harbor to the Gulf of Mexico, jetties and entrance channel, and recreational facilities adjacent to the east jetty. Features associated with the diversion of the Colorado River are the diversion channel itself, the diversion dam across the river, the dam across Parker's Cut, the connecting channel that joins the east side of the GIWW East Lock with the navigation channel just south of the diversion dam, and an oyster cultch (material such as oyster shell laid down on oyster grounds to furnish points of attachments for the spat) in Matagorda Bay.

Table 3-1

Existing Reservoirs

FEDERAL				
Reservoir	**Stream**	**River Mile**	**Contributing Drainage Area (sq mi)**	**Total Storage (ac-ft)**
O.C. Fisher	North Concho River	6.6	1,383	396,400
Twin Buttes	South Concho River	13	3,015	640,600
	Middle Concho River	4		
Hords Creek	Hords Creek	27.8	48	25,310
Brady Creek	Brady Creek	34	508	90,480

NON-FEDERAL				
Reservoir	**Stream**	**River Mile**	**Contributing Drainage Area (sq mi)**	**Total Storage (ac-ft)**
J. B. Thomas	Colorado River	837	987	204,000
Colorado City	Morgan Creek	2.5	290	32,000
Champion Creek	Champion Creek	0.9	203	42,000
E.V. Spence	Colorado River	730.9	4,044	489,000
Oak Creek	Oak Creek	20	244	39,000
Nasworthy	South Concho River	7.6	2,655	14,000
O.H. Ivie	Colorado River	615.1	12,647	550,000
Brownwood	Pecan Bayou	57.1	1,544	150,000
Coleman	Jim Ned Creek	52.2	292	40,000
Buchanan	Colorado River	413.6	20,685	992,000
Inks	Colorado River	409.4	20,724	17,000
LBJ	Colorado River	388	25,750	137,000
Marble Falls	Colorado River	381.8	25,810	9,000
Lake Travis	Colorado River	318	27,567	1,951,400
Lake Austin	Colorado River	297.6	27,670	21,000

*Source: U.S. Army Corps of Engineers, Reconnaissance Report, Central Colorado River Basin, September 1989a.

In the Coastal Reach, the drainage basin of the lower Colorado River covers approximately 867 square miles. The width of the river in the Coastal Reach ranges from 288 ft along most of its length through the delta to about 368 ft at the point of junction with GIWW (Diener 1973). The average surface width of the GIWW is approximately 500 ft. Depths of the GIWW and river channel at its mouth are maintained at -12 ft mean low water (mlw) and the width at bottom is roughly 123 ft. Tides in the Matagorda Bay area typically vary less than 1.6 ft.

Flood Peak Discharges. In response to the June 1997 flood on the Highland Lakes, the LCRA initiated steps to review flood management of the Colorado River, including a critique of reservoir operations and the initiation of the USACE Flood Damage Evaluation Feasibility Study. USACE's Fort Worth and Galveston Districts and the LCRA developed as a cooperative effort, a two-phase flood damage evaluation feasibility study. Phase I of the feasibility study identified problems, need and opportunities within the lower Colorado River basin (USACE 2003b).

A summary of 100-year frequency flood peak discharges at selected locations is shown in Table 3-2. In general, the peak discharges computed for this study were lower than published FEMA flood insurance study values. In some cases, lower peak discharges did not always produce lower flood elevations, due to more advanced modeling data and techniques. Earlier flood studies utilized steady-state hydraulic models while this study incorporated unsteady modeling technologies along the Colorado River. The use of updated and detailed topographic mapping along the river corridor, state-of-the art GIS technology, and statistically sound hydrologic modeling tools also contributed to the differences.

100-Year Floodplains. Based on recent investigations conducted under the LCRBS (Halff, 2002), 100-year peak flood elevations within the lower Colorado River basin have been shown to be different than previously documented. The differences range from 0.2 ft up to 5.8 ft. The larger differences occurred along the banks of Lake Travis. A summary of 100-year frequency peak flood elevations at selected locations is shown in Table 3-3. The peak flood elevations computed for this study differ from earlier FEMA flood insurance study values. For the computed pool elevations at the upstream face of the dams, this study has equal or lower flood elevations at the upstream face of five dams (Buchanan, LBJ, Inks, Austin and Town Lake); and higher elevations on two dams (Marble Falls and Travis). In the Austin gage area, the current study elevations are slightly higher. At Bastrop, the estimated flood elevation is lower and at Wharton the estimated flood level is below the

Table 3-2
Summary and Comparison of 100-Year Flood Peak Discharges (cfs)
Colorado River at Selected Points

Location on the Colorado River	Computed 100-Year Discharge (1)	FEMA 100-Year Discharge
Red Bluff Gauge Near San Saba	237,100	N/A
Tom Miller Dam	90,100(2)	170,000 (3)
Austin Gauge Upstream of U.S. 183	90,300(2)	170,000 (3)
Below Mouth of Onion Creek	138,300	210,000 (4)
Bastrop Gauge at Loop 150	142,000	149,300
Columbus Gauge at U.S. 90	135,200	136,000
Wharton Gauge at U.S. 59 (Business)	114,100	139,500

*Source: USACE (2003)

(1) Computed values used to determine flood elevations

(2) Releases from Mansfield Dam.

(3) Value in Published Flood Insurance Study is 170,000 cfs. Values in the effective FEMA models range from 90,000 to 100,000 cfs.

(4) Value from Travis County FIS at Travis-Bastrop County Lines.

earlier studies. Some minor differences in the vertical elevation datum from the previous studies (National Geodetic Vertical Datum [NGVD] 29-1929 msl) to the current datum (North American Vertical Datum [NAVD] 88-1988 msl) were noted in the study.

There are several reasons that the 100-year flood elevations differ from earlier studies along the Colorado River and especially on the Highland Lakes:

- This is the first detailed, comprehensive, basin-wide approach for modeling, simulating, and computing frequency-based rainfall, runoff, reservoir elevations, and flood elevations along the entire river corridor.
- There is an additional 25 years of historical flood and rainfall records that have been collected since the previous flood studies of the mid to late 1970s. This provides a more comprehensive statistical database for developing flood frequency estimates.
- The calibration and verification of the flood models used in the study has been enhanced significantly by the additional historical rainfall and flood data and the computational power of large capacity computers. The use of NEXRAD radar and GIS tools in the collection of data, development of computer models, and display of results had provided a greater degree of accuracy in the floodplain delineation and overall flood analysis

Table 3-3
Summary and Comparison of 100-Year Peak Flood Elevations
Colorado River at Selected Points

Location on the Colorado River	Computed 100-Year Elevation (Feet NAVD88)	FEMA 100-Year Elevation (Feet NAVD88) (2)	Difference Current FEMA (Feet)
Lake Buchanan (1)	1021.0	1021.2	-0.2
Inks Lake (1)	901.7	901.9	-0.2
Lake LBJ (1)	828.1	828.1	0.0
Lake Marble Falls (1)	754.3	753.2	+1.1
Lake Travis (1)	722.0	716.2	+5.8
Lake Austin (1)	492.8	493.3	-0.5
Town Lake (1)	438.6	439.8	-1.2
Austin Gauge Upstream of U.S. 183	437.0	435.3	+1.7
Bastrop Gauge at Loop 150	352.2	353.9	-1.7
Columbus Gauge at U.S. 90	192.2	194.1	-1.9
Wharton Gauge at U.S. 59 (Business)	102.4	103.3	-0.9

(1) Flood Elevation computed at upstream face of the dam. Flood elevations on each lake will rise along the river, upstream of the dam.
(2) Current effective FEMA 100-year elevations adjusted to NAVD88.

process. A more realistic assumption of the long-range river flood forecasting abilities of reservoir operators has had an effect on predicted 100-year pool levels. For example, in earlier flood studies to determine FEMA pool elevations on Lake Travis, an assumption of a reliable 36-hour flood forecast is considered by the LCRA and the USACE as the maximum time that can be safely used in flood gate operations.

- Within the historical period of record (1930-1999) used in this study, the 1938 flood would have caused Lake Travis to reach approximately the projected 100-year flood pool (722 ft) if the lakes had been in place. This 1938 flood, which was a high volume event, is statistically considered to be approximately the 100-year flood. In addition, the 1936, high volume flood, would have reached an estimated 719 ft elevation on Lake Travis.

- As noted above, there are some minor vertical elevation datum differences throughout the study area. The changes in datum from the previous studies to this study vary from near zero in the lower basin to a maximum of 0.38 ft near Winchell.

There are over 12,400 and 33,880 structures within the 100-year and 1,000-year floodplains, with an estimated value (structures and contents) of $845 million and $4.08 billion, respectively. The total value of structures and their contents, including privately owned vehicles within the 1,000-year floodplain is estimated at $4.3 billion. Tables 3-4 through 3-7 provide a summary of the number and value of floodplain structures and vehicles within the 100-year and 1,000-year floodplains.

3.2.7 Vegetational Areas and Soils

The lower Colorado River basin study area falls within six vegetation regions as designated by Gould (1975). The northern extent of the study area originates in the Rolling Plains, Cross Timbers and Prairies and Edwards Plateau, continues south and east through Blackland Prairies and Post Oak Savannah, and terminates in Gulf Prairies and Marshes (Figure 3-12). The TPWD (1984) has classified and mapped the various vegetation cover types occurring within the state. Figure 3-13 presents the vegetation cover types occurring in the study area and Table 3-8 provides a brief description of each cover type. The following provides a general description of vegetation resources within the study area by reach.

The vegetation regions of the Highland Lakes Reach include the Rolling Plains in the north, the Llano Uplift in the center, and the Edwards Plateau along its southern and eastern boundaries. Vegetation types found within the Rolling Plains can be dominated by Crops, Live Oak-Mesquite-Ashe Juniper Parks, Oak-Mesquite-Juniper Parks/Woods, and Live Oak-Ashe Juniper Parks. Vegetation types found within the Llano Uplift include Live Oak-Mesquite Parks, Live Oak-Mesquite-Ashe Juniper Parks, and Live Oak-Ashe Juniper Parks. Vegetation types of the Edwards Plateau include those found in the Rolling Plains and the Llano Uplift, as well as, Silver Bluestem-Texas Wintergrass Grassland, Mesquite-Juniper Shrub, and Mesquite-Juniper-Live Oak Brush.

The vegetation regions of the Central Reach include the Edwards Plateau to the west, and alternating bands of Blackland Prairie and Oak Woods and Prairies to the east. Vegetation types of the Edwards Plateau in the Central Reach include Live Oak-Mesquite-Ashe Juniper Parks, Live Oak-Ashe Juniper Parks, Oak-Mesquite-Juniper Parks/Woods, and Live Oak-Ashe Juniper Woods.

Table 3-4

Total Structural and Contents Value Within Floodplains of the Highlands Reach

(monetary values in thousands of dollars, year 2002 prices and level of development)

	Number		Structure Value		Content Value		Total Value	
	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr
Lake Buchanan								
Single Family	0	783	359	64,580	180	32,290	539	96,870
Public	2	24	806	509	25	220	59	1,029
Residential Outbuildings	82	856	743	6,887	782	8,181	1,525	15,068
Total Lake Buchanan	**84**	**1,663**	**1,908**	**71,976**	**987**	**40,691**	**2,123**	**112,967**
Inks Lake								
Single Family	54	115	4,229	8,762	2,441	4,381	6,343	13,143
Agricultural	0	1	0	22	0	22	0	44
Public	17	20	170	235	41	235	211	470
Residential Outbuildings	58	93	301	823	451	1,053	751	1,876
Total Inks Lake	**129**	**229**	**4,700**	**9,842**	**2,606**	**5,691**	**7,306**	**15,533**
Lake LBJ								
Single Family	708	4,008	50,258	361,125	25,129	180,562	75,387	541,687
Multi Family	22	135	2,892	20,734	1,447	10,367	4,339	31,102
Public	1	92	3	563	0	386	3	949
Agricultural	0	2	0	1	0	1	0	2
Commercial	53	9,289	1,979	13,323	2,269	9,699	4,248	23,022
Residential Outbuildings	786	2,464	7,430	20,228	8,183	18,408	15,613	38,636
Total Lake LBJ	**1,570**	**15,990**	**62,562**	**415,974**	**37,028**	**219,423**	**99,590**	**635,398**
Lower Burnet								
Single Family	96	181	5,073	10,101	2,537	5,050	7,610	15,151
Multi Family	2	2	120	120	60	60	180	180
Agricultural	1	2	254	277	130	150	384	427
Public	9	9	169	169	169	0	338	169
Commercial	1	1	22	22	22	0	44	22
Residential Outbuildings	73	113	435	606	435	700	870	1,306
Total Lower Burnet	**182**	**308**	**6,073**	**11,295**	**3,353**	**5,960**	**9,426**	**17,255**
Lake Marble Falls								
Single Family	213	941	17,544	55,036	8,772	27,518	26,316	82,554
Multi Family	0	15	0	2,244	0	1,122	0	3,366
Public	13	13	610	610	106	106	716	716
Agricultural	0	1	0	26	0	26	0	52
Commercial	14	35	671	5,050	6,013	17,375	6,684	22,425
Residential Outbuildings	93	279	242	1,223	303	1,610	545	2,833
Total Lake Marble Falls	**333**	**1,284**	**19,067**	**64,189**	**15,194**	**47,757**	**34,261**	**111,946**
Above Burnet								
Single Family	4	4	57	57	57	57	114	114
Total Above Burnet	**4**	**4**	**57**	**57**	**57**	**57**	**114**	**114**

*Table 3-4 continued on next page.

Table 3-4, continued

Total Structural and Contents Value Within Floodplains of the Highlands Reach

(monetary values in thousands of dollars, year 2002 prices and level of development)

	Number		Structure Value		Content Value		Total Value	
	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr
Upper Burnet								
Single Family	4	4	30	157	30	157	60	314
Residential Outbuildings	3	5	14	29	7	35	21	64
Total Upper Burnet	**7**	**9**	**44**	**186**	**37**	**192**	**81**	**378**
Lake Travis								
Single Family	1,212	2,135	160,661	378,892	80,330	189,446	240,991	568,338
Multi Family	15	57	11,417	20,964	5,708	10,482	17,125	31,446
Agricultural	0	3	0	77	0	77	0	154
Commercial	58	82	5,489	17,525	2,975	7,648	8,464	25,173
Public	55	73	1,910	2,889	650	1,028	2,560	3,917
Residential Outbuildings	358	588	2,449	7,422	5,567	6,340	8,015	13,762
Total Lake Travis	**1,698**	**2,938**	**181,925**	**427,769**	**95,230**	**215,021**	**277,155**	**642,790**
Lake Austin								
Single Family	49	694	10,957	226,411	5,479	113,206	16,436	339,617
Multi Family	2	32	77	6,498	38	3,249	115	9,747
Agricultural	0	1	56	26	0	26	56	52
Commercial	3	31	1,696	14,540	965	6,210	2,661	20,750
Public	2	6	11	488	11	176	22	664
Residential Outbuildings	32	212	390	2,558	434	2,419	824	4,977
Total Lake Austin	**88**	**976**	**13,188**	**250,521**	**6,927**	**125,286**	**20,115**	**375,807**
Town Lake								
Single Family	3	176	1,483	46,946	741	23,473	2,224	70,419
Multi Family	1	61	19	39,265	10	19,633	29	58,898
Commercial	1	71	764	153,186	26,000	49,011	26,764	202,197
Public	3	80	54	259,548	27	32,145	81	291,693
Residential Outbuildings	1	119	8	564	8	611	16	1,175
Total Town Lake	**9**	**507**	**2,328**	**499,509**	**26,786**	**124,873**	**29,114**	**624,382**
Total Highland Lakes	**4,104**	**23,908**	**291,852**	**1,751,318**	**188,205**	**784,951**	**479,285**	**2,536,570**

*Source: USACE 2003b.

Table 3-5

Total Structural and Contents Value Within Floodplains of the Central Reach

(monetary values in thousands of dollars, year 2002 prices and level of development)

	Number		Structure Value		Content Value		Total Value	
	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr
Lower Austin								
Single Family	15	238	10,615	87,433	5,308	43,717	15,923	131,150
Multi Family	0	13	0	4,560	0	2,280	0	6,840
Agricultural	0	23	0	466	0	141	0	607
Commercial	3	54	72	18,012	72	19,261	144	37,273
Public	7	34	5,186	20,666	2,740	8,407	7,926	29,073
Residential Outbuildings	25	191	592	2,887	888	3,787	1,481	6,674
Total Lower Austin	**50**	**553**	**16,465**	**134,024**	**9,008**	**77,593**	**25,473**	**211,617**
Upper Bastrop								
Single Family	41	236	773	7,603	386	3,801	1,159	11,404
Agricultural	11	59	149	1,041	149	1,041	298	2,082
Commercial	0	13	0	34	0	10	0	44
Residential Outbuildings	25	103	58	621	52	621	111	1,242
Total Upper Bastrop	**77**	**411**	**980**	**9,299**	**588**	**5,473**	**1,568**	**14,772**
Middle Bastrop								
Single Family	61	190	2,641	11,538	1,320	5,769	3,961	17,306
Agricultural	11	82	132	1,796	66	887	198	2,683
Commercial	3	4	1,258	1,326	500	556	1,758	1,882
Residential Outbuildings	35	100	197	729	168	1,093	365	1,823
Total Middle Bastrop	**110**	**376**	**4,228**	**15,389**	**2,054**	**8,305**	**6,282**	**23,694**
Bastrop								
Single Family	88	415	3,374	18,656	1,687	9,328	5,061	27,984
Multi Family	0	5	0	592	0	296	0	888
Agricultural	2	10	21	265	32	368	53	633
Commercial	1	44	111	4,259	10	8,727	121	12,986
Public	1	8	38	347	0	203	38	550
Residential Outbuildings	35	152	324	1,165	486	1,934	810	3,099
Total Bastrop	**127**	**634**	**3,868**	**25,284**	**2,215**	**20,856**	**6,083**	**46,140**
Smithville								
Single Family	15	49	493	2,057	247	1,028	740	3,085
Agricultural	4	20	87	422	45	201	132	623
Commercial	4	10	400	1,134	1	875	401	2,009
Public	7	10	732	1,009	15	27	747	1,036
Residential Outbuildings	6	21	46	2,704	35	1,273	81	3,977
Total Smithville	**36**	**110**	**1,759**	**7,326**	**342**	**3,404**	**2,101**	**10,730**

*Table 3-5 continued on next page.

Table 3-5, continued

Total Structural and Contents Value Within Floodplains of the Central Reach

(monetary values in thousands of dollars, year 2002 prices and level of development)

	Number		Structure Value		Content Value		Total Value	
	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr
Upper Fayette								
Single Family	59	193	2,093	8,022	1,046	4,011	3,139	12,033
Agricultural	39	163	747	5,547	673	5,518	1,420	11,065
Commercial	5	11	358	382	80	92	438	473
Public	0	2	0	147	0	74	0	221
Residential Outbuildings	9	76	64	1,069	1,028	1,285	1,092	2,354
Total Upper Fayette	**112**	**445**	**3,263**	**15,167**	**2,827**	**10,980**	**6,089**	**26,147**
Lower Fayette								
Single Family	21	129	955	9,085	477	4,542	1,432	13,627
Agricultural	96	251	1,454	5,815	1,400	5,818	2,854	11,633
Commercial	4	11	57	442	57	624	114	1,066
Residential Outbuildings	23	97	210	7,163	6,447	7,583	6,657	14,746
Total Lower Fayette	**144**	**488**	**2,676**	**22,505**	**8,381**	**18,567**	**11,057**	**41,072**
Lagrange								
Single Family	159	980	728	89,713	887	44,858	1,615	134,571
Agricultural	16	39	996	3,126	1,012	2,384	2,009	5,510
Commercial	49	99	5,551	8,350	5,600	16,445	11,151	24,795
Public	11	23	781	2,695	792	1,422	1,573	4,117
Residential Outbuildings	144	478	1,643	5,260	1,787	5,260	3,429	10,520
Total LaGrange	**379**	**1,619**	**9,699**	**109,144**	**10,078**	**70,369**	**19,777**	**179,513**
Total Central Reach	**1,035**	**4,636**	**42,938**	**338,138**	**35,493**	**215,547**	**78,430**	**553,685**

*Source: USACE 2003b.

Table 3-6

Total Structural and Contents Value Within Floodplains of the Coastal Reach

(monetary values in thousands of dollars, year 2002 prices and level of development)

	Number		Structure Value		Content Value		Total Value	
	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr
Columbus								
Single Family	125	748	3,080	13,015	1,540	6,008	4,621	19,023
Multi Family	0	21	0	111	0	56	0	167
Agricultural	100	307	1,159	2,768	1,159	2,768	2,318	5,536
Commercial	40	214	1,594	12,709	1,347	14,416	2,941	27,125
Public	13	51	383	735	254	1,229	637	1,964
Residential Outbuildings	159	598	604	1,397	604	1,397	1,208	2,794
Total Columbus	**437**	**1,939**	**6,820**	**30,735**	**4,904**	**25,874**	**11,725**	**56,609**
Garwood								
Single Family	7	15	62	232	31	116	92	348
Agricultural	68	124	485	1,079	485	1,079	970	2,158
Residential Outbuildings	4	8	13	43	19	63	32	106
Total Garwood	**79**	**147**	**560**	**1,354**	**535**	**1,258**	**1,094**	**2,612**
Eagle Lake								
Single Family	170	520	2,570	21,816	1,285	10,908	3.855	32,724
Multi Family	2	8	117	445	59	223	176	668
Agricultural	110	341	1,236	3,878	1,236	3,878	2,472	7,756
Commercial	20	134	714	20,180	11,101	11,780	11,815	31,960
Public	20	30	344	1,04,	295	620	639	1,660
Residential Outbuildings	105	241	845	1,804	700	900	1,545	2,704
Total Eagle Lake	**427**	**1,274**	**5,828**	**49,163**	**14,676**	**28,309**	**20,503**	**77,472**
Wharton								
Residential	1,620	3,101	53,879	126,151	26,939	63,050	80,818	189,201
Multi Family	21	66	4,061	24,061	2,031	12,031	6,092	36,092
Public	55	111	5,394	105,365	9,170	27,117	14,564	132,482
Agriculture	205	262	6,570	8,210	6,600	8,214	13,170	16,424
Commercial	248	401	14,820	36,487	10,100	29,713	24,920	66,200
Residential Outbuildings	1,669	2,382	4,155	7,022	7,430	14,009	11,585	21,031
Total Wharton	3,818	6,323	88,879	307,296	62,270	154,134	151,149	461,430
Upper Wharton								
Single Family	40	179	877	7,361	438	3,681	1,315	11,042
Public	1	1	20	261	0	119	20	380
Agricultural	102	182	185	4,592	185	4,592	370	9,184
Commercial	3	8	1,769	261	66	119	1,835	380
Residential Outbuildings	78	128	218	400	227	526	445	926
Total Upper Wharton	224	498	3,069	12,875	916	9,037	3,985	21,912

*Table 3-6 continued on next page.

Table 3-6, continued

Total Structural and Contents Value Within Floodplains of the Coastal Reach

(monetary values in thousands of dollars, year 2002 prices and level of development)

	Number		Structure Value		Content Value		Total Value	
	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr	100-yr	1000-yr
Lower Wharton								
Single Family	139	357	206	23,996	103	11,988	309	35,984
Agricultural	115	205	1,500	10,415	1,500	10,325	3,000	20,740
Commercial	2	3	64	2,209	2,500	3,500	2,564	5,709
Residential Outbuildings	250	377	858	1,364	1,603	2,400	2,461	3,764
Total Lower Wharton	506	942	2,628	37,984	5,706	28,213	8,334	66,197
Glen Flora								
Single Family	212	485	6,687	13,285	3,344	6,643	10,031	19,928
Public	2	6	49	599	5	833	54	1,432
Agricultural	227	338	4,690	8,200	4,690	8,200	9,380	16,400
Commercial	7	22	239	1,552	317	1,234	556	2,786
Residential Outbuildings	294	451	758	1,656	995	2,116	1,753	3,772
Total Glen Flora	742	1302	12,423	25,292	9,351	19,026	21,774	44,318
Total Coastal Reach	5,290	9,065	106,999	383,447	78,243	210,410	185,242	593,857

*Source: USACE 2003b.

Table 3-7
Total Vehicle Value Within 1000-Year (.1%) Floodplain
(damage values in thousands of dollars)

	Number	Value
Llano County		
Lake LBJ	2,506	38,470
Lake Buchanan	460	6,240
Inks Lake	97	1,235
Total Llano County	**3,063**	**45,945**
Burnet County		
Lower Burnet	184	1,562
Lake Marble Falls	975	9,489
Lake LBJ	1,606	23,475
Lake Buchanan	226	2,536
Inks Lake	109	1,368
Above Burnet	3	12
Upper Burnet	6	30
Total Burnet County	**3,109**	**38,472**
Travis County		
Town Lake	243	14,894
Lower Travis	457	4,833
Lower Austin	240	9,912
Lake Travis	2,158	57,302
Lake Austin	751	34,814
Total Travis County	**3,849**	**121,755**

	Number	Value
Three County Area		
Upper Fayette	191	1,226
Upper Bastrop	238	1,391
Smithville	50	357
Middle Bastrop	192	1,848
Lower Fayette	123	1,338
Lagrange	945	13,050
Garwood	16	45
Eagle Lake	549	3,584
Columbus	852	6,201
Bastrop	431	3,088
Three County Total	3,587	32,128
Wharton County		
Wharton	126	1,256
Upper Wharton	18	143
Lower Wharton	0	51
Glen Flora	76	329
Total Wharton County	**220**	**1,779**
Matagorda County		
Matagorda	321	2,656
Upper Matagorda	250	2,474
Total Matagorda County	**571**	**5,130**

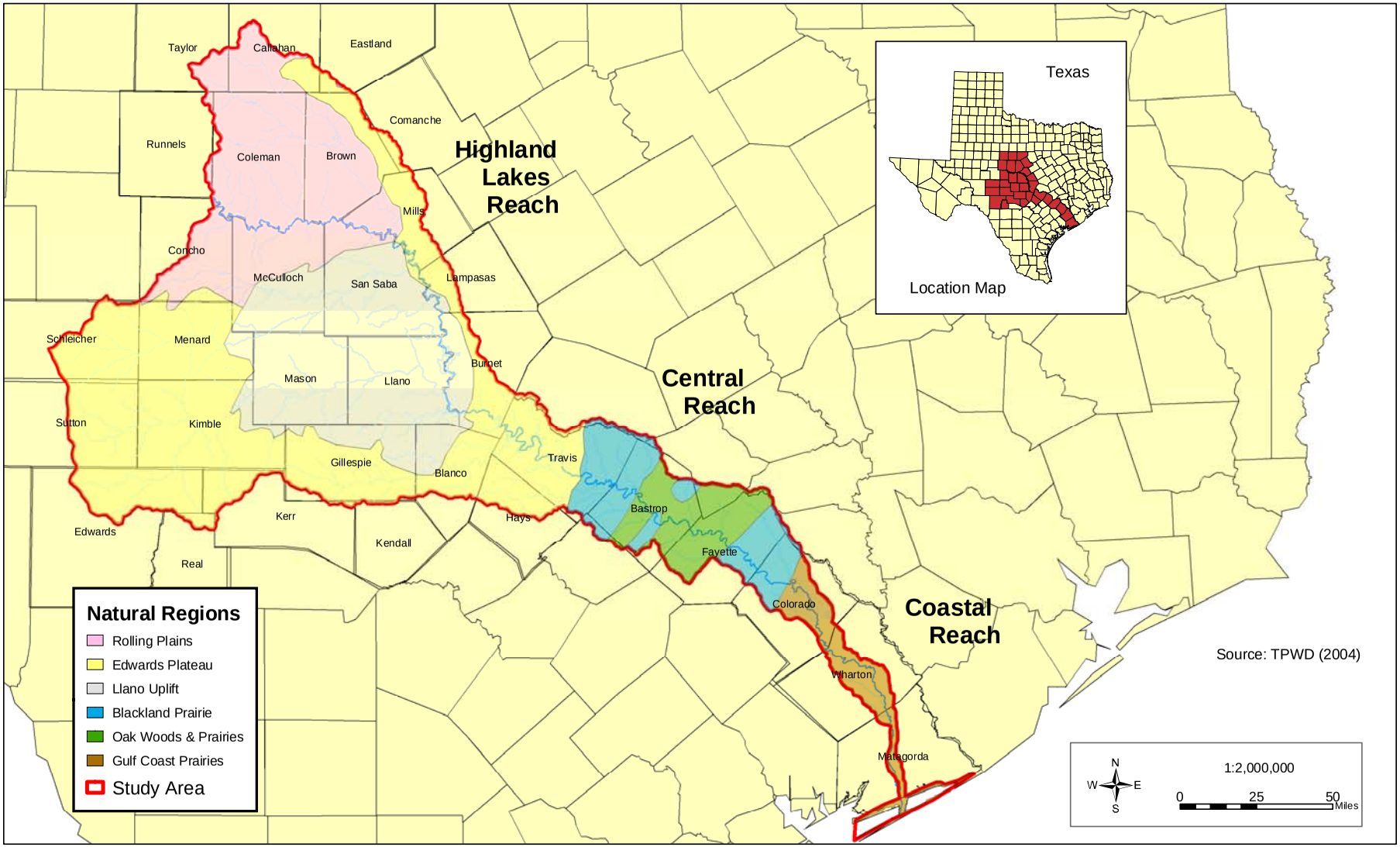

Figure 3-12: Natural Regions

Date: October 2004

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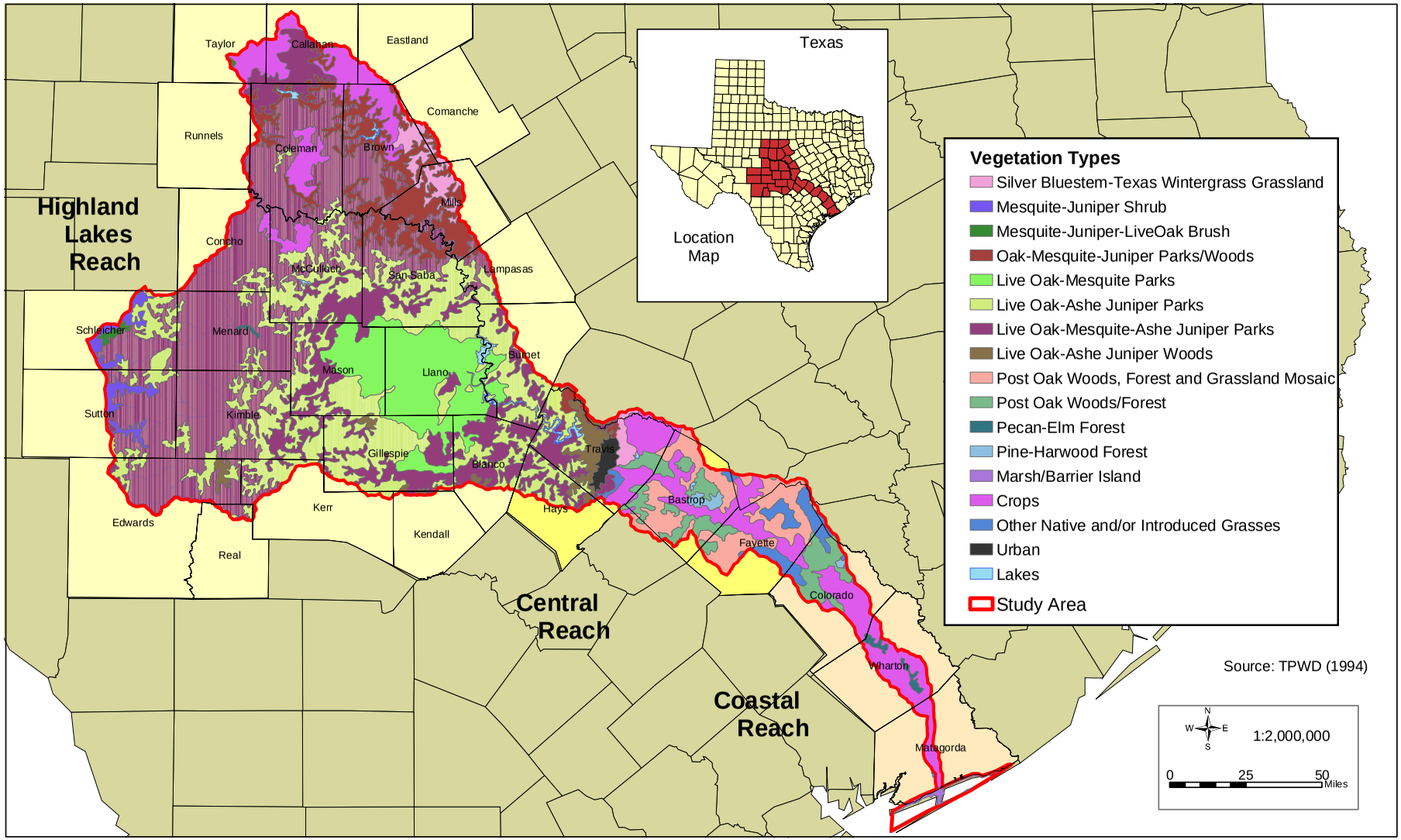

Figure 3-13: Vegetation Cover Types

Date: October 2004

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Table 3-8

Vegetational Types Within the Lower Colorado River Basin

Vegetation Type	Commonly Associated Plants	Distribution
Live Oak/Mesquite-Ashe Juniper Parks	(Edwards Plateau): Live oak, mesquite, Ashe juniper, Texas oak, shin oak, cedar elm, netleaf hackberry, flameleaf sumac, agarito, Mexican persimmon, Texas pricklypear, kidneywood, saw greenbriar, Texas wintergrass, little bluestem, curly mesquite, Texas grama, Halls panicum, purple three-awn, hairy tridens, cedar sedge, two-leaved senna, mat euphorbia, rabbit tobacco.	Chiefly on level to gently rolling uplands and ridge tops, Edwards Plateau.
Crops	Cultivated cover crops or row crops providing food and or fiber for either man or domestic animals. This type may also portray grassland associated with crop rotations.	Statewide.
Live oak/Ashe Juniper parks	(Edwards Plateau): Live oak, Texas oak, shin oak, cedar elm, netleaf hackberry, flameleaf sumac, agarito, Mexican persimmon, Texas pricklypear, kidneywood, saw greenbriar, Texas wintergrass, little bluestem, curly mesquite, Texas grama, Halls panicum, purple three-awn, hairy tridens, cedar sedge, two-leaved senna, mat euphorbia, rabbit tobacco.	Chiefly on level to gently rolling uplands and ridge tops, Edwards Plateau.
Oak-Mesquite-Juniper Parks/Woods	Post oak, mesquite, Ashe juniper, shin oak, Texas oak, blackjack oak, live oak, cedar elm, agarita, soapberry, sumac, hackberry, Texas pricklypear, Mexican persimmon, purple three-awn, hairy grama, Texas grama, sideoats grama, curly mesquite, Texas wintergrass.	This type occurs as associations or as a mixture of individual (woody) species stands on uplands in the Cross Timbers and Prairies.
Live Oak-Mesquite Parks	Live oak, mesquite, post oak, blackjack oak, cedar elm, black hickory, whitebrush, agarita, Mexican persimmon, woollybucket bumelia, elbowbush, buffalograss, curly mesquite, Texas grama, sideoats grama, hairy grama, little bluestem, Texas wintergrass, purple three-awn, Indian mallow, Texas bluebonnet, firewheel.	Primarily on granitic soils of the Edwards Plateau (Central Mineral Region)
Live oak/Ashe juniper woods	Live oak, Texas oak, shin oak, cedar elm, Ashe juniper, evergreen sumac, escarpment cherry, saw greenbriar, mescal bean, poison oak, twist-leaf yucca, elbowbush, cedar sedge, little bluestem, Neally grama, meadow dropseed, Texas wintergrass, curly mesquite, pellitory, noseburn, spreading sida, woodsorrel, mat euphorbia	Chiefly on shallow limestone soils on the hills and escarpment of the Edwards Plateau.

*Table 3-8 continued on next page.

Table 3-8, continued

Vegetational Types Within the Lower Colorado River Basin

Vegetation Type	Commonly Associated Plants	Distribution
Silver Bluestem-Texas Wintergrass Grassland	Little bluestem, silver bluestem, Texas wintergrass, sideoats grama, Texas grama, three-awn, hairy grama, tall dropseed, buffalograss, windmillgrass, hairy tridens, tumblegrass, western ragweed, broom snakeweed, Texas bluebonnet, live oak, post oak, mesquite.	Primarily in the Cross Timbers and Prairies.
Post Oak Woods/Forest	(Post Oak Savannah): Post oak, blackjack oak, eastern redcedar, mesquite, black hickory, live oak, sandjack oak, cedar elm, hackberry, yaupon, poison oak, American beautyberry, hawthorn, supplejack, trumpet creeper, dewberry, coral-berry, little bluestem, silver bluestem, san lovegrass, beaked panicum, three-awn, sprangle grass, tickclover.	Most apparent on the sandy soils of the Post Oak Savannah.
Pine-Hardwood Forest Loblolly Pine-Post Oak	Post oak, loblolly pine, black hickory, blackjack oak, eastern redcedar, cedar elm, hackberry, greenbrier, yaupon, elbowbush, purpletop, sand lovegrass, broomsedge bluestem, little bluestem, brownseed, paspalum, bushclover, tickclover, gay feather, yellow neptunia, bitter sneezeweed, velvet bundleflower.	The “Lost Pines” in Bastrop County and westward of the pine producing region of east Texas.
Post Oak Woods, Forest and Grassland Mosaic	(Post Oak Savannah): Post oak, blackjack oak, eastern redcedar, mesquite, black hickory, live oak, sandjack oak, cedar elm, hackberry, yaupon, poison oak, American beautyberry, hawthorn, supplejack, trumpet creeper, dewberry, coral-berry, little bluestem, silver bluestem, san lovegrass, beaked panicum, three-awn, sprangle grass, tickclover.	Most apparent on the sandy soils of the Post Oak Savannah
Pecan-Elm Forest	Pecan, American elm, cedar elm, cottonwood, sycamore, black willow, live oak, Carolina ash, bald cypress, water oak, hackberry, virgin’s bower, yaupon, greenbrier, mustang grape, poison oak, Johnson grass, Virgina wildrye, Canada wildrye, rescuegrass, frostweed, western ragweed.	Bottomlands in the Brazos, Colorado, Guadalupe, San Antonio, and Frio River basins and Gulf Coast Prairie reaches of the San Bernard, Navidad and Lavaca Rivers.

*Table 3-8 continued on next page.

Table 3-8, continued

Vegetational Types Within the Lower Colorado River Basin

Vegetation Type	Commonly Associated Plants	Distribution
Marsh/Barrier Island Maidencane-Alligator Weed (fresh) Marsh	Maidencane, alligator weed, water hyacinth, cattail, water-pennywort, pickerelweed, arrowhead, white waterlily, cabomba, coontail, duckweed.	Hydric lowlands landward of brackish marsh, Coastal Prairies and Marshes
Marsh/Barrier Island Marshay Cordgrass-Olneyi Three-Square-Leafy Three-Square (brackish) Marsh	Marshhay cordgrass, big cordgrass, widgeongrass, California bulrush, seashore paspalum, sacahuista, common reed.	Generally landward of normal tidelands to storm tide, Coastal Prairies and Marshes.
Marsh/Barrier Island Smooth Cordgrass-Marsh Saltgrass-Sea Ox-eye (saline) Marsh	Smooth cordgrass, saltgrass, sea ox-eye, black rush, vidrillos, black mangrove, glasswort, seashore paspalum, shoalgrass.	Tidally-inundated shores of bays, Gulf Coast.
Marsh/Barrier Island Seaoats-Seacoast Bluestem Grassland	Seaoats, seacoast bluestem, croton, single-spike paspalum, Pan American balsamscale, flat sedge, sea purslane, cenicilla bulrush, beach morningglory, goatfoot morningglory, sea rocket, lime pricklyash.	Sandy coastal barrier islands from high tide mark to leeward marshes.

*Source: TPWD 1984

Vegetation types of the Blackland Prairie and Oak Woods and Prairies include Crops, Silver Bluestem-Texas Wintergrass Grassland, Other Native and/or Introduced Grasses, Live Oak-Mesquite Parks, Pine-Hardwood Forest, and Post Oak Woods/Forest.

The vegetation regions of the Coastal Reach include the Blackland Prairie to the west and Gulf Coast Prairies near the coast. Vegetation types of the Blackland Prairie in the Coastal Reach include Crops, Other Native and/or Introduced Grasses, and Pine-Hardwood Forest. Vegetation types of the Gulf Coast Prairies include Crops, Pecan-Elm Forest, and Marsh/Barrier Island.

A variety of different types of soils are present in the study area as well (USDA 1968, 1970, 1974a, 1974b, 1974c, 1974d, 1975, 1976, 1977a, 1977b, 1978, 1979a, 1979b, 1979c, 1980a, 1980b, 1981a, 1981b, 1982a, 1982b, 1984, 1986, 1988, 1992, 2000, 2001, 2002). A separate treatment of all the soil types would be exhaustive and is not appropriate for the level of detail presented in this report. However, there are generalizations that may be made of the different soil types within the study area.

In the North-Central Plains, Central Texas Uplift, and Edwards Plateau regions, parent material for soils includes shale, sandstone, granite, and limestone bedrock, and topography is rolling to rugged. Soils in these areas tend to be shallow, stony and sloping. Soils formed over shale or limestone tend to be calcareous, while soils formed over sandstone or granite are more likely to be neutral or acidic. In the Blackland Prairies, Coastal Prairies, and the Interior Coastal Plains, parent material grades from chalks and marls to bands of sands and shales. Soils tend to be deeper and more level in slope. In the Gulf Coastal Plains, soils primarily formed from deltaic sands, silts and clays and are generally level, young soils.

Prime farmlands are protected under the Farmland Protection Policy Act (FPPA) of 1980 and 1995. The purpose of the FPPA is to minimize the extent to which Federal programs contribute to unnecessary and irreversible conversion of farmland to nonagricultural uses. As required by section 1541(b) of act, 7 U.S.C. 4202(b), Federal agencies are (a) to use the criteria to identify and take into account the adverse effects of their programs on the preservation of farmland, (b) to consider alternative actions, as appropriate, that could lessen adverse effects, and (c) to ensure that their programs, to the extent practicable, are compatible with state and units of local government and private programs and policies to protect farmland.

Prime farmlands are those farmlands that have best combinations of physical and chemical properties to be able to produce fiber, feed, or food, and are available for these uses. Prime farmlands in Texas are classified as Prime Farmland Code 4 spoils. Unique farmland is defined as land other than prime farmland that is used for producing specific high-value food and fiber crops.

Highland Lakes Reach.

Rolling Plains. The Rolling plains vegetation area is a part of the Great Plains region of the central U.S. Soils vary from coarse sands along stream terraces to tight clays or red-bed clays and shales. Soils are typically neutral to slightly calcareous. Approximately two-thirds of the region is still in rangeland with cattle as the primary class of livestock. The original prairie vegetation included tall and mid-grasses, such as little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), sideoats grama (*Bouteloua curtipendula*), Indiangrass (*Sorghastum nutans*), switchgrass (*Panicum virgatum*), hairy grama (*Bouteloua hirsuta*), Canada wildrye (*Elymus canadensis*), and western wheatgrass (*Agropyron smithii*). Buffalograss (*Buchloe dactyloides*), curly mesquite (*Hilaria mutica*), threeawns (*Aristida* spp.), and hooded windmill grass (*Chloris cucullata*) tend to increase with grazing. Mesquite (*Prosopis glandulosa*) is a common invasive on all soils and shinnery oak (*Quercus* spp.) and sand sage (*Artemisia filifolia*) tend to invade disturbed areas with sandy soils. Under heavy grazing pressure, species such as sand bur (*Cenchrus insertus*), Texas grama (*Bouteloua rigidiseta*), western ragweed (*Ambrosia psilostachya*) and species of croton (*Croton* spp.) increase.

Cross-Timbers and Prairies. The Cross Timbers and Prairies region varies widely in soils and land use, but remains fairly uniform in climax understory vegetation. Brushy species such as mesquite and juniper (*Juniperus* spp.*)* have invaded much of the prairie proper. The region includes the Western Cross Timbers, the North Central Prairies and the Grand Prairie. Surrounded by prairie on both sides, the Cross Timbers represent the western extension of woody components of the eastern deciduous forest before the vegetation changes into the vast expanse of central U.S. grasslands known as the Great Plains.

The Cross Timbers and Prairies ecoregion encompasses a range of vegetation communities from woodlands to open parks or savannahs and pockets of tallgrass prairie primarily on deeper uplands soils. Climax vegetation is generally composed of tall and mid-height prairie grasses such as little bluestem, big bluestem, Indiangrass, switchgrass, Canada wildrye, and sideoats grama. In most grassland areas, earlier successional species have increased with grazing. These increaser or invader species include Texas wintergrass (*Stipa leucotricha*), threeawns (*Aristida* spp.) and annual

forbs. Land use practices such as heavy grazing and fire suppression have resulted in increase cover of woody species such as mesquite and juniper with mid and short grass understories. Range and pasture occupy approximately 75% of the Cross Timbers and Prairies. Major crops on the sandy soils include peanuts, fruits, sorghum, wheat, oats, corn, and forages.

Woodlands are dominated by post oak (*Quercus stellata*), Ashe juniper (*Juniperus ashei*), shin oak (*Quercus sinuata*) and blackjack oak (*Quercus marilandica*). Wooded bottomlands are vegetated primarily with hardwoods such as cedar elm (*Ulmus crassifolia*) and hackberry (*Celtis* spp.). The Western Cross Timbers contains the least developed oak-hickory forest due to more arid conditions. These forests are less dense than forests further east and contain fewer eastern species.

Edwards Plateau. The Edwards Plateau ecoregion is defined by the Balcones Escarpment on the east and south, while to the north and west it grades into adjacent vegetation areas. According to historical reports, the original vegetation on much of the Edwards Plateau ecoregion was grassland or open savannah with dense woodlands and brush generally restricted to rocky slopes and stream bottoms. Tallgrasses such as little bluestem, Indiangrass, big bluestem, and silver bluestem (*Bothriochloa saccharoides*) are still common along rocky outcrops and areas having good soil moisture. Midgrasses and shortgrasses such as sideoats grama, buffalograss, seep muhly (*Muhlenbergia reverchonii*) hairy grama, and Texas grama dominate the shallow xeric sites. Wooded areas are dominated by plateau live oak (*Quercus fusiformis*) and Ashe juniper. Commonly wooded areas include slopes, canyons, and uplands where land practices such as heavy grazing and fire suppression have resulted in former grasslands being converted to woodland. Mesquite and prickly pear (*Opuntia* spp.) are also common woody invaders on uplands. Bottomland woodlands are dominated by bald cypress (*Taxodium distichum*), cedar elm, pecan (*Carya illinoensis*), cottonwood (*Populus deltoides*), hackberry, and black willow (*Salix nigra*).

The portion of the watershed spanning the Edwards Plateau is primarily rangeland; arable lands are found only along the narrow streams and some divides.

In the Highland Lakes Reach, soils on uplands formed over parent bedrock materials including shale, sandstone, granite, and limestone. Soils in these areas tend to be shallow, stony and sloping and may have frequent rock outcrops or rock fragments on the surface. Soils formed over shale or limestone tend to be dark, shallow calcareous clays, with low available water capacity. Soils formed over sandstone or granite tend to be loamy and are more likely to be neutral or acidic. Upland soils are generally unsuitable for cultivation because they are shallow, rocky, and often too

steep. These soils may support grassland, savannah or woodland/brushland, depending on land use and management.

Soils encountered along the Colorado River and tributaries in the Highland Lakes Reach include steam terrace soils and bottomland soils. Terrace soils tend to be deep, gently sloping, loamy or clayey and moderately alkaline. These soils tend to have a high available water capacity and are often suitable for cultivation. Alluvial soils in the bottomlands are generally shallow until the Colorado River nears Austin and enters the Balcones Escarpment. Here, alluvial soils along the Colorado River and tributaries become deeper, and ancient gravel terrace deposits flank the river and tributaries due to geologic influence of ancient faulting within the Balcones fault zone. Alluvial bottomland soils are clayey or loamy soils with gentle to nearly level slopes moderately alkaline to acidic in reaction. Like the terrace soils, bottomland soils tend to have a high available water capacity and are often suitable for cultivation; however, frequent flooding may be a limitation for may land uses.

Data for prime farmland was not available for 5 of the 25 counties in the Highland Lakes Reach (Coleman, Comanche, Eastland, Mason, and Schleicher). Of the available data, approximately 1,081,288 acres in the Highland Lakes Reach, or 16% of the land area, meet the soil requirements for prime farmland (USDA 1994). An additional 339,245 acres would qualify if altered (i.e., irrigated, drained, etc.).

Central Reach

Blackland Prairie. Portions of the Central Reach lie within the region known as the Blackland Prairie. This area grades into the Post Oak Savannah in the southeast and has divisions known as the San Antonio and Fayette Prairies. This ecoregion represents the southern extension of the North American true prairie that occurs from Texas to Canada.

Much of the Blackland Prairie has been cultivated to produce cotton, sorghum, corn, wheat, and forage during the latter part of the 19th century and the first part of the 20th century. However, many areas have lost productivity through erosion and continues cropping. Since the early 20th century, pasture and forage crops have increased for the production of livestock.

Tallgrasses dominated the Blackland Prairie prior to its widespread conversion to crops and grazing land. Dominant climax grass species included big and little bluestem, switchgrass, Indiangrass, and tall dropseed (*Sporobolus asper*). Under grazing or other disturbances, the community shifts to earlier successional grass species such as Texas wintergrass, silver bluestem, hairy grama, and buffalograss as well as woody invaders such as mesquite, hackberry, post oak and Ashe

juniper. Common forbs include western ragweed, broom snakeweed (*Xanthocephulum dracunculoides*), various clovers (*Trifolium* spp.) and vetch (*Vicia* spp.). Lowland hardwood tree species that are common along drainages include oaks, elm, cottonwood, eastern red cedar (*Juniperus virginiana*), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanicas*), and pecan.

Post Oak Savannah. The Post Oak Savannah, sometimes referred to as Oak Woods and Prairies, mixes considerably with the Blackland Prairies area in the south. This area includes the entire Claypan land resource area of Texas, which is part of the Southern Coastal Plains. The Post Oak Savannah is a gently rolling, moderately dissected wooded plain.

The Post Oak Savannah is characterized by woodland and savannah dominated by post oak with a tallgrass understory, and is similar in species composition to the Cross Timbers and Prairies discussed above. However, the Post Oak Savannah contains a more developed oak-hickory forest due to a higher rainfall than in woodlands further west. Pockets of deep soils support tallgrass prairies. In uplands, woody species include post oak, blackjack oak, and eastern red cedar, with an understory of yaupon (*Ilex vomitoria*), farkleberry (*Vaccinium arboreum*) and dewberry (*Rubus* spp.). In riparian areas and bottomlands, dominant trees include water oak (*Quercus nigra*), green ashe (*Fraxinus pennsylvanica*), American elm, willow oak (*Quercus phellos*), and hickory (*Carya* spp.). Common shrubs include deciduous holly (*Ilex decidua*), hawthorns (*Crataegus* spp.) and American beautyberry (*Callicarpa americana*). Climax grasses are little bluestem, silver bluestem, splitbeard bluestem (*Andropogon ternaries*), Indiangrass, switchgrass, and brown seed paspalum (*Paspalum plicatulum*). Forbs similar to the true prairie species are wild indigo (*Baptisia* spp.), senna (*Cassia* spp.), tick clover (*Desmodium* spp.), bush clover (*Lespedezas* spp.), prairie clovers, western ragweed, crotons (*Croton* spp.), and sneezeweeds.

As discussed for the Blackland Prairies, grasslands tend to be converted to woodlands in the absence of recurring fires or other methods of woody plant suppression. The area is well suited to grain crops, cotton, vegetables, and fruit trees. It was extensively cropped through the 1940s, but many acres have since been returned to native vegetation or tame pastures. Pasturelands have frequently been seeded with introduced species such as bermudagrass (*Cynodon dactylon*), bahia grass (*Paspalum notatum*), weeping love grass (*Eragrostis curvula*), King Ranch bluestem (*Bothriochloa ischaemum*), and clover.

Livestock grazing occurs in tame pastures, native pastures, or the woodland areas throughout the year. Wheat, oats, and rye are often planted for winter pasture.

As the Colorado River enters the Blackland Prairie region, upland soils become thicker and more fully developed over clayey, silty, and sandy bedrock units. Alluvial soils in floodplains along the river and tributaries also become thicker and wider in extent as a result of the gentler gradient of the river, allowing development of deeper soils. Parent material along floodplains and terraces of the Colorado River and its major tributaries includes Pleistocene and Recent age deposits. These soils are generally deep, nearly level, well drained, loamy in texture and moderately alkaline. Many of these soils are suitable for cultivation for crops or improved pastureland, as well as rangeland and wildlife habitat uses. Frequent flooding may limit land uses in bottomland areas.

Approximately 343,719 acres in the Central Reach, or 24% of the land area, meet the soil requirements for prime farmland (USDA 1994). Data for counties in the Central Reach are not available to determine the amount of prime farmland that would be available if soils were altered (i.e. drained, irrigated, etc.).

Coastal Reach

The Coastal Reach lies within the Blackland Prairies and Gulf Prairies and Marshes vegetational regions (Gould 1975). Coastal prairies in Texas have dwindled from an original 13 million acres, to fewer than 250,000 acres today (TPWD 1996). Approximately 80% of the native prairie within the Coastal Reach has been converted to cropland. Predominant crops in the region are rice, corn, grain sorghum, and cotton.

Post Oak Savannah. The Post Oak Savannah covers much of the northwest third of Colorado County and accounts for about 10% of the Coastal Reach. As described in the Central Reach section, typically, oaks such as post oak, water oak, and blackjack oak are the dominant overstory species interspersed with various native grass species. Much of this vegetation type has been converted to pasture. Many of these pastures have been seeded with nonnative species such as bermudagrass, bahiagrass, weeping lovegrass, King Ranch bluestem, and clover. Native grasses and herbs are also found in these pastures, but in lower densities than in their native habitat

Gulf Prairies and Marshes. The Gulf Prairies and Marshes region is nearly level with slow surface drainage and elevations from sea level to +250 ft msl. The original vegetation types of the Gulf Prairies were coastal prairie and Post Oak Savannah. Characteristic overstory species are live oak and post oak. Other common woody species are huisache (*Acacia farnesiana*), mesquite, baccharis (*Baccharis halimifolia*), and the introduced and heavily invasive Chinese tallow (*Sapium sebiferum*).

Principal climax grasses of the Gulf Prairies are little bluestem, big bluestem, Indiangrass, and switchgrass, with gulf cordgrass (*Spartina spartinae*) and marshhay cordgrass (*Spartina patens*) common in more saline sites. The Gulf Prairies are used for crops, livestock grazing, wildlife production, and increasingly for urban and industrial centers. About one-third of the area is cultivated mostly for rice, sorghum, corn, and tame pastures. Bermudagrass and introduced bluestems are common introduced pasture grasses.

The Elm/Pecan Forest occupies parts of the Colorado River floodplain in central Wharton County. Trees commonly found in the bottomland hardwood forests include American elm, pecan, oaks, cottonwood and hackberry.

One of the more unique bottomland forest systems within the basin is the Columbia Bottomlands. The Columbia Bottomlands is a natural forested area of about 170,000 acres that extends in a 50-mile wide corridor alongside the Brazos, San Bernard, and Colorado rivers (USFWS 1997a). A double canopy of trees and shrubs and a network of rivers, creeks, oxbows, sloughs, ponds, and marshes represent this ecosystem (TPWD 2004a).

Approximately 5% of the Coastal Reach consists of the Marsh/Barrier Island vegetation type and covers all of the Coastal Reach in Matagorda County south of the GIWW. Marshy areas are dominated by a variety of hydrophytes such as grasses, rushes (*Juncus* spp.) and sedges (*Carex* spp.) and often form dense stands. Vegetation of the barrier islands is typically sparse and contains halophytic grasses, forbs, and shrubs.

The Gulf Marshes occur on a narrow strip of lowlands adjacent to the coast and the barrier islands, which extend from Mexico to Louisiana. The Gulf Marshes are low, wet, marshy coastal areas that range from sea level to a few feet in elevation. The marsh areas of the Matagorda Bay system consist mostly of smooth cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*Spartina patens*), and gulf cordgrass (*Spartina spartinae*) but also support other species of sedges, rushes, bulrushes (*Scirpus* spp.), seashore saltgrass (*Distchlis spicata*), common reed (*Phragmites communis*), glassworts (*Salicornia* spp.) and sea ox-eye daisy (*Borrichia frutescens*).

Upland soils within the upper portion of the Coastal Reach are typically gray, slightly acidic sandy loams that overlay gray, mottled, or red, firm clayey subsoils. Infiltration-resistant claypan layers occur at varying soils depths, which impedes the percolation of moisture. Bottomland soils are reddish-brown to dark gray, slightly acid to calcareous, loamy to clayey alluvial.

Farther downstream, soils are acid sands, sandy loams and clays (USDA 1974). Upland prairie soils tend to be heavier textured acid clays or clay loams, although some sandy loams are present. In general, soils have slowly permeable profiles and soil moisture is not readily available to vegetation. Better soils are highly productive under cultivation, or as improved pasture or native range. Soils of the Coastal Reach marshes are dark, poorly drained sand loams and clays, and light neutral sands, typically showing little textural change with depth. The loamy and clayey soils are commonly saline and sodic. Prairie soils are dark, neutral to slightly acidic clay loams and clays.

A narrow band of light acid sands and darker loamy to clayey soils stretch along the coast. The lower reach of the Colorado River Floodplain is characterized by nearly level to weakly undulating soils that are very deep, clayey to loamy, and well drained to poorly drained. Soils in areas with high clay tend to have high shrink-swell potential that may limit urban uses. Flooding is infrequent because of upstream flood control dams and deepening of the river channel. These soils are very fertile and well suited to cropland, pasture and rangeland.

Nearly half of the land in the Coastal Reach (303,963 acres) is designated as prime farmland with 2,434 acres of that land requiring drainage (USDA 1994).

Noxious and Invasive Species. Over the past 100-200 years, there has been a significant expansion of undesirable or invasive species across the nation and Texas. A species is termed "invasive" if it is able to spread aggressively outside of its original environment and out-compete native species. Invasive species include exotic ornamental plants that were imported for horticultural use; grasses that were introduced from other countries for use in lawns or as improved pasture or grazing species; and exotic species that were introduced by natural resource agencies for erosion control. There are also native plant species that may become invasive under certain land management scenarios.

There are several problems associated with undesirable or invasive species expansion. Although these plant species may provide shelter, they usually have minimal if any food value to fish and wildlife, particularly if they are not native. They tend to out compete native species and develop monotypic stands resulting in decreased diversity. Invasive aquatic species in particular may cause serious problems in state waters. Invasive aquatic species such as hydrilla (*Hydrilla verticillata*) can reduce flow in waterways, impede boating, fishing, swimming and clog water intakes for irrigation and electrical generation. Thick vegetation mats also reduce oxygen content and degrade water quality for fish and other aquatic organisms.

The Texas Legislature, recognizing the potential ecological and economic impacts of invasive and exotic noxious plant species, has amended the Texas Agricultural code to require the establishment of a noxious plant list. The plants on the list are those determined to have serious potential to cause economic or ecological harm to the state. Section 19.200 of the Texas Agriculture Code, Chapter 71, prohibits selling, distributing or importing plants on the list into Texas. The draft noxious plant list for Texas, as published by the Natural Resources Conservation Service, is presented in Table 3-9. Those with potential to occur in significant amounts in the lower Colorado River basin are shown in bold. In addition to those species identified in Table 3-9 in the Colorado River basin, other exotic species, or species that are potentially invasive include Ashe juniper (*Juniperus ashei*), Bermudagrass, elephant ear (*Colocasia esculenta*), King Ranch bluestem, and *Ligustrum* spp.

3.2.8 Wildlife Resources

From a wildlife standpoint, the Balcones Escarpment is the most important physiography boundary in the basin as it creates a sharp division between the relatively xeric and rocky upland habitats of the Highland Lakes Reach and the more mesic, deep-soiled habitats of the Central and Coastal Reaches. Many terrestrial species of wildlife find the limits of their range at the Balcones Escarpment.

Human activities have altered wildlife habitats nearly throughout the basin, with habitats in the Central and Coastal Reaches having been most greatly affected. Based on TPWD (2002), approximately 74.5% of the Blackland Prairie eco-region, 58.2% of the Gulf Coast Prairies and Marshes eco-region, and 44.7% of the Post Oak Savannah eco-region have been converted to urban or agricultural use. Habitats in the Highland Lakes Reach are expected to be much less disturbed, as approximately 20.1% of the Edwards Plateau has been converted to these uses (TPWD 2002). Far greater amounts of the Rolling Plains and Cross Timbers and Prairies eco-regions have been converted to urban or agricultural uses (74.6% and 63.6%, respectively), but these eco-regions make up only a small portion of the Highland Lakes Reach.

Many State Parks, WMAs, State Natural Areas, Federal National Wildlife Refuges and LCRA parks are present within the basin. These are listed, by reach, in Table 3-10. Additionally, COA owns and operates approximately 88 parks on the mainstem of the Colorado River or tributaries with a total acrea in excess of 17,000 acres. Additionally, all of the other communities along the

Table 3-9
Natural Resources Conservation Service
Noxious Plants of Texas

Common Name	Scientific Name	State Status	U.S. Nativity
Alligatorweed	*Alternanthera philoxeroides (Mart.) Griseb.*	Noxious Plant	I
Balloonvine	*Cardiospermum halicacabum L.*	Noxious Plant	N
Branched broomrape	*Orobanche ramosa L.*	Noxious Plant	I
Brazilian peppertree	*Schinus terebinthifolius Raddi*	Noxious Plant	I
Camelthorn	*Alhagi camelorum Fisch.*	Noxious Plant	?
Chinese tallow	*Sapium sebiferum (L.) Roxb.*	Noxious Plant	?
Eurasian watermilfoil	*Myriophyllum spicatum L.*	Noxious Plant	I
Field bindweed	*Convolvulus arvensis L.*	Noxious Plant	I
Giant duckweed	*Spirodela oligorrhiza (Kurz) Hegelm.*	Noxious Plant	?
Giant reed	*Arundo donax L.*	Noxious Plant	I
Hedge bindweed	*Calystegia sepium*	Noxious Plant	NI
Hydrilla	*Hydrilla verticillata (L.f.) Royle*	Noxious Plant	I
Itchgrass	*Rottboellia cochinchinensis (Lour.) W.D. Clayton*	Noxious Plant	I
Japanese dodder	*Cuscuta japonica Choisy*	Noxious Plant	I
Kudzu	*Pueraria lobata (Willd.) Ohwi*	Noxious Plant	?
Lagarosiphon	*Lagarosiphon major (Ridley) Moss*	Noxious Plant	XU
Paperbark	*Melaleuca quinquenervia (Cav.) Blake*	Noxious Plant	I
Purple loosestrife	*Lythrum salicaria L.*	Noxious Plant	I
Rooted waterhyacinth	*Eichhornia azurea (Sw.) Kunth*	Noxious Plant	I
Saltcedar	*Tamarix ramosissima L.*	Noxious Plant	I
Salvina	*Salvinia séguier*	Noxious Plant	I
Serrated tussock	*Nassella trichotoma*	Noxious Plant	XU
Torpedograss	*Panicum repens L.*	Noxious Plant	N
Tropical soda apple	*Solanum viarum Dunal*	Noxious Plant	I
Water spinach	*Ipomoea aquatica Forsk.*	Noxious Plant	I
Waterhyacinth	*Eichhornia crassipes (Mart.) Solms*	Noxious Plant	I
Waterlettuce	*Pistia stratiotes L.*	Noxious Plant	N

N=native
n?=probably native
NI=some populations native, some introduced
I=introduced
XU=not in U.S. or cultivated
?=unknown

*Source: USDA Plants Database 2003.

Table 3-10

Federal, State, and LCRA Lands in the Lower Colorado River Basin

(out of approx. 50,000 acres, acreage above and below NPE–Normal Pool Elevation)

Highland Lakes Reach			
National Wildlife Refuges	County	Resource Emphasis	Acreage
Balcones Canyonlands	Burnet, Travis, Williamson	Black-capped vireo, golden-cheeked warbler	20,000
State Parks	County	Resource Emphasis	Acreage
Abilene	Taylor	Lake Abilene	330
Colorado Bend	Lampasas, San Saba	Edwards Plateau habitats	5,328
Inks Lake	Burnet	Inks Lake, Llano Uplift habitats	1,201
Lake Brownwood	Brown	Lake Brownwood, recreation	538
Lake Colorado City	Mitchell	Lake Colorado City, recreation	500
Longhorn Cavern	Burnet	Longhorn Cavern	646
McKinney Falls	Travis	Recreation	744
Pedernales Falls	Blanco	Edwards Plateau habitats	5,212
San Angelo	Tom Green	Recreation, O.C. Fisher Reservoir	7,677
South Llano River	Kimble	Edwards Plateau habitats	524
State Natural Areas	County	Resource Emphasis	Acreage
Bright Leaf	Travis	Edwards Plateau habitats	217
Enchanted Rock	Gillespie, Llano	Recreation	1,644
State Wildlife Management Areas	County	Resource Emphasis	Acreage
Mason Mountain	Mason	White-tailed deer, African ungulates	5,000
Walter Buck	Kimble	Edwards Plateau habitats	2,155
LCRA Tracts	County	Resource Emphasis	Acreage
*Arkansas Bend	Travis	Habitat conservation and recreation	637
Black Rock	Llano	Recreation	25
Camp Creek	Travis	Conservation, Recreation	445
Canyon of the Eagles	Burnet	Habitat conservation, Public Education, Recreation	925
Cedar Point	Llano	Conservation, Recreation	878
*Cypress Creek	Travis	Recreation	102
Gloster Bend	Travis	Recreation	620
**Granite Beach	Burnet	Recreation	NA
Grelle	Travis	Recreation	582
*Mansfield Dam	Travis	Recreation	392

*Table 3-10 continued on next page.

Table 3-10, continued

Federal, State, and LCRA Lands in the Lower Colorado River Basin

(out of approx. 50,000 acres, acreage above and below NPE–Normal Pool Elevation)

Highland Lakes Reach			
LCRA Tracts con…	County	Resource Emphasis	Acreage
McGregor Resource Area	Travis	Conservation, BCP Land, Recreation	531 total
*Bob Wentz at Windy Point	Travis	Recreation	211
*Hippie Hollow	Travis	Recreation	109
Muleshoe Bend	Travis	Conservation, Recreation	1,305
Narrows	Burnet	Conservation, Recreation	59
Nightengale Archaeological Center	Burnet	Cultural Resources, Public Education, Recreation	13
*Pace Bend	Travis	Recreation	2,741
*Sandy Creek	Travis	Recreation	25
Shaffer Bend	Burnet	Conservation, Recreation	523
Turkey Bend	Travis	Conservation, Recreation	1,316
Westcave Preserve	Travis	Conservation, BCP land, Public Education	28
Wheless Preserve	Travis	Conservation, BCP land	2,400

Central Reach			
State Parks	County	Resource Emphasis	Acreage
Bastrop	Bastrop	Lost Pines habitats, Houston toad	3,504
Buescher	Bastrop	Lost Pines habitats, Houston toad	1,017
LCRA Tracts	County	Resource Emphasis	Acreage
Cooper Farm FPP Resource Area	Fayette	Power Production, Conservation, Recreation	6610 total
Oak Thicket	Fayette	Recreation	85
Park Prairie	Fayette	Recreation	20
Lake Bastrop Resource Area (including North and South Shore Parks)	Bastrop	Conservation, Recreation	2817 total
North Shore Park	Bastrop	Recreation	
South Shore Park	Bastrop	Recreation	
McKinney Roughs Nature Park	Bastrop	Habitat Conservation, Public Education, Recreation	1,789
Plum Creek Resource Area	Fayette	Conservation, Recreation	39
#White Rock Park	Fayette	Recreation	23

*Table 3-10 continued on next page.

Table 3-10, continued

Federal, State, and LCRA Lands in the Lower Colorado River Basin

(out of approx. 50,000 acres, acreage above and below NPE–Normal Pool Elevation)

Coastal Reach			
National Wildlife Refuges	County	Resource Emphasis	Acreage
Big Boggy	Matagorda	Waterfowl, coastal habitats	5,000
San Bernard	Matagorda	Waterfowl, coastal habitats	28,000
State Wildlife Management Areas	County	Resource Emphasis	Acreage
D.R. Wintermann	Wharton	Waterfowl, coastal habitats	246
Peach Point	Brazoria	Waterfowl, coastal habitats	10,311
LCRA Tracts	County	Resource Emphasis	Acreage
Hollywood Bottom	Wharton	Recreation	36
Matagorda Bay Nature Park	Matagorda	Habitat Conservation, Public Education, Recreation	1,600

* Public park area is operated by Travis County

** Leased to private operations

Developed in cooperation with the City of La Grange

Colorado River have park lands that contribute to wildlife habitat. Other important wildlife habitats protected in the basin include the Balcones Canyonlands Preserve of the Highland Lakes Reach, and some properties in the Highland Lakes and Coastal reaches owned by TNC.

Based on Schmidly (2004), a total of 72 native mammal species, excluding marine species, may be permanent residents somewhere within the basin. Total mammal diversity is considerably higher in the Highland Lakes Reach, with 59 of the 72 species present (81.9%). The Central and Coastal reaches are each expected to have 46 species present (63.9%). Mammals as a group typically contain more habitat generalists than do other vertebrate groups. As a result, the Balcones Escarpment has less influence on the distribution of mammals within the basin than it does on these other groups.

Of the 72 mammal species, 40 (55.6%) are expected to occur in all three reaches, albeit some may occur more commonly east or west of the Balcones Escarpment and some may be absent from large portions of a particular reach altogether. Common medium-sized or larger native species of mammals expected to occur nearly throughout the basin include Virginia opossum (*Didelphis virginiana*), nine-banded armadillo (*Dasypus novemcinctus*), eastern cottontail (*Sylvilagus floridanus*), coyote (*Canis latrans*), common raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and white-tailed deer (*Odocoileus virginianus*). Small mammals expected to occur nearly throughout the basin in appropriate habitat include Brazilian free-tailed bat (*Tadarida brasiliensis*), eastern fox squirrel (*Sciurus niger*), hispid pocket mouse (*Chaetodipus hispidus*), white-footed mouse (*Peromyscus leucopus*), deer mouse (*Peromyscus maniculatus*), and hispid cotton rat (*Sigmodon hispidus*).

Based on review of Lockwood and Freeman (2004), 129 bird species are expected to be permanent residents in some portion of the lower Colorado River basin, with another 58 migratory species occurring in the basin during the breeding season as nesting species or post-breeding wanderers. Of these 187 total species, 80 (42.8%) breed in at least portions of all three reaches. Breeding bird diversity is highest in the Coastal Reach, with 138 of the 171 species present (80.7%), and lowest in the Central Reach, with 115 species present (61.5%). An additional 111 species of birds winter regularly within some portion of the basin, and 62 more species are regular migrants through the region.

Many permanent resident bird species are widespread and occur nearly throughout the basin, excluding some coastal habitats. Widespread familiar species include great blue heron (*Ardea herodias*), black vulture (*Coragyps altratus*), red-tailed hawk (*Buteo jamaicensis*), killdeer

(*Charadrius vociferous*), great horned owl (*Bubo virginianus*), mourning dove (*Zenaida macroura*), blue jay (*Cyanocitta cristata*), Carolina chickadee (*Poecile carolinensis*), Carolina wren (*Thryothorus ludovicianus*), northern cardinal (*Cardinalis cardinalis*), red-winged blackbird (*Agelaius phoeniceus*), and great-tailed grackle (*Quiscalus mexicanus*).

Birds present nearly throughout the basin but only during the breeding season include yellow-billed cuckoo (*Coccyzus americanus*), common nighthawk (*Chordeiles minor*), chimney swift (*Chaetura pelagica*), scissor-tailed flycatcher (*Tyrannus forficatus*), cliff swallow (*Petrochelidon pyrrhonota*), and painted bunting (*Passerina ciris*). Common wintering bird species present throughout the basin include American kestrel (*Falco sparverius*), house wren (*Troglodytes aedon*), ruby-crowned kinglet (*Regulus calendula*), hermit thrush (*Catharus guttatus*), cedar waxwing (*Bombycilla cedrorum*), yellow-rumped warbler (*Dendroica coronata*), savannah sparrow (*Passercuclus sandwichensis*), and American goldfinch (*Carduelis tristis*). Although not considered common, the bald eagle (*Haliaeetus leucocephalus*) is a regular breeding and winter resident of all reaches.

A total of 39 species of amphibians are known or expected to occur in portions of the lower Colorado River basin (Dixon 2000). However, because of the relatively drastic change in habitat types at the Balcones Escarpment, only 13 species (33.3%) are expected to occur in all three reaches and just eight (20.5%) are widely distributed throughout the basin. Some of these include Blanchard's cricked frog (*Acris crepitans blanchardi*), Gulf Coast toad (*Bufo valliceps*), bullfrog (*Rana catesbeiana*), and Great Plains narrowmouth toad (*Gastrophryne olivacea*). Total amphibian diversity is relatively equal between reaches, with 27 species (69.2% of basin total 39) present in the Highland Lakes and 25 species each present in the Central and Coastal reaches (64.1%).

A total of 103 species or subspecies of reptiles are known or expected to occur in the lower Colorado River basin (Dixon 2000). These include 16 species of turtle (including two sea turtles know, from the Matagorda County coast), American alligator (*Alligator mississippiensis*), 24 species or subspecies of lizard, and 62 species or subspecies of snake. Total reptile diversity is greatest in the Highland Lakes Reach, with 75 taxa expected to occur (72.8% of the basin total), and lowest in the Central Reach, with 58 taxa (56.3%) present. The Highland Lakes Reach also has the highest diversity of snakes and lizards, while the Coastal Reach has the greatest diversity of turtles.

Seven turtle species occur in all three reaches (Dixon 2000). Widespread turtles within the basin include common snapping turtle (*Chelydra serpentina*), yellow mud turtle (*Kinosternon flavescens*), red-eared slider (*Trachemys scripta elegans*), ornate box turtle (*Terrapene ornata ornata*), and Guadalupe spiny softshell (*Trionyx spiniferus guadalupensis*).

Because of the relatively drastic change in habitat types at the Balcones Escarpment, only six of the 24 lizard taxa (25.0%) occur widely throughout the basin. These include Texas spiny lizard (*Sceloporus olivaceus*), Texas spotted whiptail (*Cnemidophorus gularis gularis*), six-lined racerunner (*Cnemidophorus sexlineatus sexlineatus*), and an introduced species, Mediterranean gecko (*Hemidactylus turcicus*). All are expected to be absent from the coastal marshes.

The change in habitat types caused by the Balcones Escarpment also affects distribution of snakes. Of the 62 snake taxa present in the basin, only 19 (30.6%) are expected to occur in all three reaches. Some of the widespread snakes within the basin are eastern yellow-bellied racer (*Coluber constrictor flaviventris*), Texas rat snake (*Elaphe obsoleta lindheimeri*), eastern hog-nosed snake (*Heterodon platirhinos*), western coachwhip (*Masticophis flagellum*), diamondback water snake (*Nerodia rhombifer rhombifer*), and rough earth snake (*Virginia striatula*).

A more detailed description of each of the three reaches is provided below. Included with each description are names of some of the wildlife species characteristic of that reach.

Highland Lakes Reach. Habitats of the Highland Lakes Reach are relatively arid and rocky compared to those present in the lower two reaches. Because the Edwards Plateau, Rolling Plains, and Cross Timbers and Prairies eco-regions occur only in the Highland Lakes reach, this reach contains many habitats unique to the basin and, consequently, many wildlife species occur regularly in the basin only within this reach.

Because of the comparative aridity of this reach, the highest quality wildlife habitats occur along riparian corridors and in relatively mesic canyons along the Balcones Escarpment. Rangelands and upland woodlands provide moderate to good quality habitat if not too heavily grazed. Areas that have been grazed heavily for long periods of time, especially if grazed by goats since they often remove nearly all vegetative ground cover, generally provide wildlife habitats of low to poor quality.

Based on Davis and Schmidly (1994), mammals that are widespread within this reach but that generally do not occur in the lower reaches include Mexican ground squirrel (*Spermophilus mexicanus*), rock squirrel (*Spermophilus variegatus*), Botta's pocket gopher (*Thomomys bottae*), Merriams' pocket mouse (*Perognathus merriami*), Texas mouse (*Peromyscus attwateri*), southern plains woodrat (*Neotoma micropus*), porcupine (*Erethizon dorsatum*), and common hog-nosed skunk (*Conepatus mesoleucus*).

Characteristic birds of the Highland Lakes Reach include several permanent resident and breeding season resident species. Permanent residents that typically occur only within this reach include, but not limited to, golden-fronted woodpecker (*Melanerpes aurifrons*), western scrub-jay (*Aphelocoma californica*), bushtit (*Psaltriparus minimus*), canyon wren (*Catherpes mexicanus*), and rufous-crowned sparrow (*Aimophila ruficeps*). Migratory species that breed only in this reach include the federally listed endangered black-capped vireo (*Vireo atricapillus*) and golden-cheeked warbler (*Dendroica chrysoparia*), as well as the more common black-chinned hummingbird (*Archilochus alexandri*), ash-throated flycatcher (*Myiarchus cinerascens*), black-and-white warbler (*Mniotilta varia*), and lesser goldfinch (*Carduelis psaltria*).

At least seven species of salamander occur in this reach, including four neotenic taxa that occur at springs and in groundwater at the downstream end of the reach along the Balcones Escarpment. These include the federally endangered Barton Springs salamander (*Eurycea sosorum*), the federal candidate Austin blind salamander (*Eurycea waterlooensis*), and the Jollyville Plateau salamander (*Eurycea tonkawae*) and Texas salamander (*Eurycea neotenes*). Twenty species of frogs and toads are known to occur in the Highland Lakes Reach (Dixon 2000). Those characteristic of this reach include Couch's spadefoot (*Scaphiopus couchi*), cliff chirping frog (*Syrrhophus marnocki*), eastern green toad (*Bufo debilis debilis*), red-spotted toad (*Bufo punctatus*), and Plains leopard frog (*Rana blairi*).

Eleven species of turtles occur in the Highland Lakes Reach (Dixon 2000). None of the 11 is restricted to the Highland Lakes Reach. However, one, the Texas map turtle (*Graptemys versa*), is somewhat characteristic of the reach as it is restricted to the Colorado River mainstem downstream of the Balcones Escarpment and is absent from the Coastal Plain (Dixon 2000).

A total of 21 lizard taxa occur in the Highland Lakes Reach, of which 10 are entirely or largely restricted to this segment. These include Texas earless lizard (*Cophosaurus texanus texanus*), eastern collared lizard (*Crotaphytus collaris collaris*), plateau earless lizard (*Holbrookia lacerata lacerata*), crevice spiny lizard (*Sceloporus poinsetti poinsetti*), and Great Plains skink (*Eumeces obsoletus*). Another species, the Texas alligator lizard (*Gerrhonotus infernalis*), also is generally characteristic of this reach, although it has also been recorded in Fayette County (Dixon 2000).

A total of 43 snake taxa occur in the Highland Lakes Reach (Dixon 2000). Seventeen of these occur only in, or primarily within, this reach, including the federally threatened Concho water snake (*Nerodia harteri paucimaculata*), as well as the more widespread Great Plains rat snake (*Elaphe guttata emoryi*), central Texas whipsnake (*Masticophis taeniatus girardi*), Texas garter snake (*Thamnophis sirtalis annectens*), and black-tailed rattlesnake (*Crotalus molossus molossus*).

Two WMAs are present in the Highland Lakes Reach, the Mason Mountain WMA in Mason County and the Walter Buck WMA in Kimble County. According to the TPWD, Mason Mountain WMA is used to study the ecology of the Llano Uplift region, while emphasis at the Walter Buck WMA is put on managing for healthy native wildlife habitats. Walter Buck WMA has been identified by TPWD as a high priority for expansion because of high natural and recreational values, and because undeveloped lands are available nearby that would allow for expansion (TPWD 2002).

Central Reach. The vegetation communities of the Central Reach share many habitat characteristics with the grasslands and woodlands of the Coastal Reach. Consequently, these two reaches share many wildlife species, with much of their fauna distinct from that present in the Highland Lakes Reach.

Highest quality wildlife habitats occur along river bottomlands and riparian corridors. Habitat quality of woodlands and grasslands generally decreases with increased grazing pressure and increased dominance of nonnative plant species. Croplands typically provide wildlife habitats of low to poor quality, but along with pastures and grasslands can provide important habitat for wintering raptors.

One species of mammal may be unique within the study area to the Central Reach, the eastern flying squirrel (*Glaucomys volans*). This species is known to occur in the "Lost Pines" woodland of Bastrop County. Several species of mammals occur in this reach that are shared with the Coastal Reach but that do not occur, or occur only in limited portions of, the Highland Lakes Reach. Some of these include least shrew (*Cryptotis parva*), northern yellow bat (*Lasiurus intermedius*), swamp rabbit (*Sylvilagus aquaticus*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), and Attwater's pocket gopher (*Geomys attwateri*).

Several bird species are resident in the Central Reach that do not occur, or rarely occur, as breeding species farther upstream in the basin (Lockwood and Freeman 2004). Examples of such species include common ground-dove (*Columbina passerina*), pileated woodpecker (*Dryocopus pileatus*), tufted titmouse (*Baeolophus bicolor*), and pine warbler (*Dendroica pinus*). Migratory

birds that breed in the Central Reach but typically do not breed farther upstream in the basin include anhinga (*Anhinga anhinga*), ruby-throated hummingbird (*Archilochus colubris*), eastern kingbird (*Tyrannus tyrannus*), and prothonotary warbler (*Protonotaria citrea*).

Amphibians present in the Central Reach include one species of siren, three species of salamander, and 21 species of frogs and toads. One of these, the Rio Grande chirping frog (*Syrrhophus cystignathoides campi*), is unique to this reach, but it is an exotic species accidentally introduced to the Fayette County fairgrounds (Dixon 2000). Eight amphibians shared with the Coastal Reach do not occur in the Highland Lakes Reach. These include western lesser siren (*Siren intermedia nettingi*), eastern tiger salamander (*Ambystoma tigrinum tigrinum*), bronze frog (*Rana clamitans clamitans*), and the federally endangered Houston toad (*Bufo houstonensis*).

Eleven species of turtles are expected to occur in the Central Reach (Dixon 2000). None of the species is unique to this reach, but one, the western chicken turtle (*Deirochelys reticularia miaria*), is unique to the combined Central and Coastal reaches.

The American alligator occurs in this reach, although it occurs much more commonly in the Coastal Reach. Fourteen lizard taxa occur in the Central Reach. None is unique to this reach; although two, northern fence lizard (*Sceloporus undulatus hyacinthinus*) and broad-headed skink (*Eumeces laticeps*) do not occur in the Highland Lakes Reach (Dixon 2000).

A total of 32 snake taxa are expected to occur in the Central Reach, giving this reach the lowest snake diversity in the basin. Almost all of these taxa are shared with the Coastal Reach. Some not shared with the Highland Lakes Reach include Texas glossy snake (*Arizona elegans arenicola*), broad-banded water snake (*Nerodia fasciata confluens*), eastern garter snake (*Thamnophis sirtalis sirtalis*), and the state threatened timber rattlesnake (*Crotalus horridus*).

Coastal Reach. The division between the Blackland Prairie and Gulf Coast Prairies and Marshes eco-regions in western Colorado County marks the geographic range limit for many species of wildlife; however, this physiographic boundary does not have nearly as strong an influence on wildlife distribution as does the Balcones Escarpment. Much of the land in this reach has been converted to agriculture, with highest quality wildlife habitats occurring in riparian woodlands and bottomlands, woodlands of western Colorado County, and in the coastal marshes. The Colorado River corridor extending south of the City of Columbus to the Gulf of Mexico lies within an area known as the Columbia Bottomlands, an area that historically contained extensive bottomland hardwood woodlands and continues to provide important habitat for breeding and migratory songbirds.

Croplands typically provide low wildlife habitat values, but these areas can provide important feeding areas for wintering waterfowl.

Four non-marine mammals likely occur exclusively in this reach, the Seminole bat (*Lasiurus seminolus*), Baird's pocket gopher (*Geomys breviceps*), marsh rice rat (*Oryzomys palustris*), and eastern harvest mouse (*Reithrodontomys humulis*). One marine mammal, the bottlenose dolphin (*Tursiops truncatus*), is expected to occur regularly in near-shore marine habitats, and another, the federally endangered West Indian manatee (*Trichechus manatus*), may occur very rarely (Davis and Schmidly 1994).

Two federally endangered birds, Attwater's prairie-chicken (*Tympanuchus cupido attwateri*) and brown pelican (*Pelecanus occidentalis*), occur regularly in the basin only in this reach, as does the federally threatened piping plover (*Charadrius melodus*). Other birds characteristic of this reach are many and include mottled duck (*Anas fulvigula*), reddish egret (*Egretta rufescens*), roseate spoonbill (*Platalea ajaja*), white-tailed hawk (*Buteo albicaudatus*), clapper rail (*Rallus longirostris*), American oystercatcher (*Haematopus palliatus*), laughing gull (*Larus atricilla*), gull-billed tern (*Sterna nilotica*), marsh wren (*Cistothorus palustris*), seaside sparrow (*Ammodrammus maritimus*), and boat-tailed grackle (*Quiscalus major*).

Amphibians in the Coastal Reach include one siren, two salamanders, a newt, and 21 species of frogs and toads (Dixon 2000). Four of these species may be unique to the reach, the central newt (*Notophthalmus viridescens*), spring peeper (*Pseudacris crucifer*), pickerel frog (*Rana palustris*), and southern crawfish frog (*Rana areolata areolata*).

All 16 of the turtle species that occur in the basin likely occur in the Coastal Reach (Dixon 2000). Species unique to this reach include the federally endangered Kemp's ridley sea turtle (*Lepidochelys kempi*), hawksbill sea turtle (*Eretmochelys imbricata*), and leatherback sea turtle (*Dermochelys coriacea*), the federally threatened loggerhead sea turtle (*Caretta caretta*) and green sea turtle (*Chelonia mydas*), the state threatened Texas tortoise (*Gopherus berlandieri*), and Texas diamondback terrapin (*Malaclemys terrapin littoralis*). The latter is the only non-sea turtle occurring in the basin restricted to saline habitats.

Twelve lizard taxa are expected to occur in this reach. One of these, five-lined skink (*Eumeces fasciatus*), is unique to the segment. Half of the taxa occur basin-wide and the other five taxa are largely shared with the Central Reach (Dixon 2000).

A total of 37 snake taxa are expected to occur in the Coastal Reach (Dixon 2000). Several of these are unique to the reach, including the state threatened Texas scarlet snake (*Cemophora coccinea lineri*) and smooth green snake (*Liochlorophis vernalis*), as well as western mud snake (*Farancia abacura reinwardti*), Gulf salt marsh snake (*Nerodia clarki*), and western pygmy rattlesnake (*Sistrurus miliarius*).

Two WMAs are present in the Coastal Reach, the D.R. Wintermann WMA in Wharton County and Peach Point WMA in Brazoria County. Primary emphasis on both WMAs is managing for wintering waterfowl and other water birds. Peach Point also strives to accommodate research projects and management projects to improve knowledge of coastal ecosystems. Both D.R. Wintermann WMA and Peach Point WMA have been identified by TPWD as high priorities for expansion because of high natural and recreational values, and because undeveloped lands are available nearby that would allow for expansion (TPWD 2002).

Exotic and Invasive Animals. Exotic species of wildlife occur throughout the lower Colorado River basin. Many of these are also invasive, meaning that their activities cause economic damage or are detrimental to human health or to native species of wildlife and/or their habitats.

Several invasive species of mammal occur widely within the lower Colorado River basin. Three of these, the Norway rat (*Rattus norvegicus*), roof rat (*Rattus rattus*), and house mouse (*Mus musculus*), are widespread in cultural areas and can cause damage to property and food stores, and transmit disease. Another, the nutria (*Myocastor coypus*), occurs in fresh and saline aquatic habitats. Nutria can occur in high enough densities that their consumption of vegetation can lead to significant damage to aquatic environments or crops (Davis and Schmidly 1994, Union of Concerned Scientists 2004). A fifth species, the feral pig (*Sus scrofa*), occurs in a wide variety of wooded habitats and in coastal marshes. Rooting by pigs can cause long-term damage to vegetation and soils, as well as to ground-nesting birds, small mammals, and herpetological communities.

Other exotic species of mammals in the basin include many ungulates originally released on ranches for hunting or aesthetic purposes and that have since formed free-ranging populations in some areas, primarily within the Highland Lakes Reach. Based on Traweek and Welch (1992), some of the more common species include axis deer (*Cervus axis*), fallow deer (*Cervus dama*), sika deer (*Cervus nippon*), nilgai (*Boselaphus tragocamelus*), blackbuck (*Antilope cervicapra*), and the aoudad (*Ammotragus lervia*). Most of these species compete directly with white-tailed

deer for resources and have potential to transmit diseases to this native species (Traweek and Welch 1992). To date, however, no significant detrimental effects to white-tailed deer populations seem to have occurred.

Several well-established introduced bird species occur nearly throughout the basin, usually but not exclusively in association with cultural areas. These include rock pigeon (*Columba livia*), Eurasian collared-dove (*Streptopelia decaocto*), European starling (*Sturnus vulgaris*), and house sparrow (*Passer domesticus*). The latter two species can cause crop damage and are aggressive, often out-competing native bird species for nest sites. This competition has had detrimental effects on some cavity-nesting songbirds; e.g., purple martin (*Progne subis*) and eastern bluebird (*Sialia sialis*).

The grass carp (*Ctenopharyngodon idella*) is native to rivers in China and the Soviet Union. Grass carp were first introduced into Texas in 1981 as an experiment to control aquatic vegetation. While the aquatic vegetation was successfully removed, there was concern that the species, if introduced into other Texas waters would populate at an exponential rate adversely impacting habitats for native species. As of January 23, 1992, the use of triploid grass carp became illegal in Texas. Diploid grass carp may currently be introduced for aquatic weed control with a valid exotic species permit.

Although native invertebrates were not discussed in the previous sections, many invasive species of invertebrates are widespread throughout the lower Colorado River basin. Perhaps the most damaging of these to wildlife has been the red imported fire ant (*Solenopsis invicta*). Fire ants can have devastating and long-lasting impacts on native ant populations and other invertebrate communities (Vinson and Sorensen 1986, Porter and Savignano 1990). Widespread reductions in populations of Texas horned lizard (*Phrynosoma cornutum*) have also been blamed on the fire ant, although it is possible these reductions were the indirect result of fire ant control methods (Dixon 2000).

Africanized bees (*Apis mellifera scutellata*) occur nearly throughout the basin. The greatest threat from Africanized bees is their potential to reduce the ability to manage valuable pollination activities (Texas A&M University 2004). Other invasive invertebrates occurring in all three reaches are expected to include the cabbage white butterfly (*Pieris rapae*), Asian tiger mosquito (*Aedes albopictus*), boll weevil (*Anthonomus grandis*), German cockroach (*Blattella germanica*), and Asian clam (*Corbicula fluminea*). Invasive invertebrates known to occur, or that may occur primarily, in the Central and/or Coastal reaches include Formosan subterranean termite (*Coptotermes*

formosanus), Asian ambrosia beetle (*Xylosandrus crassiusculus*), and channeled apple snail (*Pomacea canaliculata*). The latter species is considered to have potential to cause great damage to the Texas rice crop (Howells 2002).

3.2.9 Freshwater Resources

Aquatic Habitats. The types of aquatic habitats present in the lower Colorado River basin include flood control and water supply reservoirs, cooling reservoirs, riverine systems, second and third order streams, wetlands, ponds, and flooded gravel quarries. Streams throughout this reach exhibit a wide variety of flow and physical characteristics. The smaller streams exhibit typical riffle-run-pool complexes, while the larger streams are more channelized and contain extensive pool habitats. Physical features in aquatic habitats that contribute to high ecological values are those that either directly or indirectly support some aspect of an aquatic organism's life history. Examples include features or objects that provide shelter, food, spawning habitat, or improve water quality. Specific features include flow, water quality, bottom substrate, overhanging vegetation, structure, and bank configuration. Aquatic habitats of the lower Colorado River basin range from sites with very low quality habitat, to systems that are ecologically and structurally diverse.

Stream banks within the basin are typically steep and deeply incised. The composition of bank materials is quite variable depending on location, but may include limestone, granite, clay, loams, and gravelly alluvium. The composition of the stream bottoms is extremely variable in the basin and includes areas with well-sorted gravel and cobble bottoms, limestone and granitic bedrock, sand, clay, and silty mud. Bottom substrates within the reservoirs are primarily silty mud and rock.

Instream structure can provide cover, resting areas, and refugia for aquatic organisms. Common instream structure includes cut banks, large rocks and rock outcrops, snags, logs, and standing timber, low water dams, bridge pilings, and in some areas, submerged aquatic vegetation. Various types of rock structure are the most common forms of structure in the streams and reservoirs of the basin. Aquatic vegetation is limited in many of the streams due to seasonal variations in flows and/or the rocky bottom substrate common to many of the streams. Lake Austin and Town Lake are two exceptions on the main stem of the river. Both lakes are experiencing problems with encroachment of hydrilla and Eurasian water milfoil. Other reservoirs within the basin are also experiencing problems to varying degrees with invasive aquatic species.

Macroinvertebrates serve a wide variety of functions in the aquatic community. In addition to servings as a prey base for higher aquatic and terrestrial organisms, they also serve important roles as herbivores, carnivores, and detritivores and can be an important indicator of water quality. The major groups represented in the basin are the Insecta (mainly immature forms), Mollusca (snails and mussels), Oligochaeta (aquatic worms) and Crustacea (crayfish and shrimp). Macroinvertebrates inhabit a variety of aquatic habitats within the basin including submerged vegetation, vegetation or debris piles, and various bottom sediments. Some species require flowing water to satisfy their biological requirements and cannot survive in standing water. Within the reservoirs of this reach, the greatest diversity of macroinvertebrates is generally found along the shallow, vegetated littoral zone.

Connor and Suttkus (1986) reviewed the zoogeography of fishes from the Western Gulf Slope drainages and reported 59 primary freshwater species native to the Colorado River basin. The ichthyofauna of the Colorado River represents a pronounced break between eastern (typically Mississippi Valley) and western (Rio Grande) fish communities (Mosier and Ray 1992). Table 3-11, taken from Mosier and Ray (1992), presents a list of freshwater fishes known to have occurred in the Colorado River including several native species that appear to have become extirpated in recent years and several exotic species that have developed established populations.

As a result of the passage of Senate Bill 1 in 1997 by the Texas State Senate, water planning in Texas became the domain of regional planning groups rather than the TWDB. As a part of the planning process, each regional planning group may include recommendations for the designation of ecologically unique river and stream segments in their adopted regional water plan (Texas Commission on Environmental Quality [TCEQ] 2002, 2004). In accordance with the Texas Administrative Code 31 § 357.8, the following criteria are to be used when identifying a river or stream segment as being of unique ecological value:

Biological Function: Segments which display significant overall habitat value including both quantity and quality considering the degree of biodiversity, age, and uniqueness observed and including terrestrial, wetland, aquatic, or estuarine habitats;

Hydrologic Function: Segments, which are fringed by habitats, that performs valuable hydrologic functions relating to water quality, flood attenuation, flow stabilization, or groundwater recharge and discharge;

Table 3-11

Freshwater Fishes Reported from the Colorado River System

Family	Species	Common Name(s)	TPWD Code
Lepisosteidae	*Lepisosteus oculatus*	Spotted Gar	2
	L. osseus	Longnose Gar; Needlenose Gar	3
	L. spatula	Alligator Gar	6
Amiidae	*Amia calva*	Bowfin; Dogfish; Grinnel	
Anguillidae	*Anguilla rostrata*	American Eel	8
Clupeidae	*Dorosoma cepedianum*	Gizzard Shad	15
	D. petenense	Threadfin Shad	16
Characidae	*Astyanax mexicanus* [a]	Mexican Tetra	
Cyprinidae	*Campostoma anomalum*	Stoneroller	93
	Cyprinus carpio [a]	Carp	45
	Cyprinella lutrensis	Red Shiner	47
	C. venusta	Blacktail Shiner	59
	Dionda episcopa	Roundnose Minnow	76
	Hybognathus placitus	Plains Minnow	
	Lythrurus fumeus	Ribbon Shiner	
	Macrhybopsis aestivalis	Speckled Chub	192
	Notemigonus crysoleucus	Golden Shiner	
	Notropis amabilis	Texas Shiner	24
	N. amnis [b]	Pallid Shiner	
	N. atrocaudalis [c]	Blackspot Shiner	
	N. buccula	Smalleye Shiner	
	N. buchanani	Ghost Shiner	
	N. oxyrhynchus	Sharpnose Shiner	
	N. potteri	Chub Shiner	
	N. shumardi	Silverband Shiner	
	N. stramineus	Sand Shiner	
	N. texanus	Weed Shiner	33
	N. volucellus	Mimic Shiner	69
	Opsopoeodus emilae [b]	Pugnose Shiner	
	Phenocobius mirabilis	Suckermouth Minnow	20
	Pimephales vigilax	Bullhead Minnow	87
	P. promelas	Fathead Minnow	
Catastomidae	*Carpoides carpio*	River Carpsucker	55
	Cycleptus elongatus	Blue Sucker	60

*Table 3-11 continued on next page

Table 3-11, continued

Freshwater Fishes Reported from the Colorado River System

Family	Species	Common Name(s)	TPWD Code
	Ictiobus bubalus	Smallmouth Buffalo	66
	Minytrema melanops	Spotted Sucker	70
	Moxostoma congestum	Gray Redhorse Sucker	73
Ictaluridae	*Ictalurus furcatus*	Blue Catfish	81
	1. melas	Black Bullhead	
	1. natalis	Yellow Bullhead	83
	1. punctatus	Channel Catfish	86
	Pylodictus olivaris	Flathead; Yellow Catfish	91
Aphredoderidae	*Aphredoderus sayanus*	Pirate Perch	
Cyprinodontidae	*Fundulus notatus*	Blackstripe Topminnow	101
	F. chrysotus	Golden Topminnow	
	F. zebrinus	Plains Killifish	
Poeciliidae	*Gambusia affinis*	Mosquitofish	50
	G. heterochir [d]	Clear Creek Gambusia	
	Poecilia latipinna [a]	Sailfin Molly	745
Atherinidae	*Menidia beryllind* [a]	Inland Silversides	51
Percichthyidae	*Morone crysops*	White Bass	
	M. saxatilise	Striped Bass	
Centrarchidae	*Lepomis auritus* [a]	Redbreast Sunfish	119
	L. cyanellus	Green Sunfish	120
	L. gulosus	Warmouth	122
	L. humilis	Orangespotted Sunfish	123
	L. macrochirus	Bluegill Sunfish	124
	L. rnegalotis	Longear Sunfish	126
	L. microlophus	Redear Sunfish	127
	L. punctatus	Spotted Sunfish	128
	L. symnetricus	Bantam Sunfish	
	Micropterus dolomieui [a]	Smallmouth Bass	131
	M. punctulatus	Spotted Bass	133
	M. salmoides	Largemouth Bass	134
	M. treculi	Guadalupe Bass	135
	Pomoxis annularis	White Crappie	
Percidae	*Etheostoma chlorosomum*	Bluntnose Darter	
	E. gracile	Slough Darter	

*Table 3-11 continued on next page.

Table 3-11, continued

Freshwater Fishes Reported from the Colorado River System

Family	Species	Common Name(s)	TPWD Code
	E. lepidum	Greenthroat Darter	162
	E. proeliare		
	E. spectabile	Orangethroat Darter	161
	Percina carbonaria	Logperch	145
	P. macrolepidum	Roughscale Logperch	144
	P. sciera	Dusky Darter	142
Sciaenidae	*Aplidinotus grunniens*	Freshwater Drum	151
Cichlidae	*Cichlasoma cyanoguttatum* [a]	Rio Grande Perch	158
	Sarotherodon aurea [a]	Blue Tilapia	

[a] Non-native fishes that have become established in the Colorado River basin

[b] Collected since 1980 but not reported in the present study

[c] Outside of range, unconfirmed identification

[d] Restricted to Clear Creek, Menard County

[e] Actively stocked by the Texas Parks and Wildlife Department but reproduction has not been confirmed

Riparian Conservation Areas: Segments which are fringed by significant areas in public ownership including state and federal refuges, WMAs, preserves, parks, mitigation areas, or other areas held by governmental organizations for conservation purposes under a governmentally approved conservation plan;

High Water Quality/Exceptional Aquatic Life/High Aesthetic Value: Segments and spring resources that are significant due to unique or critical habitats and exceptional aquatic life uses dependent on or associated with high water quality; or

Threatened or Endangered Species/Unique Communities: Sites along segments where water development projects would have significant detrimental effects on state or federally listed threatened and endangered species, and sites along segments that are significant due to the presence of unique, exemplary, or unusually extensive natural communities.

The Lower Colorado Regional Water Planning Group (LCRWPG) has identified eight stream segments in the lower Colorado River basin as warranting further study for possible designation as Ecologically Unique under 31 § TAC 357.8 (LCRWPG 2000). They include the following segments: Barton Springs segment of the Edwards Aquifer (1430); Bull Creek (1403A); Colorado River (1409 and 1410) in Burnet, Lampasas, and Mills counties; Colorado River (1428 and 1432) in Travis, Bastrop and Fayette counties; Colorado River (1402) in Fayette, Colorado, Wharton, and Matagorda counties; Cummins Creek (1402A) from the confluence upstream to FM 159 in Fayette County; Llano River (1415) from the confluence with Johnson Creek to CR 2768 in Llano County; and the Pedernales River (1415) in Kimball, Gillespie, Blanco, and Travis counties (LCRWPG 2000). The following provides a description of each stream segment as taken from (LCRWPG 2000).

Segment 1402

The Colorado River within segment 1402 extends from just downstream of the Missouri-Pacific railroad trestle in Matagorda County to a point 320 ft downstream of SH 71 in La Grange, a distance of 150 miles. Substrate varies from primarily gravel in the upper reaches of the segment to gravel/cobble riffles and extensive sand-dominated reaches downstream. Instream flow is largely dependent on upstream releases for rice irrigation, but also receives contributions from the intervening watershed. The water quality of the segment is typically good, and supports a high aquatic life use designation. Nutrient levels are elevated, but dissolved oxygen concentrations are typically higher than the minimum required to maintain a high aquatic life use designation. The fish community is generally diverse and includes the blue sucker (*Cycleptus elongatus*). The segment meets the following criteria for designation as ecologically unique:

- Biologic Function: undeveloped riverine habitat, includes Central Flyway for migratory waterfowl, a flyway corridor and stop over habitat for neotropical migratory songbirds, and;
- Endangered/Threatened Species: blue sucker, a state-listed endangered species, and wintering and breeding habitat for the bald eagle.

Segment 1402A

Cummins Creek is characterized by shallow to moderately deep pools, riffles, and occasional shallow runs. Substrate is predominantly fine sands with gravel and rubble in riffles and runs. Cummins Creek is within the post oak savannah vegetation region. The surrounding land use is mostly agricultural. Water quality is generally good, and the stream supports diverse macroinvertebrate and fish communities. The LCRA rated the creek, which has at least 27 species of fish, as suitable for a high aquatic life use for fish. Among the fish species that have been collected in the stream is the Guadalupe bass (*Micropterus treculi*). Cummins Creek supports at least 28 species of aquatic macroinvertebrates. Several varieties of mayflies and caddisflies, which are considered intolerant of pollution, are present. Cummins Creek was rated an excellent aquatic life use category for macroinvertebrates based on work by the LCRA; however the lower 25 miles of the stream are experiencing impaired fish and macrobenthos communities due to low flows (TCEQ 2004). The segment meets the following criteria for designation as ecologically unique:

- High Water Quality/Exceptional Aquatic Life/High Aesthetic Value: the stream was selected as an ecoregion stream based on its physical attributes, water quality, and biological assemblages;
- Exhibits high dissolved oxygen concentrations and a diverse and complex benthic macroinvertebrate community.

Segment 1409 and 1410

The Colorado River upstream of Lake Buchanan to the Brown/San Saba/Mills county line, including the Gorman Creek tributary, is wide and relatively shallow, flowing over a bed of limestone and gravel. A few stretches of small rapids exist on the upper part of the river down to the point where the backwaters of Lake Buchanan deepen the river and slow its flow.

Among the segment's scenic attributes are high limestone bluffs, vistas of rugged cedar-covered hills, and the existence of one of the most spectacular waterfalls in Texas. Gorman Falls is formed at the point where Gorman Creek tumbles into the Colorado over a 75-ft tall limestone bluff. The water coming from the creek is clear and cold, and many ferns and mosses grow on the slippery

rocks and travertine deposits below the falls. The TCEQ identifies the segment as having a high aquatic life use. The National Park Service identified the segment for inclusion in the National Rivers Inventory based on the degree to which the river is free-flowing, the degree to which the river and corridor is undeveloped, and the outstanding natural and cultural characteristics of the river and its immediate environment. The segment meets the following criteria for designation as ecologically unique:

- Biologic Function: white bass (*Morone crysops*) spawning area;
- Riparian Conservation Area: Colorado Bend State Park;
- High Water Quality/Exceptional Aquatic Life/High Aesthetic Value: exceptional aesthetic value; and,
- Endangered/Threatened Species: Concho water snake (*Nerodia paucimaculata*), a federal and state listed threatened species, as well as two rare and endemic mollusks.

Segment 1414

The Pedernales River in general has high water quality and supports a high aquatic life use. The stream is within the Central Texas Plateau ecoregion. The river is spring-fed and free flowing, with many limestone outcroppings. The National Park Service identified the segment for inclusion in the National Rivers Inventory based on the degree to which the river is free flowing, the degree to which the river and corridor is undeveloped, and the outstanding natural and cultural characteristics of the river and its immediate environment. Among the fish species that occur in the stream is the Guadalupe bass. Other aquatic species typical of Hill Country spring-fed streams also inhabit the Pedernales River. Along the river are several state and national parks including Pedernales Falls State Park, LBJ State Park, and LBJ National Park. The segment meets the following criteria for designation as ecologically unique:

- Biologic Function: significant natural area;
- Riparian Conservation Area: Pedernales Falls State Park, LBJ State Park, LBJ National Park, and Stonewall Park; and,
- High Water Quality/Exceptional Aquatic Life/High Aesthetic Value: exceptional aesthetic value.

Segment 1415

The Llano River between the confluence with Johnson Creek and County Road 2768 in Llano County is part of TCEQ classified stream segment 1415. The Llano River is a spring-fed stream of the Edwards Plateau and is widely known for its scenic beauty. Riparian vegetation in-

cludes elms (*Ulmus spp.*), black willow, sycamore (*Platanus occidentalis*), and salt-cedar (*Tamarix sp.*). Among the fish found in the stream is the Guadalupe bass (*Microptus treculi*). The substrate is composed of limestone bedrock and gravel. In addition, large boulders and slabs of granite and gneiss occur in the river. This section of the Llano River is widely known for the one billion year old igneous and metamorphic rocks, which form the riverbed. The area is a part of the Llano Uplift, which is one of the most unique geologic features in Texas. The segment meets the following criteria for designation as ecologically unique:

- High Water Quality/Exceptional Aquatic Life/High Aesthetic Value: exceptional aesthetic value.

Segment 1428 and 1432

The Colorado River downstream of Longhorn Dam to 320 ft downstream of SH 71 in La Grange is generally controlled by releases from Lake Travis and Lake Buchanan. The occurrences of low instream flows often depend on the discharge rate of return flows from the COA.

Subtrate in the streams is typically sand and/or gravel. Several reaches of the segment are characterized by rubble and boulder fields. The TCEQ has classified the mainstem river as supportive of exceptional aquatic life uses. Water quality is generally good, although nutrient levels are often elevated. Water quality in the creeks is typically good, but influenced by flow levels, land use patterns, and wastewater discharges. Cedar Creek contains an exceptional macroinvertebrate community and, based on the ichthyofauna, a high Index of Biotic Integrity rating. This portion of the Colorado River has a diverse fish community, including the state-threatened blue sucker. In addition, the state and federally listed endangered Houston toad occurs in the area. The segment meets the following criteria for designation as ecologically unique:

- Biologic Function: undeveloped riverine habitat, includes Central Flyway for migratory waterfowl, a flyway corridor and stop over habitat for neotropical migratory songbirds, and;
- Hydrologic Function: extensive riparian zone attenuates flooding and improves water quality via filtration and soil stabilization; riparian and stream channels hydrologically connected to an alluvial aquifer and the Carrizo-Wilcox aquifer;
- Riparian Conservation Area: McKinney Roughs Environmental Learning Center;
- High Water Quality/Exceptional Aquatic Life/High Aesthetic Value: exceptional aquatic life use; and,

- Endangered/Threatened Species: blue sucker, a state-listed endangered species; and wintering and breeding habitat for the bald eagle.

Segment 1430

Streams within the recharge area of the Barton Springs segment of the Edwards Aquifer are generally influenced by the interaction between groundwater and surface water and the physico-chemical conditions of the karst Edwards Aquifer. Water quality is generally good to exceptional, although coliform levels are occasionally elevated after storm events. Nitrite levels can also be high due to the influence of groundwater. Substrate is typically limestone bedrock with rubble, boulders, and gravel. The upper portions of the streams are generally intermittent, except in spring-fed reaches, which limits aquatic habitat. However, these portions of the stream can be important for aquifer recharge. Barton Creek meets the following criteria for designation as ecologically unique:

- Riparian Conservation Area: the lower end of the stream is in the COA's Zilker Park;
- High Water Quality/Exceptional Aquatic Life/High Aesthetic Value: the stream was selected as an ecoregion stream based on its physical attributes, water quality, and biological assemblages; the stream exhibits high dissolved oxygen concentrations and a diverse and complex benthic macroinvertebrate community; and,
- Endangered/Threatened Species: the stream contains the only known population of the Barton Springs salamander (*Eurycea sosorum*), a federally listed endangered species.

Segment 1430A

Bull Creek lies wholly within Travis County in the northwest portion of the COA. The watershed for the stream is approximately 32 square miles in a rapidly developing area. The watershed is located on the eastern edge of the Texas Hill Country and immediately west of the Balcones Fault Zone. Numerous seeps and springs provide base flow to Bull Creek. Water quality is generally good, although some degradation has occurred due to development. The Bull Creek watershed contains suitable habitat for a variety of rare and endangered species. In addition, the watershed contains a very diverse flora. Bull Creek was recommended for further study based on the following criteria:

- Biologic Function: nearly pristine stream with a largely intact riparian area;
- Hydrologic Function: pervious cover and intact riparian zone reduce downstream flooding;
- Riparian Conservation Area: Bull Creek Preserve;

- High Water Quality/Exceptional Aquatic Life/High Aesthetic Value: overall pristine nature gives the stream a high aesthetic value; stream has a diverse and complex benthic macroinvertebrate community, and an abundance and diversity of amphibians; and,

Endangered/Threatened Species: the watershed contains habitat for two federally endangered songbirds, six federally endangered karst invertebrates and a rare salamander species.

Instream Flow. In 1992, the LCRA and TPWD performed a joint study to determine the required instream flows of the Colorado River below Longhorn Dam in Austin to maintain water quality and aquatic habitat. Mosier and Ray (1992) recommend monthly critical and target flows to maintain water quality for the river in areas that were determined to be critical habitat. The resulting critical flows (Table 3-12) that must be maintained to sustain water quality are 46 cfs at the gauging station in Austin and 120 cfs at Bastrop (except for March, April and May). During the spring months 500 cfs is required for the spawning habitat of the state threatened blue sucker. The LCRA has water set aside to ensure that the instream flows are met. According to the 1999 Lower Colorado River Management Plan, in order to meet instream flow requirements, the LCRA will release water from the Highland Lakes to:

1) Maintain the daily river flows at no less than the critical instream flow need in all years, and,
2) Maintain daily river flows at the target instream flow needs in those years when the four major irrigation districts are not curtailed, to the extent of inflows each day to the Highland Lakes available for storage as measured at the upstream stream gages.

This recommendation fully meets the most important instream flow needs at all times and meets the desirable (target) flows during periods of normal or above normal streamflow conditions. Total commitments of the combined firm yield from the Highland Lakes for instream flow maintenance will be an average of 12,860 acre-ft per year, with a maximum of 36,720 acre-ft in any one year; 58,700 acre-ft in any two consecutive years, 76,800 acre-ft in any three or four consecutive years, 106,100 acre-ft in any five consecutive years and 128,600 acre-ft in any six to ten consecutive years. The total firm stored water commitment for both instream flow maintenance and estuary inflows will be an average of 15,950 acre-ft per year. Estimated interruptible stored water supplied during the critical drought for both purposes will be an additional 10,060 acre-ft per year.

Table 3-12

Instream Flows of the Lower Colorado River

	Subsistence/Critical Flows (cfs)		Target Flows (cfs)		
Month	**Austin**	**Bastrop**	**Bastrop**	**Eagle Lake**	**Egypt**
January	46 c	120	370	300	240
February	46 c	120	430	340	280
March	46 c	500 b	560	500 a	360
April	46 c	500 b	600	500a	390
May	46 c	500 b	1030	820	670
June	46 c	120	830	660	540
July	46 c	120	370	300	240
August	46 c	120	240	200	160
September	46 c	120	400	320	260
October	46 c	120	470	380	310
November	46 c	120	370	290	240
December	46 c	120	340	270	220

*Source: LCRA Water Management Plan 1999

(a) Since target flow at Eagle Lake (Based upon overall community habitat availability) were insufficient to meet blue sucker spawning requirements during March and April, target flows were superseded by critical flow recommendations for this reach.

(b) This flow should be maintained for a continuous period of not less than six weeks during these months. A flow of 120 cfs will be maintained on all days not within the six-week period.

(c) LCRA will maintain a mean daily flow of 100 cfs at the Austin gage at all times, to the extent of inflows each day to the Highland Lakes as measured by upstream gages, until the combined storage of Lakes Buchanan and Travis reaches 1.1 million acre-feet of water. A mean daily flow of 75 cfs, to the extent of inflows each day to the Highland Lakes as measured by upstream gages, will then be maintained until the combined storage of Lakes Buchanan and Travis reaches 1.0 million acre-feet of water, then a subsistence/critical flow of 46 cfs will be maintained at all times, regardless of inflows.

3.2.10 Wetlands

The lower Colorado River basin has two major wetland types comprising 0.43% (50,361 acres) of the 18,300 square mile basin. These wetland types are coastal wetlands, which include marshes and barrier island communities, and terrestrial wetlands, which include vegetated riparian areas and freshwater marshes (LCRA 2003).

Only Matagorda County (Coastal Reach) contains coastal wetlands. Bays, estuaries, marshes, barrier islands, and tidally-influenced wetlands represent most of the system. Approximately 31,000 acres of salt and brackish marsh fringe Matagorda Bay (USACE 2003b). These marshes act as a natural filter for both anthropogenic and naturally occurring contaminants, serving to protect estuarine systems. Marshes aid in the control of excessive runoff to bays, protection of land from erosion, and protecting the people and property from the storm surges and floods by acting as a buffer between land and water. They provide habitat for waterfowl, reptiles, mammals, fish, invertebrates, and other wildlife and provide nutrients to the bay ecosystem. The marshes provide economic benefit in the form of commercial and recreational fishing, hunting, tourism, and bird watching.

Wetlands in non-tidally influenced portions of Matagorda County, as well as, Wharton, Colorado, Fayette, Bastrop, and Travis (east of Austin, Texas) counties are largely riparian vegetated communities, freshwater marshes, man-made ponds, and oxbows. Many of these wetlands are located within the 100-year floodplain of the Colorado River and its associated tributaries. Crop production dominates the land use of the area (see Figure 3-2; TPWD 1984) and is expected to have altered many wetland communities.

Riparian communities in this portion of the lower Colorado River basin are typically vegetated buffer strips along the river that are frequently flooded. Some of these areas are bottomland hardwood communities while the others areas are riparian woodland communities that do not necessarily contain bottomland hardwood species, but due to the communities' functional value and scarcity, are still considered wetlands in Texas. These also include forested wetlands created by oxbows, which occur at numerous locations throughout the middle of the lower Colorado River basin.

Freshwater marshes along the Colorado River are comprised mainly of abandoned gravel pits along the sides of the river. This type of wetland is normally in a degraded state because the land was abandoned and not revegetated after gravel-mining operations ceased. Invasive or undesirable species such as hydrilla, Chinese tallow, mesquite, and salt cedar commonly invade these areas.

West of the COA, in the Highland Lakes Reach and remainder of the Central Reach, Riverine and Lacustrine wetlands are more common. Riverine wetlands are closely associated with drainages and narrow floodplain reaches and often consists of palustrine forested habitats. Bald cypress, pecan, American sycamore, black willow, and cottonwood are dominant species within these wetlands. Lacustrine wetlands include all of the Highland Lakes (Lake Buchanan, Inks Lake, Lake LBJ, Lake Marble Falls, Lake Travis, and Lake Austin) as well as other man-made, privately owned lakes and stock tanks.

The U.S. Fish and Wildlife Service (USFWS) has mapped wetlands throughout the basin through their National Wetland Inventory program (NWI). NWI mapping is available in digital format for the coastal reach of the basin. The remainder of the basin is available in hard copy.

Texas has lost 60% of its terrestrial wetlands and 50% of its coastal wetlands in the last 200 years (Texas Center for Policy Studies 2005). In 2001, there were 18,000 acres of wetland and aquatic habitats found in and around the Colorado River delta and peninsulas in the project area (White et al. 2002). Within the Matagorda Bay system, these habitats experienced a net loss in total area of 6,000 acres since the 1950s, with estuarine marshes being the only habitat to show significant gains over this time period. Freshwater marshes have experienced a 54% decline from the 1950s to 1989 due to draining and conversion to urban areas, rangeland, and cropland (TPWD 2005). Freshwater marshes have also declined because of saltwater intrusion and erosion on the coast. This conversion of freshwater marshes has been extensive in the coastal reach of the lower Colorado River basin where irrigated croplands occupy a majority of the area.

3.2.11 Marine Resources Including Essential Fish Habitat

The Colorado River empties into the Matagorda Bay system near Matagorda, Texas (Figure 3-14). The Matagorda Bay system is the second largest estuary on the Texas Gulf Coast covering approximately 352 square miles. It is separated from the Gulf of Mexico by the Matagorda Peninsula and parallels the coastline of the Coastal Bend region of Texas. The bay system includes a series of smaller, shallow bays along the northern periphery. A natural opening between Matagorda Peninsula and Matagorda Island, known as Pass Cavallo, and the Matagorda Ship Channel (MSC) that is cut through the peninsula serve as the primary outlets of the bay system into the Gulf of Mexico. The Matagorda Bay system supports many recreationally and commercially important marine fish species including various finfish species, shrimp, crabs and oysters. Matagorda Bay, Eastern Matagorda Bay, and tidally influenced sections of the Colorado River and its tributaries are

located within an area that has been identified as essential fish habitat (EFH) for many marine fish species that are federally managed by the Gulf of Mexico Fishery Management Council (GMFMC) and National Oceanographic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS). EFH is defined in § 600.10 of the regulations implementing the EFH provisions of the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act; P.L. 104-297) as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.

EFH has been designed for each life stage of federally managed marine fish species by either the GMFMC and/or NMFS. Table 3-13 provides a list of federally managed fish species and life stages for which EFH has been designated in the project area.

Categories of EFH that could be impacted by projects various flood control and ecosystem restoration projects in the lower Colorado River basin include estuarine water column, estuarine mud and sand bottoms (unvegetated estuarine benthic habitats), estuarine shell substrate (oyster reefs and shell substrate), estuarine emergent wetlands, and seagrasses. Detailed information on EFH for federally managed shrimp (*Penaeus spp.*), red drum (*Sciaenops ocellatus*), reef fish, and coastal migratory pelagic species is provided in the 1998 generic amendment of the Fishery Management Plans (FMPs) for the Gulf of Mexico prepared by the GMFMC. Information on EFH for highly migratory species (HMS) is contained in the Atlantic Billfish and Atlantic Tunas, Swordfish, and Sharks FMPs prepared by the Secretary of Commerce. The generic amendment and HMS FMPs were prepared as required by the Magnuson-Stevens Act.

In addition to providing EFH for the species listed above, the Matagorda Bay estuary provides nursery and foraging habitat that supports various forage species and economically-important marine fishery species such as spotted seatrout (*Cynoscion nebulosus*), flounder (*Paraichthys spp.*), Atlantic croaker (*Micropogonias undulates*), black drum (*Pogonias cromis*), gulf menhaden (*Brevoortia patronus*), striped mullet (*Mugil cephalus*), and blue crab (*Callinectes sapidus*). Some of these estuarine-dependent organisms also serve as prey for other fisheries managed under the Magnuson-Stevens Act by the GMFMC (e.g., red drum, mackerels, snappers, and groupers) and highly migratory species managed by the NMFS (e.g., billfishes and sharks).

The bay system supports an extensive seagrass bed along the northern shoreline of Matagorda Peninsula, the northeastern end of Matagorda Island, and the east shoreline of Matagorda Bay including Keller Bay. These seagrass beds are composed primarily of shoalgrass (*Halodule wrightii*) but also contain large stands of widgeon-grass (*Ruppia maritima*) and turtlegrass (*Thalassia*

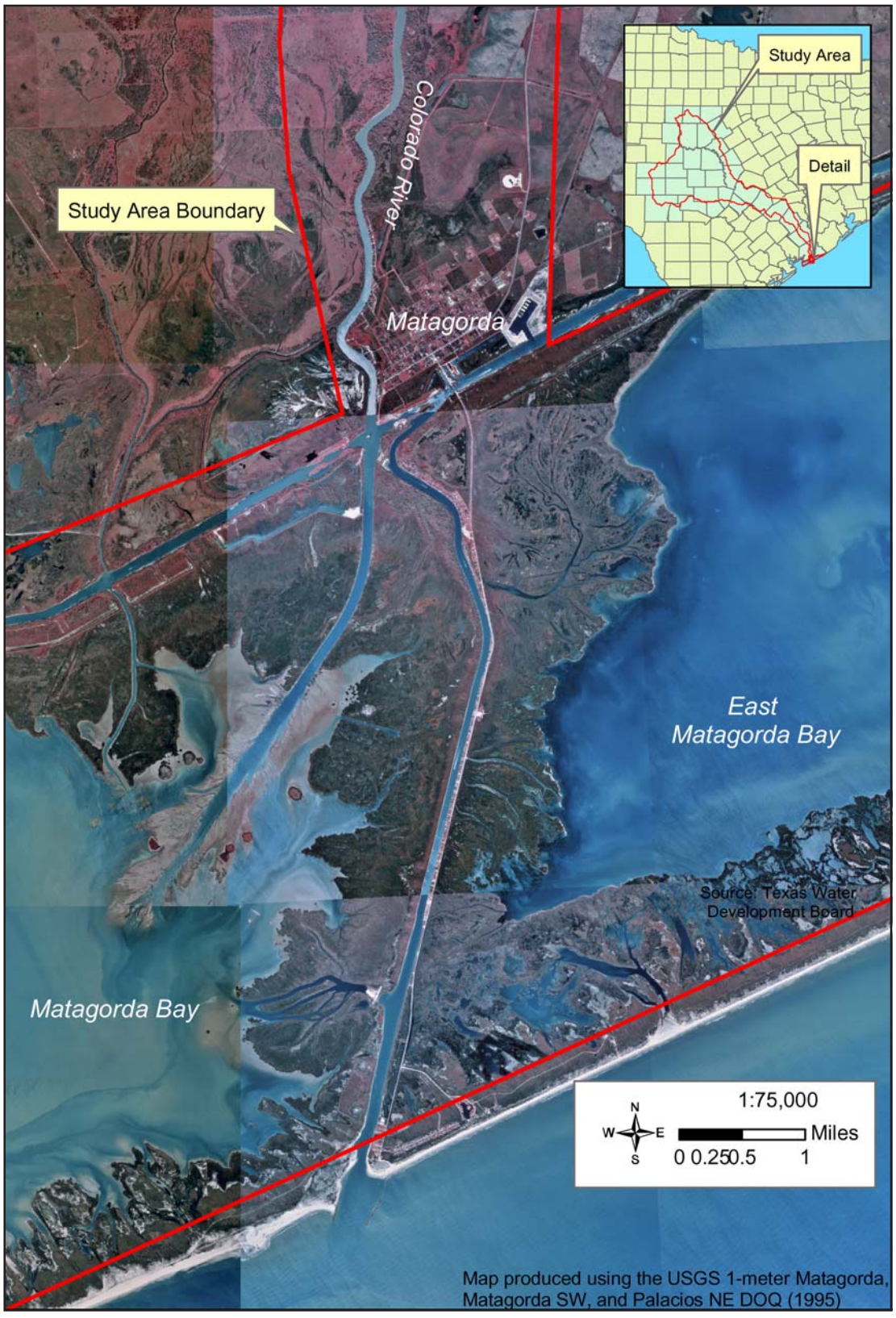

Figure 3-14 Mouth of the Lower Colorado River Date: October 2004

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Table 3-13

Federally Managed Fish Species and Life Stages for the Study Area

Managed Species	Life Stages
Brown shrimp	Eggs, larvae, postlarvae, juvenile, subadult, and adult (all life stages)
White shrimp	All life stages
Pink shrimp	All life stages
Red drum	All life stages
Spanish mackeral	All life stages
Red snapper	All life stages
Lane snapper	Juveniles, adults
Greater amberjack	Juveniles, adults
Lesser amberjack	Juveniles, adults
Gray triggerfish	All life stages
King mackerel	Juveniles, adults
Spanish mackerel	Juvenile, subadult
Cobia	All life stages
Dolphin	All life stages
Bluefish	Postlarvae, juveniles, adults
Little tunny	Postlarvae, juveniles, adults
Atlantic bluefin tuna	Eggs, larvae, spawning adults
Bonnethead shark	Juveniles, adults
Blacktip shark	Juveniles
Bull shark	Juveniles
Atlantic sharpnose shark	Juveniles

testudinum). Migratory waterfowl use much of this habitat during the winter and many commercially and recreationally important saltwater fish species use the bays' seagrasses extensively for foraging and nursery habitat. TPWD (1999) estimated that approximately 3,830 acres of seagrass meadows are present in both Matagorda and East Matagorda Bays. Seagrass meadows provides a critical nursery function for many fish species and are very important for wintering populations of redhead ducks.

Tidal salt marsh habitat in Matagorda Bay provides important breeding and foraging habitat for marine fish. A portion of numerous important commercial and recreational fish species life cycles are dependent upon the estuarine environment and intertidal salt marsh habitat. Additionally organic matter production from tidal salt marshes that is exported from the estuary into marine environments provides food for some adult and juvenile marine fish species.

Oyster (*Crassostrea virginica*) reefs occur in extensive beds, primarily in the northern and

eastern portions of the system. Oyster reefs clarify bay waters by ingesting and solidifying dissolved particulate matter (PM) and they provide excellent habitat for small prey organisms. Oyster reefs regularly harbor populations of finfish and shellfish at levels nearly as high as intertidal marsh and much greater on the average than open bay bottoms. Historically, Matagorda Bay was an important oyster producing area, yielding approximately half of the Texas oyster production in the 1930s. Matagorda Bay and East Matagorda Bay were once a continuous estuary into which the Colorado River discharged and served as one of the two primary sources of nutrients and freshwater (the other being the Lavaca River). During the time of early European settlement, the Colorado River became plugged by a large logjam. In 1929, this logjam was freed and the large volume of collected sediments and debris was dislodged thus forming a delta that reached all the way across the bay to the Matagorda Peninsula by 1935. This resulted in the separation of East Matagorda Bay from the rest of Matagorda Bay.

Consequently, all of the freshwater flowing down the Colorado River began discharging directly into the Gulf of Mexico and was therefore no longer available to provide for the proper salinity and nutrient conditions necessary to support healthy oyster production within Matagorda Bay leading to a decline in both health and productivity within the bay. This was a primary reason for the oyster declines in Matagorda Bay. Other contributing factors included substantial oyster dredging that removed shell substrate, increased volumes of saltwater entering the bay up the Matagorda Ship Channel and the GIWW, and subsequent proliferation of oyster parasites including the oyster drill and Dermo. In 1992, the USACE, in cooperation with the state and federal resource agencies, completed a very successful large scale ecosystem restoration project designed to improve bay health by diverting the Colorado River back into the Matagorda Bay system to restore, to the extent possible, the freshwater inflow containing river borne nutrient rich water and sediments as had been the case prior to the 1920's (NOAA, 2005). Oyster health within the bay system has been improving since 1992.

Open-water habitats of Matagorda Bay tend to lack substantial cover or physical diversity. They are depositional environments where relatively featureless, silty substrates predominate. Portions of the bay with lower turbidity tend to support planktonic production. This production and the use of deposited nutrients (e.g., carbon) in the sediments supports a strong benthic food base which extracts food through a variety of feeding strategies from filter feeders through deposit feeders. The area supports large populations of polychaete worms, mollusks, crabs, and shrimp. Crabs and shrimp prey upon the polychaetes and all are eaten by various fish species including spotted sea trout,

flounder and redfish, supporting the second largest commercial fishery in Texas behind Galveston Bay.

Freshwater Needs of Matagorda Bay. In addition to instream needs to meet water quality in the riverine ecosystem, there is also a freshwater need for the health of Matagorda Bay. Ninety-seven percent of the fishery species (shellfish and finfish) in the Gulf of Mexico spend all or a portion of the lifecycle in estuaries. According to the Lower Colorado River Management Plan, the freshwater inflow needs for the estuarine ecosystem associated with the Matagorda Bay system were estimated for two levels of inflow needs: target and critical (LCRA 1999). The target inflow needs are the monthly and seasonal inflows that produced 98% of the maximum normalized population biomass for nine key estuarine fin fish and shellfish species while maintaining certain salinity, population density and nutrient inflow conditions. The salinity condition requires that estimated salinity fall within a predetermined range preferred by most species. The population density of any species has to be greater than 80% of its historical average. Finally, the total inflow of nutrients is at least equal to the natural nutrient losses from the ecosystem.

The critical inflow needs were determined by finding the minimum total annual inflow needed to keep salinity near the mouths of the Colorado and Lavaca Rivers at no more than 25 parts per thousand. These inflow needs are termed critical since they provide a fishery sanctuary habitat during droughts. From this sanctuary, the fin fish and shellfish species, particularly oysters, could be expected to recover and repopulate the bay when more normal weather conditions returned.

The Matagorda Bay system receives a freshwater inflow from the Colorado River, the Lavaca River, and surface runoff from the contributing drainage basins. Target and critical inflow needs from all sources were calculated to be 2.0 million and 287,400 acre-ft per year, respectively. The Colorado River provides 52% of target inflows and 60% of critical inflow needs. Both the LCRA recommended target and critical monthly freshwater inflow needs from the Colorado River are indicated in Table 3-14. Total commitments of the combined firm yield from the Highland Lakes for bays and estuaries will be an average of 3,090 acre-ft in any five years and 30,900 acre-ft in any six to ten consecutive years.

It should be noted that the LCRA, Lavaca Navidad River Authority, TWDB, TCEQ, and TPWD are updating the 1997 Freshwater Needs Study for Matagorda Bay. The update is scheduled for completion in late 2005. If the study is approved by all parties to the MOA, then LCRA would begin the process of determining whether to revise the water management plan within 6 months of the completion of the study. Senate Bill 3, if passed, would also set out a methodology,

Table 3-14
Recommended Target and Critical Freshwater Inflow Needs from the Colorado River for the Matagorda Bay System

Month	Target Needs (1,000 Acre-Feet)	Critical Needs (1,000 Acre-Feet)
January	44.1	14.26
February	45.3	14.26
March	129.1	14.26
April	150.7	14.26
May	162.2	14.26
June	159.3	14.26
July	107	14.26
August	59.4	14.26
September	38.8	14.26
October	47.4	14.26
November	44.4	14.26
December	45.2	14.26
Total	**1,033.10**	**171.1**

Note: Totals do not sum due to rounding

*Source: LCRA (1999).

process and timeline for determining freshwater inflow needs for Texas bays and estuaries, which may or may not affect the use of the Matagorda Bay study. A separate Bay Health Study is also being conducted as a part of the SAWS/LCRA project feasibility study.

3.2.12 Water and Sediment Quality

The TCEQ carries out a regular program of monitoring and assessment to compare conditions in Texas surface waters to established standards and to determine which water bodies are meeting the standards set for their use, and which are not. The TCEQ works in collaboration with the Texas Clean Rivers Program and other federal, state, regional, and local agencies to collect and assess water quality data. The results of the assessment are published every two years in the *Texas Water Quality Inventory and 303(d) List*, as required by Sections 305(b) and 303(d) of the CWA. The *Texas Water Quality Inventory and 303(d) List* is an overview of the status of surface waters of the state, including concerns for public health, fitness for use by aquatic species and other wildlife, and specific pollutants and their possible sources. From 1996 to 2001, over 700 water bodies were

assessed in Texas; 299 have been identified on the draft 303(d) List for 2002 because they are not supporting one or more beneficial uses. The 303(d) List identifies:

- water bodies that do not meet the standards set for their use, or are expected not to meet their use in the near future;
- which pollutants or conditions are responsible for the failure of a water body to meet standards; and
- water bodies that are targeted for cleanup activities within the next four years.

Common impairments include:

- bacteria levels that exceed the criterion established to assure the safety of contact recreation
- dissolved oxygen levels that are lower than the criterion established to assure optimum conditions for aquatic life
- total dissolved solids, sulfate, and chloride that exceed the criterion established to safeguard general water quality uses
- contaminants in fish tissue that pose a risk to consumers

Some water bodies also have:

- toxic substances in water that exceed the criterion to protect aquatic life
- conditions of acidity (measured as pH) and high temperatures that exceed the criterion to safeguard general water quality uses

For 2004, the TCEQ conducted a targeted water quality assessment of 182 water bodies (out of 731 assessed in 2002). The targeted water bodies were identified as concerns in 2002 because of the data set for them was too small to allow for a full assessment, but a number of measurements did not meet the criteria defined in the standards. These 182 targeted water bodies were prioritized for more intense monitoring over the last two years. The *2004 Draft Texas Water Quality Inventory and 303(d) List,* (TCEQ 2004) provides an up-to-date status for them.

The increase in the number of water bodies and conditions that are monitored has led to a concurrent rise in the number of water bodies that are identified as impaired, from 147 identified in 1996, to 309 water bodies identified in 2004, with a total of 413 impairments. However, overall water quality remains good, with most meeting their standards.

Highland Lakes Reach. The Colorado River upstream of the Highland Lakes is high in total dissolved solids, especially chlorides and sulfates. Although the upper drainage is naturally high in dissolved solids, levels have been increasing, presumably due to the ground water contamination from oilfield activity. Water quality generally improves below the San Saba River confluence due to freshwater inflows of the San Saba River.

Water quality continues to improve downriver through the Highland Lakes chain. Lake Buchanan, the first lake in the Highland Lakes chain, is generally higher in dissolved solids than the downstream reservoirs. Lake LBJ impounds the confluences of the Llano River and Big Sandy Creek that contribute a substantial amount of water that is low in dissolved solids to the system. Lake Travis impounds the Pedernales River confluence, which is also lower in dissolved solids. This progressive improvement in water quality is typical of reservoir chains and the contributions of high quality water from several major tributaries combine to make Lake Travis one of the cleanest reservoirs in Texas.

According to the *Draft Texas Water Quality Inventory and 303(d) List* (TCEQ 2004), six assessment units (portions of designated stream segments) within the Highland Lakes Reach were identified with use concerns in 2004. One of the assessment units is on the San Saba River, one occurs at the headwaters of Inks Lake, and four are located in the Austin area.

The portion of the San Saba River immediately below Brady Lake Dam and the headwaters of Inks Lake were both listed as partially supporting for aquatic life use (TCEQ 2004). Depressed dissolved oxygen levels immediately below the dams of these two water bodies were the reason for the designation.

In the Austin area, portions of Bull Creek (1403A_04), Spicewood tributary to Shoal Creek (1403J_01), Taylor Slough South (1403K_01), and Waller Creek (1429C_01) were designated with use concerns for at least one criterion (TCEQ 2004). Waller Creek was unsupporting for aquatic life use due to an impaired macrobenthic community and was also unsupporting for recreation use due to high bacteria levels. Additional data and information will be collected before a Total Maximum Daily Load (TMDL) study is scheduled. Bull Creek was unsupporting for aquatic life use due to impaired macrobenthic communities; and Spicewood tributary to Shoal Creek and Taylor Slough South were unsupporting for recreation use due to high bacteria levels.

Central Reach. Water quality conditions in the Colorado River downstream of Austin are dominated by releases from the Highland Lakes, the discharge of treated sewage effluent from several COA sewage treatment plants, and non-point source loadings during rainfall events. During

the normal irrigation season (mid-March to mid-October), the LCRA releases an average of 2,000 cubic feet per second (cfs) of high quality water from the Highland Lakes to meet downstream demand. Releases from Lake Travis are minimal from mid-October to mid-March and the Colorado River downstream of Austin is predominately composed of treated wastewater effluent.

In the Austin area, Onion Creek (1427_01), Slaughter Creek (1427A_01), and Gilleland Creek (1428C_01) were identified with use concerns in the *2004 Draft Texas Water Quality Inventory and 303(d) List* (TCEQ 2004). Onion Creek exhibited depressed dissolved oxygen levels and did not meet the recreation use criteria due to increased bacteria levels (TCEQ 2004). A TMDL for Onion Creek has been completed. Slaughter Creek did not support aquatic life use criteria due to impaired macrobenthos community. A TMDL for this stream segment is not scheduled at this time pending the collection of additional data and information. Gilleland Creek was identified as not supporting the recreation use criteria due to increased bacteria levels. A TMDL is currently underway.

Coastal Reach. Based on 2002 limited data, average and minimum 24-hour dissolved oxygen levels are a "use concern" to aquatic life in the lower 25 miles of Skull Creek (1402H_01). Of four samples taken for each parameter, 75% exceed water quality standards for the 24-hour average and 50% exceed the 24-hour minimum. The *2004 Draft Water Quality Inventory and 303(d) List* (TCEQ 2004) indicates that further sampling has eliminated "use concerns". The remainder of the water body has not bee assessed for aquatic life use.

Aquatic life use in waters of the 55-mile long reach of Cummins Creek (1402A) is designated as exceptional. Based on limited data, habitat impairment is a "use concern" to diverse benthic macroinvertebrate and fish communities (Bayer et al. 1992; Linam et al. 1999) in the lower 25 miles of the water body. In 2004, it was determined that although the macrobenthic and fish communities do not support the designated standard for aquatic life, this condition is caused by low flow conditions and not by a pollutant. Thus, no TDML is scheduled for this segment. Aquatic life use has not been assessed for the upper 30 miles of this stream. One fish kill was recorded for the 150-mile long reach of the Colorado River below La Grange (1402). The event occurred in August 1998 near La Grange and pollutants were determined as the cause of death for 28,760 fish.

In East Matagorda Bay (2441), oyster waters use (i.e. shellfish harvesting) is not fully supported due to the presence of bacteria. A TMDL study is underway, scheduled, or will be scheduled. Two fish kills are recorded for this segment. The first occurred in December 1996 when temperature killed 500 fish from Drews Lamp to Bird Island and Dressing Point Island. The second

occurred in July 1999 when physical damage/trauma killed 444,742 fish in East Matagorda Bay and Matagorda Bay.

Oyster waters use in the 21.7 square mile area at the east end of Matagorda Bay/Powderhorn Lake (2451) is not supported due to the presence of bacteria. A TMDL will be scheduled. Aquatic life use in the east half of the bay is only partially supported due to depressed oxygen levels. Additional data and information will be collected before a TMDL is scheduled.

In the Gulf of Mexico (2501), fish consumption use is not fully supported due to high levels of mercury found in king mackerel (greater than 43 inches). Additional data and information will be collected before a TMDL is scheduled. Historic fish kills in the area include a 100,000 disease related kill occurring May 1996 from Louisiana to Matagorda Bay area, and a 148,000 disease related kill occurring August 1997 west of the swing bridge on Sargent Beach.

Ground-Water

Major Aquifers. Several major aquifers underlie the study area (Figure 3-15). The outcrop portion of the Trinity Group Aquifer that underlies the study area begins in Mitchell and Nolan counties and extends along the upper basin boundary into Travis and Blanco counties. The downdip portion of the aquifer is within Travis County. The aquifer's composition is primarily fine-grained sands with interbedded clays, limestone, and shales. Thickness ranged from less than 100 ft in outcrop portions to about 1,200 ft in downdip areas.

Water quality in the outcrop area is good, with dissolved solids concentrations usually less than 500 milligrams/liter (mg/l). The quality of the downdip ground water varies between fresh and slightly saline. The fluoride content of the water in many areas of the aquifer exceeds the U.S. Environmental Protection Agency (EPA) primary standards for drinking water.

The Edwards-Trinity (Plateau) Aquifer underlies a portion of the Highland Lakes Reach. The upper part of the aquifer is up to 500 ft in thickness and is composed of various limestones and thin layers of shale. The lower part of the aquifer is generally less than 100 ft in thickness and is composed of fine-grained sands and clay.

The ground water generally flows to the southeast and is the source for numerous springs in the Edwards Plateau. The water is generally hard and quality ranges from fresh to slightly saline. Dissolved solids concentrations vary, with salinity increasing toward the west.

The Edwards (Balcones Fault Zone) Aquifer extends in a narrow band across the lower Colorado River basin in the central portion of Travis County. The river cuts the aquifer into a northern and southern (Barton Springs) segment.

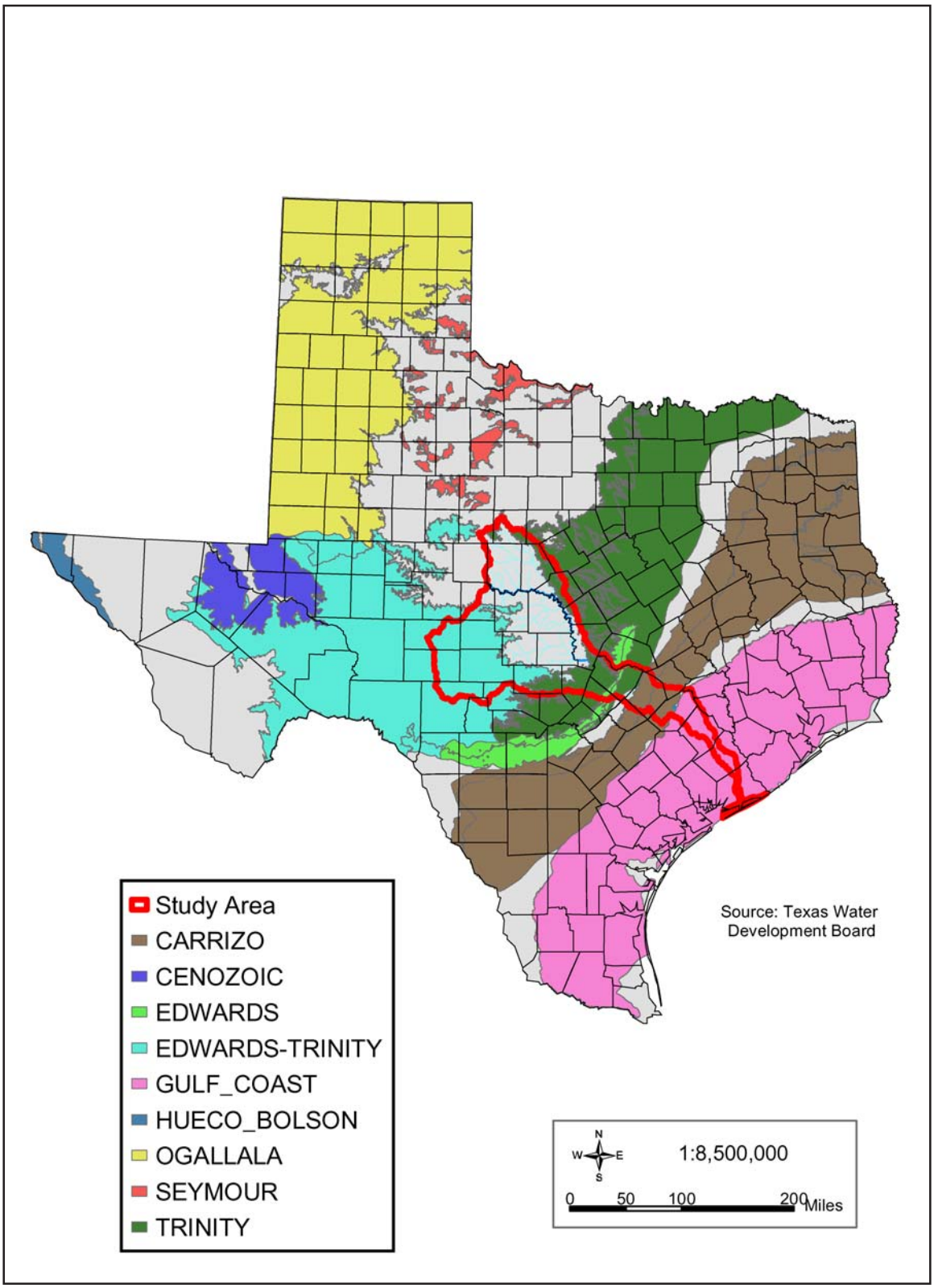

Figure 3-15 Major Aquifers of Texas Date: October 2004

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The aquifer consists of Edwards and associated limestone formations interbedded with shale acting as confining layers. The aquifer varies in thickness from 200 to 600 ft, and is primarily recharged from stream flow crossing the outcrop (Slade et al. 1986). The surface water and precipitation that recharge the aquifer move toward natural discharge points in several tributary river basins. Barton Springs in Austin is the main discharge point of the aquifer in the Colorado River basin. The water quality is generally fresh, with dissolved solids concentrations normally less than 500 mg/l.

The Carrizo-Wilcox Aquifer underlies the Colorado River basin in a band that includes most of Bastrop County and portions of Lee, Caldwell, and Fayette counties. The outcrop portion of the aquifer includes the middle half of Bastrop County. Wells in the Carrizo-Wilcox in the lower Colorado River basin average 200 gallons per minute (gpm). The aquifer is recharged by precipitation falling on the outcrop area.

The Gulf Coast Aquifer lies beneath the Coastal Reach (Ryder 1996). It is composed of the Catahoula, Oakville, Lagarto, Goliad, Lissie, and Beaumont formations. The aquifer consists of a complex system of interbedded sand and clay lenses and extends to a maximum depth of about 2,500 ft. Yields of large-capacity wells average about 1,500 gpm, but locally reach 3,400 gpm. Water in the aquifer contains less than 500 mg/l total dissolved solids, but concentrations increase down-dip, particularly near the Gulf.

Minor Aquifers. Minor aquifers of Texas and the study area are shown on Figure 3-16. The Ellenburger-San Saba Aquifer is located in the Highland Lakes Reach and forms a circle around the Llano Uplift in Llano and Mason counties. The outcrop areas of the aquifer are thin and spotty, and they are located on the edges of the uplift. The downdip portion of the aquifer if much larger and extends radically from the outcrop areas and the uplift. The aquifer is composed of limestone and dolomite with a thickness up to 2,000 ft. Much of the Ellenburger-San Saba Aquifer is under artesian pressure, and natural artesian discharges support base flows of the Llano, San Saba, Pedernales, and Colorado rivers. Well yields are usually less than 500 gpm. The dissolved solids concentration less than 3,000 mg/l extends downdip to about 3,000 ft.

The Hickory Sandstone Aquifer, like the Ellenburger-San Saba, encircles the Llano Uplift. The aquifer lies beneath most of every county that borders Llano and Mason counties. The aquifer is 50-75% fine to coarse-grained sand with sandstone. The aquifer thickness averages 400 ft with a maximum thickness of 500 ft. Well yields normally range between 200 and 500 gpm. Dissolved solids concentrations in the water usually range from 300 to 500 mg/l.

The Marble Falls Limestone Aquifer is located in a number of areas north and east of the Llano Uplift. The aquifer consists of massive, thick-bedded limestone to a thickness of about 600 ft. Well yields range up to 2,000 gpm. The outcrop areas of the aquifer produce good quality water with dissolved solids increasing with depth.

The Queen City Aquifer is beneath the eastern one-third of Bastrop County and the western one-third of Fayette County in the lower Colorado River basin. The composition of the aquifer is primarily sand with interbedded clays and loosely cemented sandstone. The maximum thickness is 200 ft and average well yields are less than 200 gpm. The water quality varies widely from low dissolved solids to moderately saline with concentrations over 3,000 mg/l.

The Sparta Spring Aquifer underlies the lower Colorado River basin along the connecting boundary of Bastrop, Fayette, and Lee counties. The Sparta is mainly sand with interbedded clays. The aquifer's thickness in the basin is normally less than 100 ft. Large-capacity wells may yield 400-500 gpm, but most wells yield less than 100ft/gpm. The water is usually low in dissolved solids concentrations. However, some areas contain excessive iron and dissolved solids over 3,000 mg/l.

The Colorado Rivere Alluvium has characteristics which qualify it as a minor aquifer by the TWDB, although TWDB has not yet made such a designation. The Colorado River Alluvium stretches for 200 miles from Austin to Wharton, Texas. Water bearing formations further downstream are grouped into the Gulf Coast Aquifer. Water in the alluvial aquifer is in direct contact with the Colorado River and has similar water quality characteristics as the river. The Colorado River Alluvium provides public water supply for municipalities and individual domestic users and is an important source for irrigation (Saunders 1996).

3.2.13 Threatened and Endangered Species

The lower Colorado River basin provides a variety of habitats for numerous species that have been listed, or are candidates for listing, as threatened or endangered by the USFWS, the NMFS, and/or the State of Texas. USACE has coordinated with both the USFWS and the NMFS with regard to threatened and endangered species. According to USFWS, 25 federally listed or candidate species have potential to occur in counties that border the Colorado River in the study area (USFWS 2003 - see Appendix 3). Many of these are also listed as threatened or endangered by the State of Texas. The TPWD includes another 25 species or sub-species with federal or state status on its annotated lists of rare species for the counties under consideration here (TPWD 2003a, 2003b,

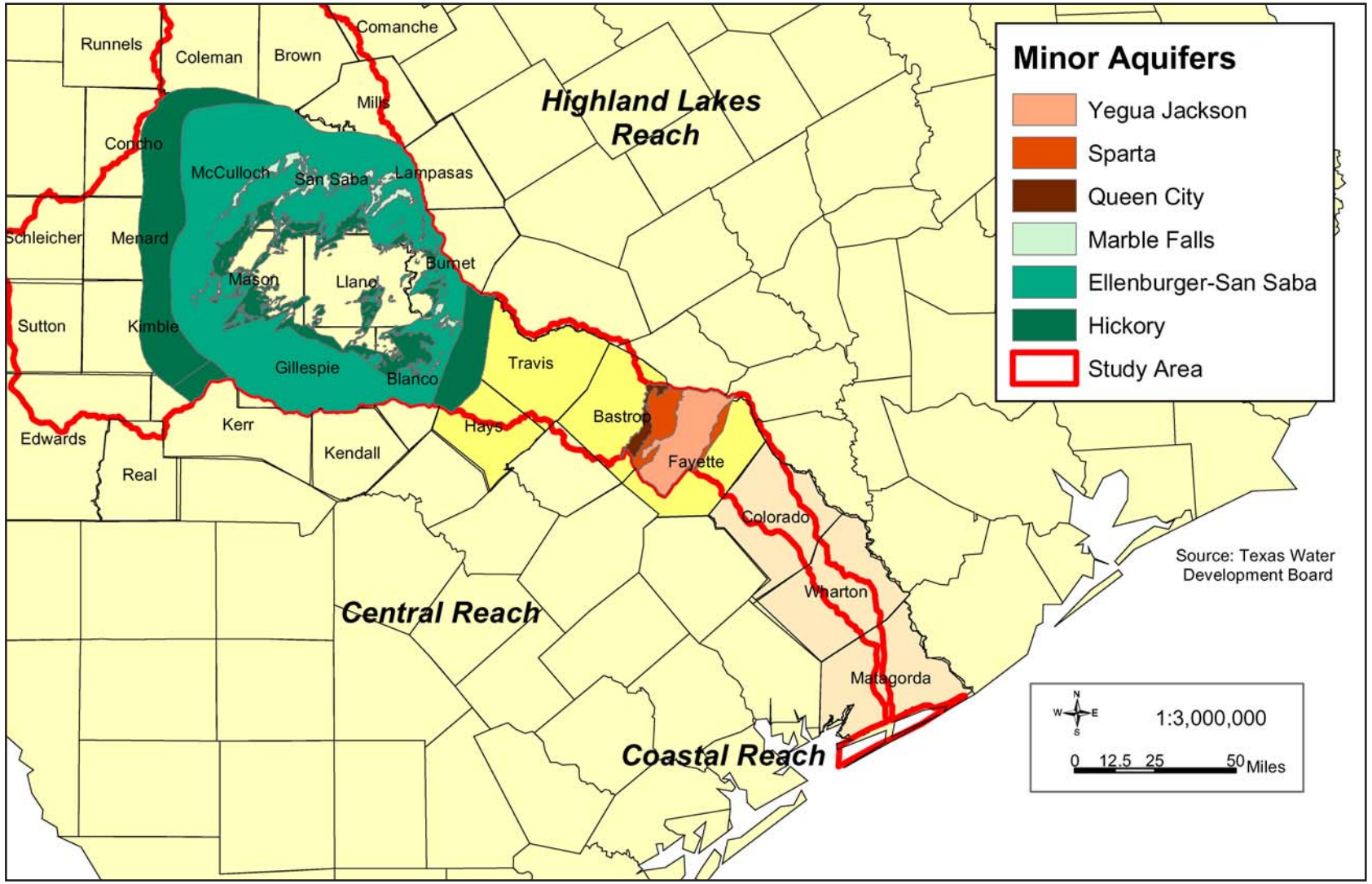

Figure 3-16 Minor Aquifers Within Study Area

Date: October 2004

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2003c, 2003d, 2004b, 2004c, 2004d, 2004e, 2004f, 2004g, 2004h, 2004i, 2004j, 2004k, and 2004l - see Appendix 3).

Federally and state-listed species known or expected to occur in the basin are discussed by reach below. Excluded from these discussions are six taxa included on annotated lists prepared by TPWD that have been extirpated from the state or that are otherwise not expected to occur in the basin. These taxa include the red wolf (*Canis rufus*), gray wolf (*Canis lupus*), black bear (*Ursus americanus*), Louisiana black bear (*U. a. luteolus*), ocelot (*Leopardus pardalis*), and Texas hornshell (*Popenaias popeii*).

Highland Lakes Reach. A total of 18 federally endangered, threatened, or candidate species are listed by USFWS (1997b, 2003) as occurring, or having potential to occur, in the counties that border the Colorado River in the Highland Lakes Reach. Sixteen of these species are known or are considered likely to occur regularly in some portion of the reach. Counties in which these 16 species are known or have potential to occur based on USFWS (2003) are identified in Table 3-15. The 16 species include: Concho water snake, which occurs in the Colorado and Concho River mainstems and tributaries; two migratory songbirds (black-capped vireo [*Vireo atricapilla*] and golden-cheeked warbler [*Dendroica chrysoparia*]) that breed in upland woody habitats; two aquatic salamanders known only from Barton Springs in Travis County; seven species of invertebrates that occur in caves formed in the Edwards Formation; three birds expected to occur only as rare to uncommon migrants (interior least tern [*Sterna antillarum athalassos*], piping plover [*Charadrius melodus*], and whooping crane [*Grus americana*]); and the bald eagle, which occurs primarily as a migrant and winter resident, but is also a rare breeder in the region. Within the reach, critical habitat has been designated only for the Concho water snake, in Concho, Coleman, and McCulloch counties (USFWS 1989).

The remaining two of the 18 species listed by USFWS (2003) as having potential to occur in the Highland Lakes Reach are the black-tailed prairie dog (*Cynomys ludovicianus*) and northern aplomado falcon (*Falco femoralis septentrionalis*). The prairie dog formerly occurred in grasslands across much of the reach and is listed by USFWS (2003) as having potential to occur in all counties under consideration here except for Burnet, Lampasas, and Travis. However, recent information suggests the species has been extirpated from the region (Texas Black-tailed Prairie Dog Working Group 2004). The original range of the falcon has been much reduced, with the species having formerly occurred in grasslands in parts of west and south Texas. It was never known to occur regularly on the Edwards Plateau, but is listed by USFWS (2003) as having potential to occur

Table 3-15

Federally Endangered, Threatened, and Candidate Species Regularly Occurring Within the Lower Colorado River Basin

Highland Lakes Reach	Counties of Potential Occurrence									
	Concho	Coleman	McCulloch	Brown	San Saba	Mills	Lampasas	Llano	Burnet	Travis
Endangered Species										
Barton Springs salamander (*Eurycea sosorum*)										X
Bee Creek Cave harvestman (*Texella reddelli*)									X	X
Black-capped vireo (*Vireo atricapilla*)	X		X	X	X	X	X	X	X	X
Bone Cave harvestman (*Texella reyesi*)										X
Golden-cheeked warbler (*Dendroica chrysoparia*)					X		X	X	X	X
Interior least tern (*Sterna antillarum athalassos*)	X	X	X	X	X	X	X	X	X	X
Kretschmarr Cave mold beetle(*Texamaurops reddelli*)										X
Tooth Cave ground beetle *(Rhadine persephone*)										X
Tooth Cave pseudoscorpion (*Tartarocreagris texana*)										X
Tooth Cave spider (*Neoleptoneta myopica*)										X
Whooping crane (*Grus americana*)	X	X	X	X	X	X	X	X	X	X
Threatened Species										
Bald eagle (*Haliaeetus leucocephalus*)	X	X	X	X	X	X	X	X	X	X
Concho water snake (*Nerodia paucimaculata*)	X	X	X	X	X	X	X			
Piping plover (*Charadrius melodus*)	X	X	X	X	X	X	X	X	X	X
Candidate Species										
Austin blind salamander (*Eurycea waterlooensis*)										X
Warton meshweaver (*Cicurina wartoni*)										X

Central Reach	Counties of Potential Occurrence		
	Travis	Bastrop	Fayette
Endangered Species			
Houston toad (*Bufo houstonensis*)		X	
Interior least tern (*Sterna antillarum athalassos*)	X	X	X
Whooping crane (*Grus americana*)	X	X	X
Threatened Species			
Bald eagle (*Haliaeetus leucocephalus*)	X	X	X
Piping plover (*Charadrius melodus*)	X	X	X

*Table 3-15 continued on next page.

Table 3-15, continued
Federally Endangered, Threatened, and Candidate Species Regularly Occurring Within the Lower Colorado River Basin

Coastal Reach	Counties of Potential Occurrence		
	Colorado	Wharton	Matagorda
Endangered Species			
Attwater's greater prairie chicken (*Tympanuchus cupido attwateri*)	X		
Brown pelican (*Pelecanus occidentalis*)			X
Hawksbill sea turtle (*Eretmochelys imbricata*)			X
Houston toad (*Bufo houstonensis*)	X		
Interior least tern (*Sterna antillarum athalassos*)	X	X	X
Kemp's ridley sea turtle (*Lepidochelys kempii*)			X
Leatherback sea turtle (*Dermochelys coriacea*)			X
West Indian manatee (*Trichechus manatus*)			
Whooping crane (*Grus americana*)	X	X	X
Threatened Species			
American alligator (*Alligator mississippiensis*)	X		X
Bald eagle (*Haliaeetus leucocephalus*) (T/SA)	X	X	X
Green sea turtle (*Chelonia mydas*)			X
Loggerhead sea turtle (*Caretta caretta*)			X
Piping plover (*Charadrius melodus*)	X	X	X

T/SA - Threatened due to similarity of appearance

*Based on USFWS 2003

in Burnet County. Over the past 15 years, captive-raised individuals of this species have been released into the wild in the southern tip of the state (Lockwood and Freeman 2004). Neither of these two species is expected to occur in the Highland Lakes Reach and neither is discussed further in this document.

State-listed species that occur in the Highland Lakes Reach include three birds, the peregrine falcon (*Falco peregrinus*), white-faced ibis (*Plegadis chihi*), and zone-tailed hawk (*Buteo albonotatus*), as well as the Texas horned lizard (*Phrynosoma cornutum*). The former two species occur as migrants, the hawk is an uncommon summer breeding resident of canyonlands, and the lizard is an uncommon permanent resident of upland bare grounds.

Natural history information and more detail on the distribution of federally and state-listed species of the Highland Lakes Reach are provided in Appendix 3. Also included in this reach are two

candidate fish species, the sharpnose shiner (*Notropis oxyyrhynchus*) and smalleye shiner (*Notropis buccula*). These species are not native to the Colorado River basin but have been collected from the river upstream of Lake Buchanan and in Travis County, respectively, presumably the result of bait-bucket releases.

Central Reach. Five federally listed endangered or threatened species are considered by USFWS (2003) as occurring, or having potential to occur, in the three counties that border the Colorado River in the Central Reach. The counties in which these species have potential to occur based on USFWS (2003) are identified in Table 3-15. These species include: three birds expected to occur only as migrants (interior least tern, piping plover, and whooping crane); the bald eagle, which can occur as a migrant, winter resident, and breeding species in the region; and the Houston toad, which typically occurs in woodlands. Within the reach, critical habitat has been designated for the Houston toad in Bastrop County (USFWS 1978).

State-listed species occurring or having potential to occur in the Central Reach include: six birds, the peregrine falcon, reddish egret (*Egretta rufescens*), swallow-tailed kite (*Elanoides forficatus*), white-faced ibis, white-tailed hawk (*Buteo albicaudatus*), wood stork (*Mycteria americana*), and zone-tailed hawk; two reptiles, the Texas horned lizard and timber rattlesnake (*Crotalus horridus*); and a fish, the blue sucker. None of the birds, except for possibly the ibis, is expected to breed in the reach. Both reptiles are permanent residents in appropriate habitat; and the blue sucker is known to occur only in the Colorado River mainstem.

Natural history information and more detail on the distribution of federally and state-listed species within the Central Reach are contained in Appendix 3. Also included are federally listed species known or considered to have potential to occur in the Central Reach (e.g., American alligator [*Alligator mississippiensis*] and Navasota ladies'-tresses [*Spiranthes parksii*]) that are not included for Travis, Bastrop, or Fayette Counties in USFWS (2003).

Coastal Reach. A total of 14 federally listed endangered or threatened species are considered by USFWS and NMFS (2003) as occurring, or having potential to occur, in the three counties that border the Colorado River in the Coastal Reach. The counties in which these species have potential to occur based on USFWS and NMFS (2003) are identified in Table 3-15. These species include: five species of sea turtles; two birds expected to occur only as migrants (interior least tern and whooping crane); the Houston toad, which occurs in sandy-soiled woodlands in Colorado County; Attwater's greater prairie-chicken (*Tympanuchus cupido attwateri*), which is known to occur at the Attwater Prairie Chicken National Wildlife Refuge in Colorado County; brown pelican (*Pelecanus*

occidentalis), a common resident of the coast; bald eagle, which can occur year-round in the region; piping plover, which winters coastally and can occur as a migrant elsewhere; American alligator, a widespread resident; and West Indian manatee (*Trichechus manatus*), which is a very rare visitor to coastal bays and estuaries. Within the reach, many of the beaches, tidal flats and coastal mud flats of Matagorda County have been designated as critical habitat for wintering piping plovers (USFWS 2001). There are increasing reports of sea turtle nesting activities on Texas beaches. Sea turtles have been observed within the waters of Matagorda Bay and have potential to nest on the Matagorda Peninsula beaches (Landry et al. 1997; Renaud and Williams 1997; Williams and Renaud 1998) However, there are no confirmed reports of nesting activities in the project area.

State-listed species lacking federal status that are known or have potential to occur in the Coastal Reach include: seven birds, the peregrine falcon, reddish egret, sooty tern (*Sterna fuscata*), swallow-tailed kite, white-faced ibis, white-tailed hawk, wood stork, and zone-tailed hawk; five reptiles, the smooth green snake (*Liochlorophis vernalis*), Texas horned lizard, Texas scarlet snake (*Cemophora coccinea lineri*), Texas tortoise (*Gopherus berlandieri*), and timber rattlesnake; and, possibly, the blue sucker.

Natural history information and more detail on the distribution of federally and state-listed species within the Coastal Reach are contained in Appendix 3.

3.2.14 Air Quality

The Clean Air Act (CAA) of 1970 (42 U.S.C. § 7401, et.seq), as last amended in 1990, requires the EPA to promulgate primary and secondary National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment (42 U.S.C. § 7409). Primary standards set limits to protect the public health, including the health of sensitive populations, such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. The EPA Office of Air Quality Planning and Standards (OAQPS) have set NAAQS for six criteria pollutants (EPA 2004f). The major pollutants of concern or "criteria pollutants" are carbon monoxide (CO), sulfur dioxide (SO_2), nitrous oxide (NOx), ozone (O_3), suspended PM, and lead. Units of measure for the standards are parts per million (ppm) by volume, milligrams per cubic meter (mg/m^3) of air, and micrograms per cubic meter of air ($\mu g/m^3$). Table 3-16 presents air pollution concentrations required to exceed the NAAQS.

Table 3-16

Air Pollution Concentrations Required to Exceed the NAAQS

	Averaging Period	Standard	Primary NAAQS	Secondary NAAQS
Ozone	1-hr	Not to be at or above this level on more than three days over the year	125 ppb	125 ppb
	8-hr	The average of the annual fourth highest daily eight-hour maximum over a three-year period is not to be at or above this level	85 ppb	85 ppb
Carbon Monoxide	1-hr	Not to be at or above this level more than once per calendar year	35.5 ppm	35.5 ppm
	8-hr	Not to be at or above this level more than once per calendar year	9.5 ppm	9.5 ppm
Sulfur Dioxide	3-hr	Not to be at or above this level more than once per calendar year	–	550 ppm
	24-hr	Not to be at or above this level more than once per calendar year	145 ppm	–
	Annual	Not to be at or above this level.	35 ppm	–
Nitrogen Dioxide	Annual	Not to be at or above this level.	54 ppm	54 ppm
Respirable Particulate Matter (10 microns or less) (PM_{10})	24-hr	Not to be at or above this level on more than three days over three years whild daily sampling.	155µg/m^3	155µg/m^3
	Annual	The three-year average of annual arithmetic mean concentrations at each monitor within an area is not to be at or above this level.	51µg/m^3	51µg/m^3
Respirable Particulate Matter (2.5 microns or less) ($PM_{2.5}$)	24-hr	The three-year average of annual 98th percentile for each population-oriented monitor within an area is not to be at or above this level.	66 µg/m^3	66 µg/m^3
	Annual	The three-year average of annual arithmetic mean concentrations from single or multiple community-oriented monitors is not to be at or above this level.	15.1 µg/m^3	15.1 µg/m^3
Lead	Quarter	Not to be at or above this level	1.55 µg/m^3	1.55 µg/m^3

Areas that do not meet these standards are called “non-attainment” areas, conversely, areas that meet both primary and secondary standards are known as “attainment” areas. The CAA requires that for areas designated as non-attainment, plans must be prepared and implemented to bring the area into attainment within a specified time period. The TCEQ is responsible for reporting air quality in the state.

The study area is divided into two regions under the TCEQ, the state agency responsible for meeting NAAQS. Bastrop, Blanco, Burnet, Fayette, Hays, Llano, and Travis counties are located in Region 11 and Colorado, Matagorda, and Wharton counties are in Region 12. Non-attainment areas are shown in Figure 3-17.

Ozone is a photochemical oxidant and the major component of smog. Ozone is not directly emitted to the air but is formed through chemical reactions between precursor emissions of volatile organic compounds (VOC) and oxides of nitrogen in the presence of sunlight. High temperatures stimulate these reactions so that elevated concentrations of ozone are typically detected during the warmer months. Precursors of ozone are emitted through transportation, industrial, and biogenic sources. The former ozone NAAQS threshold value was 125 ppb measured as 1-hour average concentration. An 8-hour average concentration standard of 85 ppb was established in 1997. EPA revoked the 1-hour standard effective on June 15, 2005. The 8-hour standard has become the applicable ozone standard.

Four metropolitan areas in Texas have exceeded the national standards for ozone often enough to be classified as non-attainment areas. They are: Houston/Galveston/Brazoria, Beaumont/ Port Arthur, Dallas/Fort Worth and El Paso. In general, Texas cities have shown a decline over the past 10 years in the number of days exceeding national standards.

Ozone is currently the most significant problem for Austin in terms of air pollution. In 1999, the Austin-San Marcos Metropolitan Statistical Area (MSA) violated the Federal 8-hour standard for ground-level ozone concentrations. For violating this standard, the Central Texas region is now subject to a near non-attainment designation by the EPA. This designation refers to a geographic area that meets NAAQS but only by a slim margin. Reducing regional ozone depends on lowering regional emissions of NOx, one of the two primary precursors of ozone. The burning of fuels, primarily in internal combustion engines, is the most significant regional source of NO_x. According to the 1996 Draft Emissions Inventory, more than 180 tons of NOx are emitted each day in the MSA, which includes Bastrop, Caldwell, Hays, Travis, and Williamson counties.

The COA has signed an Early Action Compact with the EPA. This action commits the COA to implement emission reduction strategies designed to result in sufficient emission reductions to meet and maintain the 8-hour standard by 2007. These strategies include actions to be undertaken by individuals as well as actions that involve coordination between multiple organizations. These strategies are outlined in the COA Ozone Reduction Strategies, Final Report, prepared by the COA.

Matagorda and Wharton counties are in attainment for all criteria pollutants; however, they are adjacent to Brazoria and Fort Bend counties, which are in non-attainment for ozone pollution. The Houston Air Plan has been approved by the TCEQ and has been forwarded to the EPA for its approval to bring these counties into attainment for ozone by 2007.

3.2.15 Cultural Resources

Numerous cultural resources sites and properties are currently known and recorded from the lower Colorado River basin. Portions of the study area have been surveyed for cultural resources properties, although the majority of the basin is unsurveyed. Given the magnitude of the study area, and the programmatic nature of this document, cultural resource investigations were limited to a literature search along the river corridor. The search was confined to 1,000 ft on either side of the river and included a site file search at the Texas Archaeological Research Laboratory (TARL).

Currently, the known cultural resources sites recorded and on file for the lower Colorado River corridor include 600 archaeological sites, 2 historic districts, and 11 National Register of Historic Places (NRHP) historic structures. The recorded cultural resources sites include historic sites such as old mills, homesteads, missions, historic artifact scatters, standing historic structures, burials and cemeteries, military sites, as well as prehistoric Native American sites such as lithic scatters, villages, burials and possible cemeteries, hunting and butchering sites, and alluvially buried archaeological deposits.

3.2.16 Recreation and Open Space

A diversity of recreation opportunities exist within the lower Colorado River basin. There are 14 state parks, (28,223 acres) which offer opportunities such as camping, hiking, fishing, boating, water, skiing, swimming, wildlife viewing, picnicking, tours of nature, exhibits, and historical amenities. The TPWD manages two WMAs within the basin, which consist of approximately 7,500 acres, and provide birding and wildlife viewing, hunting and fishing on seasonal basis, hiking, camping, bicycling, and horseback riding. There are four National Wildlife Refuges in the basin, (comprising

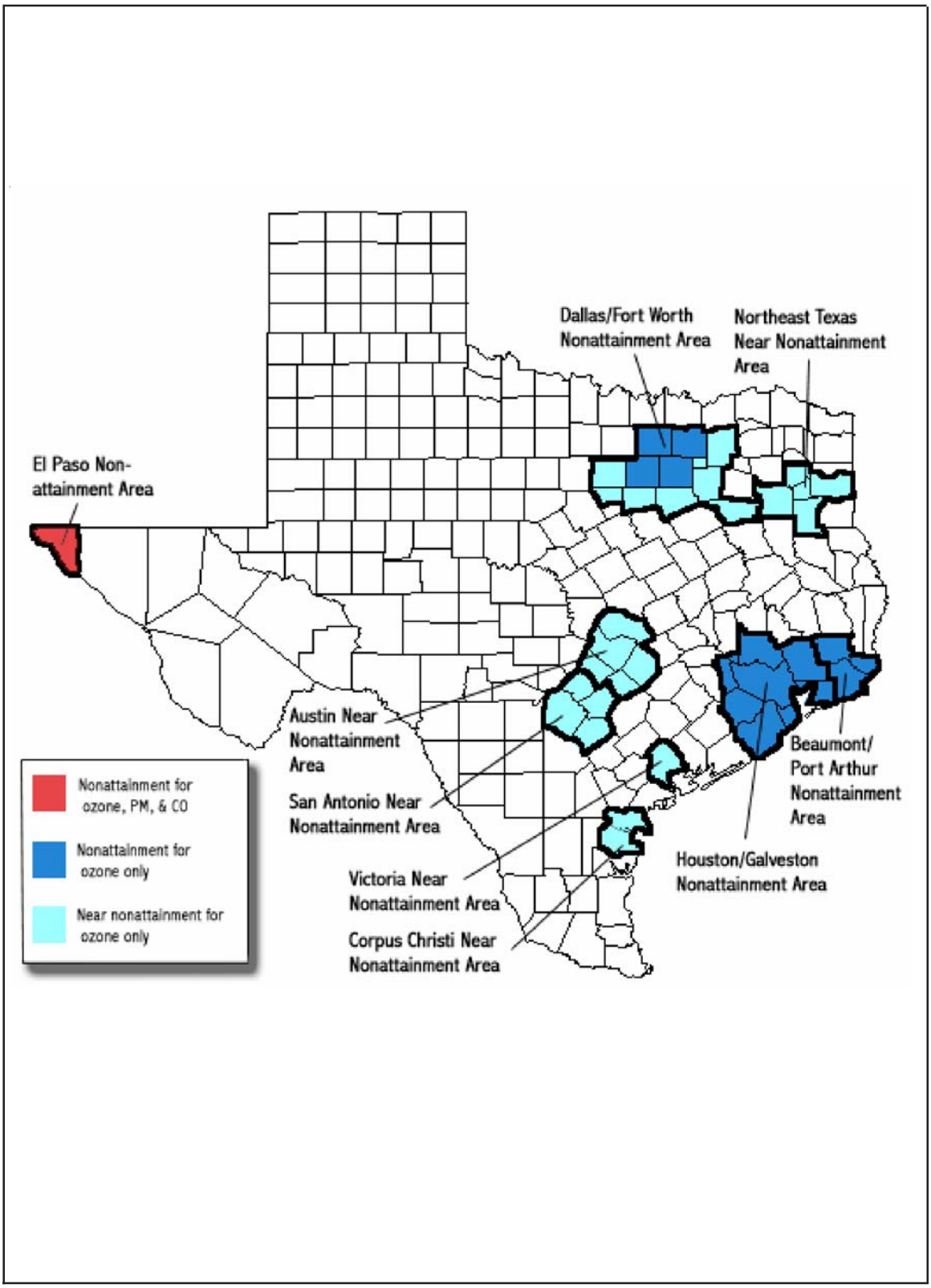

Figure 3-17 Nonattainment Areas of Texas Date: October 2004

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over 83,338 acres). Table 3-17 provides information on the state parks, wildlife refuges and WMAs within the lower Colorado River basin.

Water related recreation opportunities exist along the main stem of the Colorado River and at eleven water supply reservoirs including the Highland Lakes chain, which contains lakes Buchanan, Inks, LBJ, Marble Falls, Travis and Austin. Other major reservoirs in the region are lakes Goldthwaite, Blanco, Llano, Cedar Creek, and Lake Walter E. Long. Other surface water reservoirs in the region include the City of Llano's City Lake and City Park, Lake Walter E. Long owned by the COA, the LCRA's Lake Bastrop on Spicer Creek, Lake Fayette on Cedar Creek, and the City of Goldthwaite's two reservoir system. The LCRA operates a number of recreational facilities along the river corridor. Existing LCRA facilities are presented by county in Table 3-18. A total of 16,415 acres are operated by the LCRA within the basin, with the largest acreages occurring in Travis, Burnet, Bastrop, and Matagorda counties, respectively (USACE 2003b). Recreation opportunities provided by LCRA include camping, hiking, picnicking, swimming, boating, birding, and wildlife viewing.

Recreational activities important to the rural counties include hunting, fishing, and wildlife viewing opportunities marketed by private landowners. White-tailed deer, exotic game, migratory game birds, upland game birds, migratory waterfowl, and small game are regularly hunted in the region and provide seasonal recreation opportunities to leaseholders as well as an important source of income to landowners.

The open waters of Matagorda Bay and their associated barrier islands, marshes and coastal prairies also provide opportunities for recreation including camping, hiking, bicycling, surfing, swimming, beach combing, bird watching, nature study, fishing, a passenger ferry, on-island shuttle, and scheduled tours.

Public use data was collected for three public beaches in Matagorda County during the 2002 National Health Protection Survey of Beaches (EPA 2003). Palacios Beach is a one-mile beach open to Tres Palacios Bay and has less than 100 visitors a day with less than 10% of visitors entering the water. Two beaches, Matagorda and Sargent, open to the Gulf of Mexico. Matagorda Beach is 10 miles long, and generally receives less than 100 visitors per day except during peak season weekdays and off season holidays (500-999 visitors per day) and during peak season holidays (1,000-10,000). Sargent Beach is five miles long, and generally receives less than 100 visitors per day except during peak holidays (500-999 visitors per day) and peak season weekends (100-499).

Table 3-17

State and Federal Recreation Areas Within the Lower Colorado River Basin

Facilities	County	Acreage	Major Recreational Attraction
State Parks			
Admiral Nimitz Museum & Historical Center	Gillespie	7	Historical WWII exhibits
Bastrop State Park	Bastrop	3,504	Lost Pines habitat
Blanco State Park	Blanco	105	Fishing
Buescher State Park	Bastrop	1,017	Bird Watching, 250 species of birds
Colorado Bend State Park	San Saba	5,328	Gorman Falls, birding
Enchanted Rock State Park	Gillespie & Llano	1,644	National Natural Landmark, National Historic Site
Inks Lake State Park	Burnet	1,202	Inks Lake
Lake Bastrop S. Shore Park	Bastrop	773	Lake
Longhorn Cavern State Park	Burnet	639	Natural Landmark, prehistoric site
LBJ State Historical Park	Gillespie	718	History and wildlife viewing
Matagorda Island State Park	Matagorda	7,325	Birding
McKinney Falls State Park	Travis	744	Falls
Monument Hill State Historical Park/Kreische Brewery State Historical Park	Fayette	5	History – Salado Creek Battle 1842, brewery
Pedernales State Park	Blanco	5,212	Edwards Plateau terrain, wildlife viewing
National Wildlife Refuges			
Attwater Prairie Chicken	Colorado	8,000	Birding
Balcones Canyonlands	Travis	14,144	Birding
Big Boggy	Matagorda	4,526	Birding
Matagorda Island	Matagorda	56,668	Birding and wildlife viewing
Wildlife Management Areas			
Mad Island	Matagorda	7,281	Hunting and wildlife viewing
Dr. R. Wintermann	Wharton	246	Restricted access

Table 3-18

Existing Lower Colorado River Authority Facilities by County

County	San Saba	Lampasas	Burnet	Llano	Blanco	Travis	Bastrop	Colorado	Fayette	Wharton	Matagorda	Total
Total Acres	**0**	**0**	**3,885**	**352**	**0**	**7,684**	**2,473**	**24**	**350**	**36**	**1,611**	**16,415**
Entrance Station			21			19	2		2			44
Trail Miles			19			17	22		8			66
Picnic Tables			79	6		616	87	8	37	4	11	848
Improved Tent Camping Sites			58	36		43						137
Multiple Use/RV Sites			25	15		20	70		21			151
Shelters							6		8			14
Cabins			65			1			8			74
Dump Stations			1			1	2		1			5
Restrooms (with plumbing)			14	4		28	9	1	5			61
Restrooms (self contained)			2			9			1	1	1	14
Showers			6	1		4	2		2			15
Pavilions							4	1	1		1	7
Meeting Rooms			6			4	5		1			16
Amphitheaters			2			2	1					5
Fishing Piers			1				2	1	3		2	9
Boat Ramps			4	1		9	2		2		1	19
Canoe Launches			3			1	1	1	2	1		9
Marinas (no. of boat slips)							14		8			22
Swimming Areas			2			10	2		1		2	17
Playscapes							2		2		1	5
Athletic Fields			2			4	6	2	4			18
Concessions			3			3	2		1			9

3.2.17 Hazardous, Toxic, and Radioactive Waste

The EPA Envirofacts Data Warehouse (EPA 2004a) is a single point of access to select environmental data. It provides access to several EPA databases that provide information about environmental activities that may affect air, water, and land anywhere in the United States. A review of the following database was conducted on 04 August 2004:

- Superfund (Comprehensive Environmental Response, Compensations, and Liability Information System [CERCLIS])
- Resource Conservation and Recovery Act Information (RCRAInfo)
- Toxic Release Inventory (TRI)
- Radiation Information Database (RADINFO)

Due to the presence of industrial and commercial activities in the study area, this review does not exclude the possibility of potential hazardous wastes that may have been disposed of within the study area and are unknown to the EPA or TCEQ.

Superfund (CERLIS). According to the EPA (2004b), Superfund is a program administered to locate, investigate, and clean up the worst hazardous waste sites throughout the United States. These sites include abandoned warehouses, manufacturing facilities, processing plants, and landfills. EPA administers the Superfund program in cooperation with individual states and tribal governments.

The Envirofacts Data Warehouse lists nine Superfund sites within eight counties of the lower Colorado River basin (EPA 2004b): Bastrop (1), Caldwell (1), Comanche (1), Hays (2), Lampasas (1), Matagorda (1), Runnels (1), and Travis (1) counties. Three of these occur in the study area: Barton Springs Pool in Travis County; BNSF Train Derailment in Lampasas County; and Camp Swift Military Reservation in Bastrop county. Organic chemicals were identified in the sediments of Barton Springs Pool in 2003. The Envirofacts Data Warehouse contained no site description information for the BNSF Train Derailment. Enforcement and clean up actions at Camp Swift Military Reservation were for the weapons range / training / maintenance facility. None of the three sites is listed on the CERCLIS National Priorities List. The general locations of the Superfund sites within the study area are shown on Figure 3-18.

RCRAInfo. The EPA (2004c) contains hazardous waste information in the RCRAInfo database, a national program management and inventory system about hazardous waste handlers. In general, all generators, transporters, treaters, storers, and disposers of hazardous waste are required

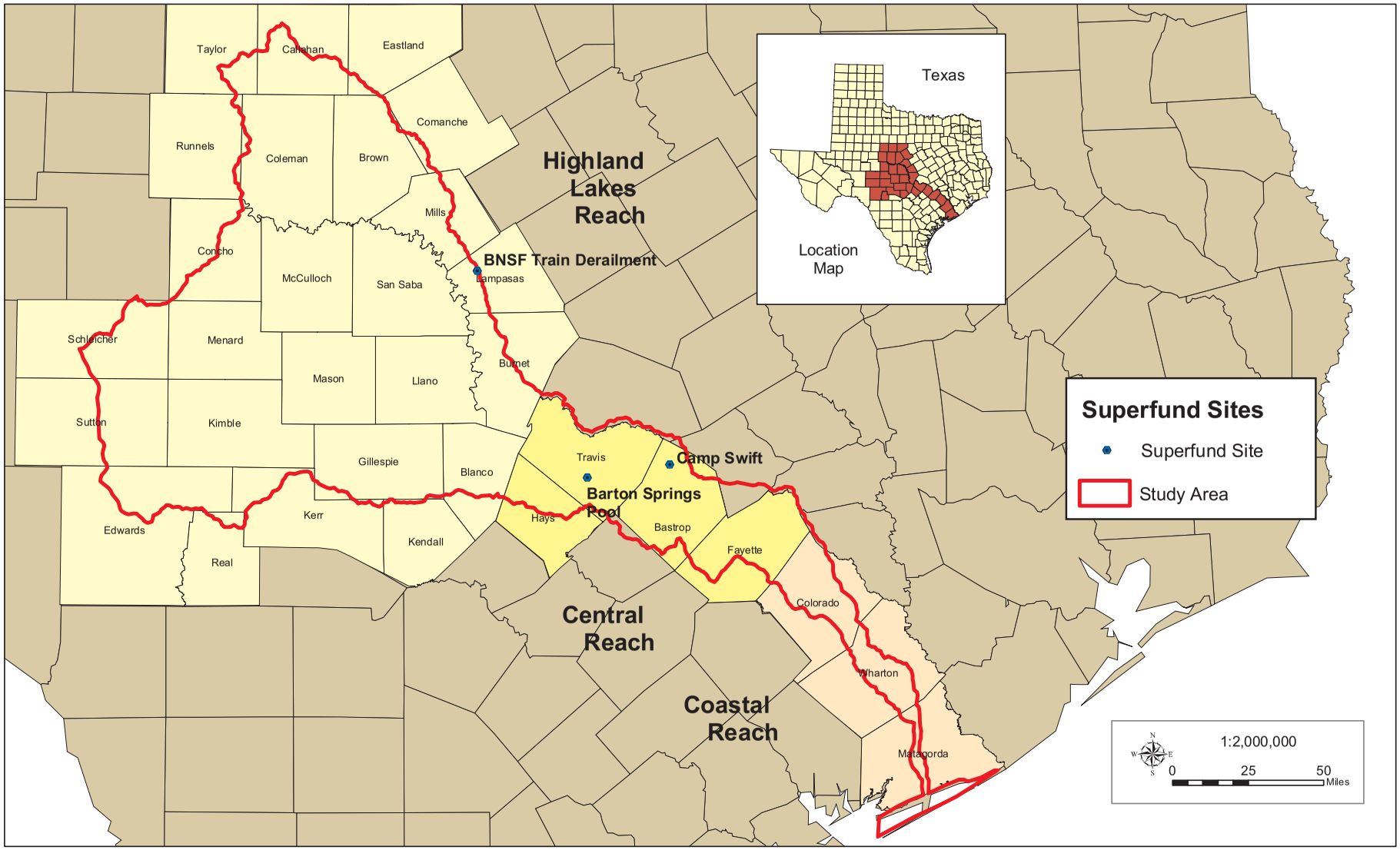

Figure 3-18: Superfund Sites

Date: October 2004

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to provide information about their activities to state environmental agencies. These agencies, in turn pass on the information to regional and national EPA offices. The RCRA governs this regulation, as amended by the Hazardous and Solid Waste Amendments of 1984.

Currently, there are 1,381 RCRA sites within the lower Colorado River basin (EPA 2004c). All counties, except Real, have listed RCRA sites. Three counties make up over half (767) the RCRA locations: Travis (500), Taylor (197), and Hays (73) counties.

TRI. The EPA (2004d) contains information about more than 650 toxic chemicals that are being used, manufactured, treated, transported, or released into the environment in the TRI database. Manufacturers of these chemicals are required to report the locations and quantities of chemicals stored on-site to state and local governments. The reports are submitted to the EPA and state governments. EPA compiles this data in an on-line, publicly accessible national computerized database. The database provides basic facility information and chemical reports, which tabulate air emissions, surface water discharges, releases to land, underground injections, and transfers to off-site locations.

Currently, there are 141 TRI sites within 20 counties of the lower Colorado River basin (EPA 2004d). Travis (63) and Taylor (23) counties make up over half (86) of the TRI locations.

RADINFO. The RADINFO (EPA 2004e) contains basic information about certain facilities that the USEPA regulates for radiation and radioactivity. The regulations that govern radiation across the federal government are complex, and, therefore, RADINFO may not include every facility you might expect to find.

The types of facilities currently included in RADINFO and the relevant Code of Federal Regulations (CFR) are Waste Isolation Pilot Plants (regulated by 40CFR Parts 191 and 194); Radioactive-National Emissions Standards for Hazardous Air Pollutants (RAD-NESHAP) regulated facilities, including inactive phosphogypsum stacks (40 CFR Part 61); and Radioactively contaminated National Priority List (NPL) Sites (400 CFR Part 300). Types of facilities not currently included in RADINFO are RCRA facilities licensed to accept radioactive waste, NPL sites not contaminated with radioactive materials, mixed waste facilities, uranium and thorium mill tailings sites, nuclear fuel cycle facilities, and active phosphogypsum stacks.

Future upgrades to RADINFO will expand the scope of facilities in RADINFO. These upgrades will capture facilities governed by EPA's RCRA regulations that are licensed by specific states to accept radioactive waste. In addition, RADINFO will include commercial nuclear power plants regulated by the Nuclear Regulatory Commission.

Because RADINFO is currently based upon information provided by those sites and facilities regulated by EPA, there may be other facilities subject to EPA regulations that handle radioactive materials that are not included in RADINFO. For example, phosphogypsum piles (also known as stacks) are regulated under 40 CFR 61, Subpart R, but the owners or operators of these stacks are not required to report to EPA until the stacks become inactive. Owners or operators of active phosphogypsum stacks are not required to report to EPA. Thus, information concerning these facilities will not be included in RADINFO.

Currently, no RADINFO sites occur within the lower Colorado River basin study area (EPA 2004e).

3.2.18 Environmental Justice

According to the EPA (2004g), environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including a racial, ethnic, or a socioeconomic group, should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies. Meaningful involvement means that: (1) potentially affected community residents have an appropriate opportunity to participate in decisions about a proposed activity that will affect their environment and/or health; (2) the public's contribution can influence the regulatory agency's decision; (3) the concerns of all participants involved will be considered in the decision making process; and (4) the decision makers seek out and facilitate the involvement of those potentially affected.

Environmental justice is achieved when everyone, regardless of race, culture, or income, enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work.

Executive Order 12898, Environmental Justice. The fair treatment of all has been assuming an increasingly prominent role in environmental legislation and implementation of environmental statutes. In February 1994, President Clinton signed Executive Order (E.O.) 12898 titled, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. This action requires all Federal agencies to identify and address disproportionately high and adverse effect of its programs, policies, and activities on minority and low-income popula-

tions. Agencies are directed to identify potential effects and possible mitigation measures in consultation with the identified affected communities. In order to determine these potential impacts to minority and/or low-income populations within the study area(s) that are planning or participating in projects, the information obtained from a review of the existing demographic and census data shall be combined with a series of community participation meetings designed to draw responses from segments of the community which typically will not be responsive to traditional NEPA information requests and meetings.

Agencies should consult the Interagency Working Group on Environmental Justice (IWG) guidelines when assessing minority and low-income populations as part of the collection of existing condition information on socioeconomic conditions for impacts of planned, proposed, or potential future, projects. The IWG guidance specifically notes that the minority population in the affected area should be meaningfully greater than the general population, or area of geographic analysis. The specific guidance suggests that the minority population in the affected area exceed 50% of the general population. The consideration for determining low-income populations is taken from the Bureau of Census reports as suggested by the IWG guidance. The review of existing general demographic and census data identifies potential areas where the criteria for minority and/or low-income populations may appear within planned or potential project areas. While the general demographic data and a large portion of the aggregated census information reviewed may mask specific locations of populations where environmental justice may be of concern, it is possible to draw some inferences which allow the identification of specific areas which should be specifically sought out to determine what the project effects may be on the population and how to avoid disproportionate application of project impacts.

Please refer to section 3.2.2 Socioeconomic Setting for population and economic demographics within the lower Colorado River basin. Race/Ethnic Group proportions (Black, Hispanic, and other) for counties in the lower Colorado River basin ranged from 5 to 53%. Counties with the highest minority rates include Edwards and Caldwell counties. The counties with the lowest minority rates were Llano and Callahan.

Executive Order 13045, Protection of Children. E.O. 13045 requires each Federal Agency "to identify and assess environmental health risks and safety risks that may disproportionately affect children; and "ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks." This E.O. was prompted by the recognition that children, still undergoing physiological growth and development, are

more sensitive to adverse environmental health and safety risks than adults. Within the 34 counties of the lower Colorado River basin, the percent of the population under 18 years of age for the year 2000 ranges between 16-30% (Texas State Data Center [TXSDC] 2004). Comanche and Llano counties contain the fewest children (<20%) whereas 30% of Matagorda County is less than 18 years of age.